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AGGREGATE SUPPLY, AGGREGATE DEMAND AND INCOME DISTRIBUTION IN IRELAND: A MACROSECTORAL ANALYSIS

JOHN BRADLEY and CONNELL FANNING

Paper No. 115

June, 1984

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Price IR£10.00

(Special rate for students: IR£5.00)

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ISBN 0 7070 0064 5

Acknowledgements

A study of the type we have undertaken here incurs an enormous debt of gratitude to a very large number of persons. Our first expression of this must be to the authors of the extensive range of published and unpublished studies on the Irish economy and its various aspects. Because of the numbers involved the reference list citation has to suffice as an inadequate expression of the fact that whatever little we have added to Irish economic studies by way of systematising the analysis within a framework of the economy as a whole, has only been possible due to this stock of ideas, insights and results. Most of these papers and books belong to what, without implying anything about chronological seniority, might be termed a third "generation" of Irish economists. And studies by two previous "generations" were important in stimulating our interests and approaches even if they did not always impinge directly on the sectoral structure followed here.

The "middle generation" is represented by three books in particular: David O'Mahony, *The Irish Economy* (1964, 1967), K.A. Kennedy and B.R. Dowling, *Economic Growth in Ireland* (1975), and N.J. Gibson and J.E. Spencer (editors), *Economic Activity in Ireland* (1977). Each of these in their own way, in terms of what they achieved as well as what they did not attempt, influenced our approach and provided a rich source of ideas and information. In some ways what we have attempted, in this and a subsequent study, is merely a conceptual and operational systematisation of the broader aspects of these books. But they also serve as a constant reminder of the insights and detail that are lost in following the approach we have taken.

The "first generation" – both chronologically in his case, as well as in terms of pioneering work on the Irish economy – is the late R.C. Geary. His early work on modelling the Irish economy, in particular his Harrodian model of 1963/64, was an important study for us and still is a fresh source of ideas about the whole method of modelling the economy. From a selfish viewpoint, anyone who has benefited, as has been our privilege, from the detailed, demanding and encouraging reader's reports, which Roy Geary mysteriously always found time to provide, will appreciate our great loss that not being able to avail of his comments has meant. It need hardly be mentioned here that this is minor compared to his loss to Irish economic studies. While we can expect in due course that his life and work will be suitably remembered we would like to dedicate this study to his memory as a token of our debt for the encouragement and help which he unselfishly and unhesitatingly gave on every occasion.

Another related study which should be mentioned at this stage, while hastening to note the author's youthfulness, is B.M. Walsh, *An Econometric Model of Ireland 1944-1962* (1966), which was the first large scale macroeconometric analysis of the type we have undertaken here and can be seen to have been the first attempt at opening up the line started by Roy Geary.

We were very lucky in having a large number of readers who endured the entire first draft and who very kindly gave us the benefit of their knowledge and feelings. The internal readers of the ESRI, Denis Conniffe and Joe Durkan, are very largely responsible for whatever degree of readability this study may have as well as for many major and minor improvements in the content. John FitzGerald and Tony Murphy of the Department of Finance took us to task on every nook and cranny. Patrick Honohan of the Central Bank used some of his precious sabbatical in the University of California in San Diego to give us detailed comments and suggestions for improvements.

Later drafts were read in parts or in their entirety by a large number of persons, individually and collectively as members of organisations. The organisations which provided reports were the Central Bank of Ireland, the Central Statistics Office and the Department of Finance. The individuals who kindly read all or parts for us or discussed aspects with us were Gerry Boyle (Agricultural Institute), Gerry Hughes (ESRI), David Lynch (Central Bank of Ireland), David O'Mahony (UCC) and Jerry Sexton and Mark Wynne (ESRI). Needless to say, none is held responsible for remaining errors. Finally, the anonymous external referee is to be thanked for a detailed reading, critical comments, and overall encouragement of the project.

Connell Fanning wishes to acknowledge the financial assistance of The Committee for Social Science Research in Ireland which provided the opportunity to study economy-wide modelling developments in the US in 1980 and to the World Bank, and particularly Francis Colaco and Peter Miovic of EPDIT, for ancillary assistance and hospitality. Further financial assistance from the Arts Faculty Fund, University College, Cork is also acknowledged. He also wishes to thank the Chancellor of the National University of Ireland, and the President, Governing Body, and Head of the Department of Economics at University College, Cork for agreeing to, and facilitating in every way, his secondment to the ESRI for the 1981/82-1982/83 academic years and to the President and Director of the ESRI for providing the opportunity to work on this project.

The typing and proofing of our paper was efficiently carried out at various stages by the Institute's secretarial staff: Mary Cleary, Pat Hughes, Regina Moore, Mary O'Sullivan, Maria Swords, Noreen Walsh and Deirdre Whitaker. Pat Hopkins gave valuable advice on the complex photocopying procedures and prepared all the graphical material. Mary McElhone carried out the vital task of translating our unwieldy typescript into a printed version and relentlessly exposed our inpenetrable prose and our rampant *non-sequiturs.* We promise to try to do better the next time!

Finally, there is always the greatest but inadequately expressed gratitude to Mary Bradley and Mary Fanning.

CONTENTS

APPENDICES

LIST OF TABLES

Table		Page

LIST OF FIGURES

GENERAL SUMMARY

The nature and seriousness of a number of major national economic problems facing the Irish economy – unemployment, inflation, government debt and foreign trade deficit – are such that their orderly solution can only be contemplated over an extended period of time. Underlying these problems are public sector/private sector imbalances, rapid labour supply growth, a slow-down in the rate of investment and, more generally, the onset of a period of slower growth expectations brought on by the depressed state of the world economy. In the light of these problems it has become important that the functioning of the economy over "medium-term" horizons (up to 5 years) be better understood, and this paper addresses itself to the more analytic and technical aspects of this task. Three complementary aspects motivated our approach.

First, the study attempts to be a comprehensive theoretical and empirical analysis of the Irish economy as a whole. The approach followed is to segregate the economy into broad sectors within an economy-wide analytical framework and attempting to ensure that there is an overall consistency across all the sectors. The purpose of this approach is to provide a clear view – albeit at a highly aggregate level – of how certain factors shape the economy. In other words, we look at how certain interrelationships hold between various elements of the economy and put numbers, or orders of magnitude, on these connections.

Second, the technique used is that of analysing and representing the entire economy by a broad system of mathematical and statistical relationships. These relationships, as well as providing useful insights in themselves, can also be brought together to make up a "working" or operationalised system of relationships which can be programmed into a computer and used to examine alternative possibilities – scenarios – for the economy. Such a computerised system of relationships representing the economy as a whole is now a standard tool of economic analysis and forecasting and contributes to public debate about policies in a wide range of countries. However, only limited use has been made of this technique for analysis in the realm of public debate about economic policy in Ireland. This is so despite the fact that there has been a substantial amount of work of this kind done on the Irish economy. In other papers we have surveyed this work and identified a number of factors involved in the relative neglect of this technique. Although

we do not report here on an operational representation of the economy, for reasons stated in Chapter 1, it was partly, at least, to help overcome these difficulties that this study was undertaken.

As mentioned already there is a substantial amount of work involving systems of relationships at the level of the Irish economy as a whole. As well as these there is a very large number of studies, of various types and approaches, for different sectors and aspects of the Irish economy. The third purpose of our paper is to bring together and survey a wide range of these studies within the context of the comprehensive analytical framework underlying our approach. In this way it is hoped that it will bridge the gap between descriptive studies of individual sectors of the Irish economy and computerised representations of the economy where sectoral detail is largely lost because of the focus on operationalisations of a completed economy-wide system of relationships.

Thus, this report is intended to be (i) a comprehensive sectoral analysis of the Irish economy during a significant phase of its economic development, (ii) an integration of previous work relevant to the topics analysed here and (iii) the basis for the compilation and operationlisation of a computerised system which can then be used for further sectoral and economy-wide analysis. The latter is the subject of a subsequent report complementing this one. The remainder of this general introduction provides an overview of the main issues addressed in this report.

A study such as this one raises very many research issues about methodology, techniques, and content and not all of these can be examined in one report. Some of the most important of these are identified in Chapter 1 and the bounds for the present paper are highlighted. Also, the relationship of this paper to studies of the same or other types is discussed, some aspects of the techniques employed are considered, and an overview is provided.

If there is to be analytical coherence across all the sectors of the economy studied there has to be some organising framework within which the analysis can be conducted. The subject matter of Chapter 2 is an outline of the economy-wide framework which ensures an overall consistency in the formalisation of behavioural, institutional and technological detail in a system of sectoral relationships. Furthermore, there is a need for quantitative data for statistical analysis on the same basis as the organising framework. This aspect is also discussed in this chapter. Both the framework and the data available for use have important consequences for the type of analysis being conducted here and so a consideration of these aspects is fundamental for an appreciation of the strengths and limitations of the study. The general organising framework and the main data source discussed in this chapter are used to provide the particular logic for the following analysis which is organised into three broad areas – total supply, total demand and income distribution – and these are the subject matter of Chapters 4 to 8.

Before turning to the actual analysis of these broad areas, and the subsectors within them, it was necessary to first explore a technical area which is crucial to a better understanding of medium-term analysis of aggregate supply, namely, the aggregate relationship between the inputs used in production and the output generated by their use. In economic terminology we are concerned, in Chapter 3, with the structure of the aggregate production function and the related factor demand decisions. This is a topic which has been relatively neglected in Irish empirical analysis at the economy-wide level. Basically, we examine how a firm's output and demand for factor inputs (labour, capital, materials) are related in an economically consistent manner. Various concepts of "capacity" output and factor utilisation are examined and a clear distinction is drawn between the decisions of firms which relate to future capacity and those which relate to current rates of utilisation of that capacity which is installed.

Before turning to the theoretical and statistical analysis of the various sectors of the economy an important point concerning statistical estimations should be noted. In reporting our results, alternatives are given for many of the key economic relationships specified. This is because, first, in conducting any analysis of the behaviour of the economy as a whole it is necessary to begin with some view of how the economic system functions and, second, even with this prior narrowing down of options there still remains a range of "mixed" results indicating that a selection will still have to be made on the basis of intuition and experience. This approach shows to what extent the prior view of the economy fits or does not fit the data. It would not be appropriate to report only a single "best" result, selected according to some simple statistical criterion, and a proper interpretation of the theoretical and statistical analysis requires that, at least, a representative selection of results should be reported and considered. For this reason only very broad statements concerning the empirical results can be made in this General Introduction.

Following the examination of aggregate production functions in Chapter 3, we then turn, in the next two chapters, to an analysis of the supply of output in the Irish economy and do so in terms of five subsectors involved in the overall output behaviour of the economy. In Chapter 4 we examine two broad, aggregated sectors, industry and agriculture. In industry total long-run capacity output levels are taken to be decided on the basis of expected domestic and foreign demand. There is then a division of total capacity into that part which will be met through domestic production capability as distinct from imports. This is done by comparing domestic and import prices. By assuming cost minimisation and appropriate short-run adjustment process we derive a set of factor demand relationships which involve explicit distinctions between long-run capacity decisions and short-run utilisation and manning levels. In the case of agriculture, suppliers are price-takers within the Common Agricultural Policy of the EEC, subject to the amount of land being fixed, and with labour requirements analysed in a manner different from the maximising behavioural approach of the sort which was used in the industry sector. However, a profit maximisation framework is used to examine output and material input decisions and allowance is made for the influence of external conditions like the weather.

Among the main results for the industry sector are the following:

(i) Capacity output explained by real gross domestic expenditure and foreign trade with about equal influence by each – a 10 per cent increase in domestic expenditure results in a 5.5 per cent increase in capacity output, while a similar increase in world exports brings about a 4.0 per cent increase. No relative price or profitability effects were isolated because of the level of aggregation;

(ii) Technology employed in industry shows a very low responsiveness of factor proportions (capital per worker) to changes in capital-labour prices – a 10 per cent decrease in the price of labour relative to capital would only bring about a 3-4 per cent decrease in the capital intensity (capital per worker) of technology – and also technical progress has been relatively heavily biased in a labour-saving direction (at 2 per cent per annum) and capital using direction (at 6 per cent per annum). This possibly reflects Ireland being an importer of technology designed in more advanced countries in response to their own needs for substitution of capital for labour; and

(iii) The modification of long-run plans in the light of emerging short-run conditions is much less for investment than for employment. (An alternative approach than that used to get this result showed that changes in output have a small effect on employment but a much larger effect on capacity utilisation – a 10 per cent increase in output resulted in a 3 per cent increase in employment and a 15 per cent increase in capacity utilisation, respectively.)

Overall, in the case of our analysis of supply in industry, the core relationship involved the determination of long-run output and long-run factor inputs. Long-run output was determined by expected domestic and foreign absorption and this relationship is central to the relationship between supply and demand in the economy. In the case of Ireland, it encompasses aspects of the process of multi-national company investment and production location and represents a simple, but useful, way of breaking into the circularity of what is obviously a highly complex problem. In the determination of factor inputs to the production process, the imposition of a specific technology assumption on the industry sector means that the long-term employment and investment developments cannot diverge and become inconsistent with each other. Finally, our approach has interesting links with the theory of export-led growth and with approaches which were explored in some earlier studies of Irish growth and development.

For the agriculture sector some of the main results were:

(i) A supply function with output determined by production capacity, profitability and weather conditions;
(ii) An employment relationship showing, for example, a 10 per cent rise in labour productivity associated with a 7.5 per cent decline in employment, a 10 per cent rise in agriculture earnings compared to non-agricultural earnings associated with a 4 per cent rise in employment, and non-agricultural employment opportunities dis-improving resulting in a slowing down in the rate of decline in agricultural employment.

In Chapter 5 we consider the broad services sector. The very heterogeneous nature of this sector is emphasised, with its mixture of private and state elements. This poses problems for any attempts to analyse this sector in terms of a single behavioural framework. Consequently the analysis and statistical results are of a very preliminary type and more precise investigation must await more and better data. As well as domestic production there is also the foreign component of goods and services supplied to the Irish economy. So in this chapter we also examine the determination of imports by means of an approach based on minimising the costs of meeting the required demand for goods given the choice of home or foreign supply. Finally, the supply of the human factor of production, currently the reason for a major policy problem in Ireland, is analysed by considering the interacting elements of population growth, participation in full-time education, labour force participation decisions and migration.

The main results for the service sector showed that output increased by 2.2 per cent in response to a 10 per cent increase in real incomes, which estimate is probably too low, and also had a trend increase of about 3 per cent per year. Omitting the trend factor resulted in the responsiveness of output to real incomes increasing to about 11 per cent. The response of employment to an output increase of 10 per cent was 2.4 per cent in the short run and 8 per cent over the long run, and to a 10 per cent increase in the product wage was 1.5 per cent decline in the short term and a 4.8 per cent decline over the long term. For capital the responsiveness was, with respect to output, 0.8 per cent in the short term and 6.6 per cent in the long term and, with respect to product capital price, 2.9 per cent (in the opposite direction) in the short term and 23.6 per cent in the long term.

Overall, in the case of agriculture and services, the theoretical models were somewhat less satisfactory than for industry and it must be recognised that institutional, governmental and demographic forces become significant. The results from the model of labour supply linked up with some other recent researches in this area and serve the purpose of placing these demographic developments within a macroeconomic framework which both influences them and is, in turn, influenced by them.

A large number of relationships at different degrees of aggregation was estimated for the imports part of total supply with, for example, the results for imports of goods for further production insensitive to the relativity of domestic to foreign prices but sensitive to industrial capacity utilisation (a 10 per cent increase in utilisation resulted in a 13 per cent increase in materials imports). Other goods and services imports, on the other hand, were somewhat less sensitive to the activity level in the economy (a 10 per cent increase in industrial capacity utilisation resulted in a 7 per cent increase in these imports) but quite sensitive to relative price effects (a 10 per cent change in relative prices resulting in a 6 per cent change in imports in the opposite direction).

Again, for labour supply, a number of aspects was involved in examining the overall rate of participation in the labour force. For the rate of participation by potential participants the main influences appeared to be increased job availability and real wages increasing this rate. Although these results need further examination there was little indication of any social welfare payments effects on aggregate labour force participation. Net migration, which changed dramatically from an outflow to an inflow during the period examined, was shown to be sensitive to the relative attractiveness of working in Ireland *vis-à-vis* working abroad with relative attractiveness measured in terms of relative unemployment rates and earnings.

In Chapter 6 we discuss the second main area of our study, the determination of total demand which is divided first into its domestic and exports categories and then into further sub-components. This is an area where much previous empirical work exists and we review studies of private consumption and housing investment. Concerning government consumption we examine two approaches. The first approach considers government expenditures on consumption goods and services as policy instruments which may be manipulated at the complete discretion of the public authorities. While an alternative approach considers these expenditures as being behaviourally linked to the level of private sector activity. The reality is probably a mixture of both approaches and the matter requires further detailed investigation. Finally, exports are examined, consistent with our organising framework, from the point of view of both the small open economy and a non-"small open economy" perspective. Bringing together the domestic production component of total supply and domestic demand (or imports and exports) results in the foreign trade balance which by and large is in deficit in Ireland and an area of policy concern and attention.

Among the main results derived for the sector were:

(i) Real household expenditure related to real disposable income with a short-run marginal propensity to consume of about 0.4 rising to a long-run value of about 0.6;

(ii) Current government expenditure related to household expenditure – a 10 per cent increase in the latter was accompanied by an 8.4 per cent increase in the former in the short run and a 13.4 per cent increase in the long run. Hence, public consumption has been growing at a faster rate than private consumption and would ultimately dominate consumption totally if these trends were, and could be, continued; and

(iii) For exports of non-agricultural goods and services a 10 per cent increase in world income resulted in a 29 per cent increase in exports while a 10 per cent increase in Irish relative to foreign prices resulted in an 11 per cent decline in exports. In the case of the determination of exports, we have examined approaches which draw on existing results. However, one of the differences between studying exports in isolation and studying them within a macroeconomic system is that it forces one to face up to constraints and interrelationships within the system. In isolated studies, the equations often take on aspects of reduced forms, i.e., a combination of many structural equations into one aggregated equation, which may become unstable if the underlying structural relations shift over time.

In Chapters 7 and 8 we take up the topic of income distribution. In our usage the term income distribution means the income accruing to the factors of production according to the sectoral and other categories used in our study, i.e., wage and non-wage income, agricultural and non-agricultural income, foreign factor income flows, etc. We do not consider the question of the distribution of personal incomes within sectoral categories, an issue which, although of extreme importance in the analysis of government social policy, falls outside the scope of the data available at present. For the setting of producer prices, a mark up approach is emphasised with prices for final buyers modified by indirect taxes, subsidies and import prices. Wage determination is examined in terms of two different approaches involving market competition or administration/bargaining. Finally, attention is given to analysis of the fiscal redistribution system of taxation, expenditure and income transfers, and to the determination of the government budget balance which is currently another significant problem facing the Irish economy and the focus of a major policy commitment by the present government.

A wide variety of relationships is examined for different types of prices and wages. For producer value added prices in industry, for example, the primary explanatory variables focused on were unit labour costs, capacity utilisation, and prices of foreign traded goods. The main effect identified was from unit labour costs. In services the impact of capital costs were also found to be significant. Wages for industry, for example, were examined using competitive and administered market approaches and the empirical results did not allow a clear choice to be made between them. In the case of a competitive market approach, for example, the wage relationship showed a very high degree of indexation for price increases and compensation for increases in labour productivity. In an administered market (bargaining) approach the results indicate that a target real wage growth of 4.3 per cent per annum was sought. The remainder of the income distribution block, Chapter 8, is concerned with fiscal aspects of income redistribution and involves, essentially, only the estimation of equations for tax revenues, etc., which is made necessary because of the inexact match of revenues and bases and rates data.

In the concluding chapter, Chapter 9, we address some implications of the approach we have followed in the study and directions for future research. Basically there are two routes which could be pursued. The first is to develop the sectoral analysis in order to improve the theoretical underpinnings and institutional content, and numerical information in order to obtain better empirical results. As we stated at the outset, one of our primary aims was to set out an appropriate analytical framework within which such sectoral studies could be conducted by specialists in a manner which is consistent across other sectors of the economy. The second route is to take the theoretical analysis and empirical results, basically as they stand here, but with improvements where possible in the light of this experience, and set down a system of relationships for the economy as a whole which can be operationalised in a computer system.

Finally, our study illustrates both the benefits to be obtained from formal analytical study of the structure of the economy and the possible dangers of such studies. Possible benefits include the prospects of enhanced understanding and quantification of interrelationships previously understood only partially or not at all. Dangers include possible misuse of the analysis based on a misunderstanding of its partial, tentative and often speculative character. The analysis may take on a reality of its own, when, in fact, it is conditioned by the view of the operation of the economy held by the analysts. This danger becomes particularly relevant when competing economic paradigms at the theoretical level translate into radically different policy prescriptions. It is for this reason that we have tried to report a wide range of empirical results and not to select a narrow subset which appeared to support only one narrow interpretation of the functioning of the economy.

PART ONE: *INTRODUCTION AND METHODOLOGY*

Chapter 1

REVIEW OF OBJECTIVES AND METHODS

I. *INTRODUCTION*

The technique of analysing and representing an entire economy by a broad system of mathematical and statistical relationships is now a standard tool of economic research, policy analysis, and forecasting in virtually all industrially developed countries and is being increasingly used in newly industrialising countries. In Ireland, however, relatively little use has been made of this technique for policy research purposes although use has been made for forecasting tax revenues, consumption expenditures, etc., within, for example, the Department of Finance and the Central Bank of Ireland. Virtually no use has been made in the wider context of the policy research and debate that has occurred, for example, in the United Kingdom during the 1970s. This is so despite the fact that there has been a substantial amount of work of this kind done on the Irish economy both within and outside Ireland. In two separate papers we surveyed this work and attempted to identify some of the factors involved in the present lack of use of this technique in the policy-making process.[1] Two groups of reasons were considered, with the benefit of hindsight, to be particularly important in bringing about this situation. First, the volume and variety of the studies over a period of twenty-five years probably contributed to the reluctance of policy researchers and formulators to enter the confusing zone of alternative representations of the economy and mathematical-statistical approaches. Second, and compounding the first set of difficulties, the variable and usually inadequate documentation available on these studies, coupled with difficulties of access to and participation in the operation of the computer facilities involved, posed virtually insurmountable difficulties for potential users of this type of research (Fanning and Bradley, 1982, Part 3). It was partly, at least, to help overcome these difficulties that this study was undertaken.

The work is also intended to be a comprehensive empirical macroeconomic analysis of the Irish economy during a significant phase of its economic development. The perspective we bring to bear on this task is that of economy-level mathematical-statistical models. The purpose of this approach is to pro-

1. These papers (Fanning and Bradley, 1982; Bradley and Fanning, 1983) constituted the preliminary review stage for the present project.

vide a clear view – at the macro level – of how certain factors shape the economy, i.e., how certain inter-relationships hold between various elements of the economy, and to put numbers or orders of magnitude on these connections. The work reported in this study is intended as the first stage in a comprehensive examination of the construction of these macroeconometric models and their use in analysing some of the major macroeconomic problems currently challenging policy research and implementation in Ireland. In particular, we are interested in developing an analytical tool for the study of medium-term development of the economy. Simultaneously we are interested in exploring the nature of this tool so as to delineate the policy research framework that makes best use of this technique. This involves examining its analytical basis, exploring inherent limitations, and identifying its appropriate uses. All the issues raised by such a research problem cannot be addressed in one report. A narrow set of topics had to be selected to provide the basis for further work involving the implementation of an operational macroeconometric model and the examination of fundamental questions about the role of models in policy design.

Although this is a macroeconometric model-based research project we do not at this stage report on an operational model of the economy. This is for two reasons. First, as we will suggest on the basis of the discussion of various approaches to analysing the economy in the following subsection, there appears to be a need for an intermediate type of study. The role of such a study is to bridge the gap between descriptive analysis of individual sectors of the economy and a report on a particular macroeconometric model where sectoral detail is lost because of the focus on operationalisation. By drawing as much as possible on previous sectoral studies, and placing them within a structurally consistent macrosectoral framework, we hope to facilitate achieving this objective. Second, the computerised mathematical-statistical representation of the economy has requirements of its own which can affect the sectoral analysis. The operationalisation of a model system imposes constraints on the theoretical and empirical analysis. Also, although a widely used technique, it is not just a matter of following a "recipe" approach. There are still methodological questions to be answered.

Overall, a project approaching the issues outlined is a large one and, as stated already, it was necessary to break it down into easily manageable segments. Stopping short of compiling and implementing an operational model of the economy provided a natural demarcation line. A structural macroeconometric model perspective imposes an overall consistency on the sectoral analysis but the analysis is not affected by the requirements of obtaining an operational model. Thus, this report is both a sectoral macroeconometric analysis of the Irish economy and, at the same time, it is the basis for the compilation of a computerised model system which can then be used for further sectoral and macroeconometric analysis. The compilation, operationalisation, and evaluation of an economy model is the subject of a subsequent report (Bradley, Fanning, and Wynne, 1984).

The remainder of this chapter is organised into three sections. In the next section we consider, in a very general manner, various approaches to analysing the economy in order to place this study in the context of other studies of the Irish economy. In the third section, we outline some aspects of the nature of the macroeconometric approach underlying our analysis. Finally, in the fourth section we briefly describe the contents of the rest of the study.

II. *APPROACHES TO ECONOMY ANALYSIS*

In this section we relate the approach to be followed in this study to other approaches used in the analysis of the Irish economy. We do not attempt to be comprehensive, especially in regard to the type of work most like our selected perspective, i.e., macroeconometric models of the economy, as we have already surveyed this area in some detail in the documents cited in Section I.1. It is important to emphasise that our work builds upon and attempts to extend existing analysis of the Irish economy and to make this relationship clear we classify these economic studies into three broad groupings.

(i) *Descriptive Studies:*

In descriptive studies formal theories or models of economic behaviour are rarely used although, of course, there may be much implicit use of theory in the quantitative and institutional empirical analysis. The *Quarterly Economic Commentary* from The Economic and Social Research Institute and the *Quarterly Bulletin* of the Central Bank of Ireland are well known examples of the kind of work which have a significant influence on policy makers and have, primarily, a short-term forecasting perspective. In contrast to these, *Economic Development* (Ireland, 1958) the policy document prepared in the Department of Finance, had a medium-term perspective and was a highly influential study using the descriptive approach in its analysis of development and planning opportunities for Ireland during a period of a major economic crisis.

The descriptive approach to analysis of the short term is characterised by a spirit of pragmatism where each period (usually one quarter) is examined and studied using the latest economic indicators and results of business sentiments surveys, and a rolling forecast (usually in national accounting terms) for the year is updated as it evolves. The virtue of this approach is that it makes use of the most up-to-date economic data. It also serves the important role of providing national accounts "forecasts" for one or two preceding years which is necessary because of the long lag between the end of a year and the first official estimates of that year becoming available. Limitations of this technique make it difficult to quantify forecasts more than a few quarters ahead, partly due to having to also "forecast" up to the two preceding years; the learning process involved and the ex-post re-evaluation of forecasts are difficult to systematise (Durkan and Kelleher, 1975); and, since a formal statement of any underlying model of the economy is rarely stated, the framework of assumptions and parameters is not systematically laid out to enable the user of the forecasts to evaluate it based on alternative assumptions or views about how the economy functions. The latter may not be very important as regards forecasting numbers but is crucial when it comes to policy research and advice, especially in a democratic context (Fanning and Bradley, 1982, Part 4).

(ii) *Analytical-Empirical Studies:*

A second group of analyses involves the use of data and statistical methods which are usually quite simple but also involve regression techniques and, sometimes, including more sophisticated methods such as time series analysis (Geary and Kennan, 1982) and spectral analysis (Bradley, 1977; and Browne and O'Connell, 1978b). These techniques are used to explore relationships between different variables and, more recently, the issue of causality. The process can include data analysis without theory, i.e., purely statistical explorations, but normally some economic theory is combined with the data experimentation. With developments in economic and statistical theory, more recent exmpirical work tends to include the formal testing of economic hypotheses on a single-equation or a system basis. The latter often involve sophisticated estimation techniques, as in the recent work of Boyle and Sloane (1982) on demand for capital and labour inputs in manufacturing industry and Browne (1982) on exports. Sectoral analytical-empirical work may culminate in and, at least, facilitates the specification, estimation, operationalisation and testing of complete models of the economy. The amount of such work in Ireland has been growing steadily over the years and has been the subject of the recent surveys mentioned above.

(iii) *Theoretical:*

The use of "abstract" models and purely theoretical reasoning to work out the consequences of formal assumptions obviously plays a major role in economics. "Economics", as Keynes said, "is a science of thinking in terms of models joined to the art of choosing models which are relevant to the contemporary world". Thus, while such models are abstractions and may sometimes seem to include little empirical detail and have little relevance, nevertheless they are intended to reflect some elements selected as crucial to some particular issue and so are highly abstract forms of more general empirical models. They influence empirical models and, more generally, empirical modelling approaches. The development of the small open economy macroeconomic theory (Prachowny, 1975) greatly influenced empirical work in Ireland (McCormack, 1979). This is particularly clear in the series of empirical papers dealing with wage and price determination by Geary and his collaborators which are discussed in Chapter 7 below. While much theoretical analysis may never turn out to be of empirical relevance the mutual interaction between purely theoretical analysis and analytical-empirical analysis of the economy is continually becoming stronger. A good, recent example of this is the work by Helliwell and McRae on the Canadian economy. They point out that in terms of the design of macroeconometric models "the crucial trick is to choose a structure of aggregation and of functional forms that exposes the key channels of influence, makes efficient use of *a priori* information, and thus allows the available observations to be used to estimate key parameters about which little is known" (Helliwell and McRae, 1981, p. 1).[2] In the area of macroeconometric analysis and model building the research process involves constant interaction between the descriptive, empirical-analytical and theoretical approaches. Major economic upheavals such as the 1973 oil price shock (and, indeed, the 1929 depression for an earlier generation of economists), focused attention on the first and last approaches when the empirical-analytical approach proved inadequate in coping with real world events. Consequently, the recent criticism of the failure of macromodels to handle the post oil price shocks period and its consequences may to some extent, at least, be misdirected. Subsequent theoretical and descriptive work has led to a radical rethinking of fundamental structures of economy-wide models and, in the words of Helliwell and McRae, "any model structure that was chosen . . . a decade ago is sure to be the wrong structure now that energy price changes and other events have posed new and largely unforeseen problems of adjustment" (1981, p. 1). In this task the directions for tackling a problem are sometimes, and it would appear increasingly, suggested by purely theoretical and "abstract" analysis.

2. A less sanguine view of the place of macroeconometric type work was offered by Harrod (1973) in a correspondence with Keynes on the role of quantification in economics: "If there is to be a developing subject with a lot of workers competent but not outstandingly inspired, who want to find systematic work to do, more or less prescribed by the state of the subject – as in other sciences – I should have thought a mixture of Tinbergen (quantification) and pure theory was the right answer. Otherwise the ordinary competent researcher finds nothing to do but to write a history of the Milk Marketing Board, or to indulge in mathematical but rather fruitless refinements of the green publication [*Review of Economic Studies*] of the LSE"!

Since our concern is with the economy as a whole, we now use the above broad classification to place in perspective some economy-wide analysis of the Irish economy. Two works, *Economic Development* (Ireland, 1958) and *The Irish Economy* (O'Mahony, 1964a), mark a turning point in the empirical study of the Irish economy although there had been a long sequence of similar studies, particularly by Government Commissions and Committees. Both of these were primarily descriptive works, but with obvious analytical foundations. The first was a detailed examination of the resources and supply potential of the economy; the second concentrated on sectoral exposition based largely on a national accounting framework.[3] During the 1960s and 1970s, these two strands of economic analysis developed. The descriptive strand found expression in a number of economic commentaries such as the ESRI's *Quarterly Economic Commentary*, the Central Bank's *Quarterly Bulletin*, and the Government's *Economic Review and Outlook*. The empirical-analytical strand was developed in a series of economic models by, among many others, Geary (1963/64), Walsh (1966), Norton (1975), Fanning (1979), and the various versions of the Central Bank/Department of Finance model (Bradley *et al.*, 1981).[4] An intermediate approach was exemplified in the study by Kennedy and Dowling (1975) of the Irish economic growth experience in the 1950s-1960s. This combined the mainly descriptive approach with some elements of an analytic approach. Although it did not propose and test a formal and integrated medium-term or growth model of the economy, the work is partly in the Kaldor tradition of growth analysis and partly in the Kuznets tradition of growth accounting. The role of the balance of payments as a constraint on economic growth was central to the Kennedy and Dowling analysis of the role of fiscal policy in permitting faster growth in the 1960s when compared with the 1950s. The constraint imposed by the balance of payments is an important feature of recent formal analysis of export/investment led growth such as that by Cornwall (1977) and, especially, Thirlwall (1980a).

Despite the superficial coverage of the preceding literature review, a gap appears to exist in the range of studies of the economy to date. First, the formal macromodels have invariably been couched in a short-term fiscal policy mould (exceptions are Geary, 1963/64; Walsh, 1966; and Fanning, 1979). This emphasis on short-term policy analysis is understandable given the institutional affiliations of, and the resource and other constraints facing,

3. While *Economic Development* was overtly descriptive, a recent attempt has been made to isolate some aspects of the conceptual economy-wide "model" underlying it (Fanning and Bradley, 1982).

4. Only to a limited extent did these models embody previous "sectoral" empirical findings. Hence, the assumption that the whole is equal to the sum of its parts is not always a safe one to make when dealing with macromodels!

model builders in Ireland. Hence, most of the Irish models are unsuitable for analysis over a period longer than about two years, and give rise to serious inconsistencies if applied to analysis of the medium term, i.e., over five years, for example, in the factor demand equations which may be inconsistent in the sense of not being derived from a unified set of technology-behavioural postulates. In addition, particularly in a large-sized model, even the short-term unifying theoretical thread is often lost under a wealth of sectoral detail. Second, the descriptive approach, even in a fairly rigorous form, falls short of providing an overall integrative framework within which to prepare for the future on the basis of experience of the past. This is particularly so when the implicit assumptions underlying such work may be unexamined and possibly of questionable relevance, due to a radically changed economic environment. Consequently, our work will be based on framework composed of formal economic-theoretic technological-behavioural assumptions with economic activity organised into sectors by means of an integrating set of economy-wide accounts. For convenience, we will refer to this as the macrosectoral framework. Also, it will be oriented explicitly to deal with medium-term issues. One of our goals will be to formalise the growth analysis of the type conducted by, for example, Kennedy and Dowling (1975) something that the authors of that work explicitly avoided doing, feeling that more insight would be gained by a less mathematical approach. Adopting this methodology will involve a careful statement of the economic assumptions in our work and an evaluation of the costs and benefits of abstraction, issues which will be explored in later sections below.

Our analysis will be carried out at a fairly high level of aggregation. The different degrees of data disaggregation lead to different insights. Here we adopt a fairly aggregate approach in order to (i) set up a "prototype" framework of analysis in a more readily understandable form, which can subsequently, if desired, be disaggregated; (ii) make the most of existing national accounting data; and (iii) provide a more suitable and usable "test-bed" for examining differing economic-theoretic paradigms of behaviour. The time-span of our analysis is explicitly medium term; hence, the nature of the system's dynamics and internal consistency will be all important and short-term forecasting accuracy will not be the overriding criterion.

This study differs from previous macroeconometric studies and models in a number of ways. The structure of the sectoral analysis is closely linked to the envisaged role and purpose of the integrated operational model to be constructed in the next stage of the project, i.e., medium-term policy analysis. We attempt to incorporate a more rigorous production side concerning factor demands and supply, drawing on much recent work in this area, a survey of which is provided in Chapter 3 below. The level of disaggregation is about midway between the small-scale model of Norton (1975) and the large-scale models of Fanning (1979) and the Central Bank/Department of Finance (Bradley *et al.*, 1981). We attempt to bring theory "up front". In some ways the work can be seen as an attempt at the explicit working out of a behavioural paradigm which, we believe, implicitly motivates much policy analysis and discussion of economic matters in Ireland. Finally, we attempt to integrate the behaviour of a major supply sector, agriculture, into the rest of the economy, a matter which has previously been largely neglected, with the exception of Walsh (1966) who made an early effort in this direction.

However, we intend that our work should complement previous economic analysis, in the sense that, for example, (i) it provides a framework within which the Kennedy and Dowling analysis of, and insights on, growth can be viewed, tested, and perhaps extended; (ii) it updates the original dualistic analysis of Walsh (1966), by adding service and government sectors to Walsh's original agriculture and non-agriculture sectors; and finally, (iii) it attempts to capitalise on the benefits which are often claimed for a formal macro-econometric approach, i.e., that it is an aid to logical thinking, as a guide to policy analysis and formulation, and as a framework for estimation, quantitative prediction and testing of hypotheses.

The limitations of the work are those associated with any macroeconometric study. We merely single out two for particular emphasis: first, the level of aggregation is quite high and so the rejection or non-rejection by the data of any particular model may often be due to data aggregation problems; and, second, the data period covered is approximately 1960 to 1979, the earlier period (which has been analysed in detail by Kennedy and Dowling, 1975) being excluded due to difficulties with the output and trade data and the termination date of 1979 being dictated by availability of national accounts data when the study was undertaken.[5]

III. *METHODOLOGY FOR A MEDIUM-TERM STUDY*

As with any analytical study the starting point is the identification of a particular problem. The broad problem area, with which we are concerned, is primarily that of aggregate real economic activity in the Irish economy. Specifically, we are concerned with providing a "medium-term" macroeconomic perspective on unemployment, price inflation, balance of payments, fiscal and monetary aspects of the public sector and income distribution. Medium term here relates to the time perspective with which the analysis is conducted and not with the periodicity or length of data sample used for

5. The follow-up report, concerned with operationalising an economy-wide model, will make use of data which has become available since then.

statistical estimation. As a rough generalisation the "short term" could be taken as referring to a time horizon of up to one or, perhaps, two years. The medium-term horizon is then held to extend to about five years. Implicit in this is an important distinction based on the different factors that have to be taken into account as the duration of analysis is lengthened. In terms of the problem area highlighted above this points to the comprehensiveness with which aggregate demand and supply and, especially, their interaction are handled in the analysis. Once again, as an approximate characterisation, in short-term analysis one may take the production capacity as given or outside the scope of the analysis and concentrate on the determination of aggregate demand. A medium-term analysis addressing the selected problems, must be concerned with capacity because over the longer time horizon it must take the supply of factors of production and the degree to which they are employed into account. This is necessary because current output may not represent production capacity and the degree of utilisation of capacity has consequences for economic activity and future developments in the economy. Thus, a medium-term macroeconometric study concerned with output and employment growth, aggregate price inflation, and income distribution must include (i) the determination of capacity, as well as accompanying definitions of full utilisation of resources and (ii) the determination of the rate of capacity utilisation.

After specifying a problem the usual scientific procedure is to generate hypotheses and identify appropriate techniques to evaluate them. In economics, however, the procedure is not so clearly divided or sequential. The hypotheses generated and the evaluation techniques used in the empirical analysis of aggregate economic activity are very much interrelated as, for example, in what constitutes "facts", as well as the availability and suitability of recorded information, including numerical data. The techniques and data available largely determine the characteristics of empirical economic analysis and problem specification. Since this study is explicitly planned within a macrosectoral empirical framework, it is necessary to consider carefully various aspects of our chosen methodology in order to be clear about what can be expected from such an approach. These aspects involve the fundamental methodology of macroeconometric, sectoral and economy-wide analysis as well as specific matters of technique, theoretical formulation and empirical analysis. Under each of these headings there is a large number of different topics which have to be considered. These include, for instance:

(i) *methodology* – nature of empirical aggregative analysis, constraints and prior influences implied in the empirical basis for analysis (e.g., national income and product accounts);

(ii) *techniques* – statistical estimation, empirical verification and hypothesis testing, modelling of aggregates, e.g., total supply and demand; and

(iii) *theory and empirical* – theories of aggregate output and demand, paradigms and representations of the economy, i.e., models, uses of models, evolution of macrostructures.

Obviously a project such as this has many facets and the task is further complicated by the fact that the macroeconometric approach itself is now subject to deeper questioning than probably it has ever been in the past. This is due, for example, to the apparent failure of operationalised macroeconometric models in forecasting and policy analysis, especially since the repeated economic crises from the mid-1970s.[6]

In order to make the project tractable, we have followed the time-honoured approach in economics of holding some aspects "constant" in order to examine, in the manner of partial analysis, the effects of some other aspects. Our initial requirement is for an analytical framework that is orientated towards the policy problem areas identified and which will also serve as a "specimen" for examination. This suggests the choice of a standard or conventional theoretical approach, focusing on a narrow set of themes from the three topic groupings stated above. The themes selected are the source of data, i.e., national income and product accounts, the determination of aggregate demand by means of its components and the analysis of aggregate supply by means of sectoral production functions. The econometric analysis theoretical specification and empirical estimation of aggregate supply, and its appropriate integration into an economy-wide framework, was previously identified (Fanning and Bradley, 1982) as an area lacking adequate treatment in Irish macroeconometric model-based research. As this is an essential element for medium-term analysis it was assigned priority at this stage of the project.

The macro-theoretic foundations for the analysis are made up of a combination of aggregate, Neo-classical and Keynesian elements. The basic features of this approach are, briefly, as follows. The economic definition of the short run is the period for which capacity (capital stock) is taken as given and fixed both in total and between sectors. In this context the Keynesian element is (i) to take output as demand determined and (ii) to approach

6. Related to this is the theoretical questioning of the role of macroeconometrics in policy research, arising, for example, from the theory of rational expectations (Lucas, 1976). Some recent evaluations of the state of the art in macroeconometric modelling are included in the books edited by Ormerod (1979) and Kmenta and Ramsey (1981). The methodology of macroeconometric modelling has long been questioned by members of the "Austrian" tradition in economics, for example Lachman (1973), and a number of their arguments have been incorporated into the rational expectations critique.

total demand as the summation of its disaggregated components which are explained by income-expenditure type relations. In particular, personal expenditures on consumption goods and services and gross fixed capital formation are the usual, but also sometimes the only, endogeneous demand relations.[7] The problem then analysed in this short-run Keynesian framework is how to ensure full-utilisation of existing capacity in an aggregate sense. However adequate this may be for short-run stabilisation analysis it raises two important points for longer-term analysis: (i) net investment adds to capital stock, that is the capacity to produce output and (ii), therefore, interrelationships between supply (capacity) and demand have to be included. The inclusion of a supply side can be done by means of the Neo-classical aggregate one-good production function with the usual assumed properties, such as a number of imputs which are continuously substitutable. Thus, for example, given the demand determined scale of output, cost-minimising behaviour in the face of given factor prices determines the optimal level, and thereby relative usages of factor inputs. Hence, the main features of this framework are that (i) output is demand determined; (ii) it is produced by a one-good production function and (iii) factor demands are affected by relative factor prices.[8] Therefore, employment of labour is not simply a matter of the level of demand (output) alone but also factor input prices and technological factors. We label this combination of aggregate Neo-classical and Keynesian elements the "Neo-classical Keynesian Specification" (NKS) as this will be useful for distinguishing it from two other paradigmatic models, the Neo-classical (NS) and Keynesian (KS) specifications, which will be the subject of a separate study. There is no claim that the NK specification is the correct, or even the best, representation of overall macroeconomic activity in the Irish economy. It is just one of a number of possible frameworks which we could have used to guide the analysis. Reflecting some of the obstacles in the way of adopting econometric macrosectoral and economy-wide analysis as a research tool, which were mentioned in the introductory section above, we have sought "maximum commonality" with the current state of economy-wide analysis in Ireland. It is more or less the standard or conventional general macroeconomic model in modern macroeconomic textbooks. Instead of pursuing the latest theory, model, or technique we have emphasised the overall design and macrostructural consistency of the empirical analysis. In attempting to achieve this it may be necessary to make

7. Government expenditures on current goods and services and expenditure on imported goods and services can also be endogenised in a similar manner to consumption and investment expenditures.

8. This is a general characterisation of the framework we are using. Features specific to different types of expenditure or sectors of production have, of course, to be allowed for in the detailed analysis.

explicit features of the overall NK specification that may have been left implicit, or even remained unexamined, in particular applications in Ireland. But, nevertheless, this overall theoretical framework, as a way of looking at the Irish economy, would appear to be the one that currently has a wide acceptance among researchers and policy-makers whether concerned with particular sectors or the entire economy.

To say that the analysis is being conducted according to Neo-classical-Keynesian specification immediately raises questions about the nature of macroeconometric methodology and techniques. This, as we mentioned earlier, is not the subject of examination in this report but, nevertheless, a number of important points about macroeconometric models should be made at the outset since they provide the basis for our empirical research. Macroeconometric models are simultaneous, endogenous and interpretative frameworks for providing a mathematical-statistical representation of, and a theoretical perspective on, the overall behaviour of the economy or its subsectors. Therefore, in their entirety, as well, of course, in their individual sectoral components, they embody an hypothesis about the operation of the economy. Their role is to facilitate descriptive analysis. By their very nature they are historical and locational since they are constructed on the basis of data recorded for a particular time and place. The purpose of conducting structural analysis and, on this basis, constructing economy-wide or sectoral models is to propose a descriptive mechanism which explains or interprets some particular feature of economic activity, that is identifies the factors, and their respective influences, which gave rise to the results recorded in the data. Structural models are, therefore, concerned with the behavioural, institutional, and technical relations, and their interrelationship in a particular economy during a particular period of time.

Although we cannot go into the nature of the econometric tool we are employing in any detail here it is nevertheless important to consider briefly some aspects in advance of using this technique. The first step in conducting a macroeconometric model-based research is to design the overall structure or framework for the analysis. This involves a process of abstraction and simplification so as to highlight certain features which are to be examined. For instance, labour and capital may be treated as homogeneous entities and output may be represented by a single "good" produced by these homogeneous factors of production. Alternatively, certain processes and variables may be omitted entirely; for instance, the time structure of production involved in responding to market demand may be ignored. This means that any analysis so conducted is inherently incomplete and only a partial analysis as becomes apparent from a brief consideration of the basic form of a simple econometric model. The starting point, by way of example, for a two variable linear econometric model is with a postulated relationship between the two variables such as

$$Y_t = \beta X_t$$

where Y is the dependent variable, X is the independent variable, β is the parameter showing the relationship between X and Y, and the subscript t is the time period index. Statistical regression techniques are used to derive the line, i.e., estimate a value for β, that by some criterion "best" fits the scatter of data points for X and Y. But some data will not be exactly on this line because the data for Y was not generated solely by this *model*. In other words, factors other than (βX) were influential in generating Y values. Therefore, the proposed model is subject to error. Assuming that there are no errors in measuring the independent variable X, then the main sources for error are:

(i) error (Ψ) due to approximating linearly some other unknown functional form;
(ii) even if all the independent variables and functional forms are controlled there are still "unexplained" variations due to intrinsic and measurement errors (H); and
(iii) not all the X variables are quantifiable so that omission of variables from the model results in a further error component (Ω).

By expressing these error components as deviations from their mean values (indicated by a dash above the variables), the basic statistical model is now

$$Y_t = \beta X_t + (\bar{\Omega} + \omega_t) + (\bar{\Psi} + \psi_t) + (\bar{H} + \eta_t)$$

where the variables in lower case greek symbols are deviations from the mean. It is usually assumed that the "pure noise" error term (H) has a mean of zero ($\bar{H} = 0$). Thus,

$$Y_t = \alpha + \beta X_t + \mu_t$$

where $\alpha = \bar{\Omega} + \bar{\Psi}$, and $\mu_t = \omega_t + \psi_t + \eta_t$.

The resulting econometric model is then a statement that the value of a random dependent outcome (Y) can be decomposed into a strictly random component (μ_t) plus a component linearly related to the independent variable (X). In itself all such a relationship says is that changes in the value of X affects Y in the manner specified and by a certain magnitude (β) *unless* something else occurs since all other possible influences on Y are represented by μ_t. The key to turning this tautological statement into a meaningful statistical statement about a relationship between Y and X depends on the assumptions made about the error term (μ_t). This is the major subject of econometric theory and is not considered further here. The point of immediate interest is that an econometric model is always incompletely specified due to incorrect specification, measurement errors and omitted variables. Thus, any analysis conducted with it is both partial in nature and entirely dependent on the appropriateness of the assumptions made about the error term.

This incompleteness of macroeconometric models must, however, be placed in a proper analytical context. Models can never be taken as "true" nor should they be judged by such a criterion. By their nature they must be unrealistic. Otherwise if they replicated reality they would be useless as *models* because they would be as complex as reality. The purpose of models is to simplify in order to yield clues about some aspect of economic activity, but not to attempt to tell the whole, or indeed the larger part, of the story. They are only more or less useful in providing insights into some selected features of economic processes, and it is against their adequacy for examining the relevant problem that they are to be evaluated: "models must be used but must never be believed" (Tukey and Wilk, 1970, p. 372). They should be viewed as *descriptive hypotheses* or perhaps as "statistical allegories" (Cooley and Smith, 1982, p. 4) about some features of the economy. In our particular case, the descriptive hypothesis we propose is based on the Neo-classical-Keynesian specification which has provided the interpretative framework for the empirical analysis. This brings us back to the starting point for this brief consideration of the nature of macroeconometric model-based research and, in particular, the imposition of a prior view, the NK specification, about the working of the economic system and its subsectors. The issue, therefore, becomes one of the manner by which macroeconometric models are validated. The procedure is not one of "scientifically" testing competing hypotheses, but really of finding a model, i.e., equation (or set of equations), that "works". Partly this arises because of the difficulty in resolving issues by an appeal to the data since there may not be enough "power" in economic data to discriminate between alternative hypotheses, or because alternatives are observationally equivalent, although conceptually quite different. In an ideal world one would have a single approach which would embrace short-term, medium-term or long-term aspects depending on the duration of the period being analysed. The fact that such a "universal" approach has not emerged is due to the inherent complexity of the problem of reconciling different theories, the inadequacy of the analytic tools available, the nature of analytical models and limitations in available data.

A final aspect which should be noted at this stage refers to the use of macroeconometric analysis in the light of the preceding discussion. Although there is no guarantee, or indeed even possibility, that the "true model", i.e., the true economic structure, can be known, we cannot avoid the necessity of having models in order to make decisions. It is not necessary, of course, to have a model of the *entire* economy. The comprehensiveness of the model, coverage and level of detail of the underlying economic structure depends on what decision-making unit is involved and what problem area is of interest. Obviously, the type of model necessary for making decisions at the level of a national policy authority, and employee or employer organisations would be quite different from that suitable or feasible for an individual household or small shopkeeper. The channels of influence, or links between decision-making units, selected to be shown in a model are related to the level of decision making and the type of problem. In addition, it is not even necessary to have a model which is "operational" in the conventional sense, i.e., in the form of estimated mathematical equations programmed into an electronic computer. Models can be heuristic or informal and only exist in the minds of specific economists or policy makers. However, exchange of ideas and dialogue may be greatly facilitated if the models are formally and explicitly specified in mathematical/statistical form.

Irrespective of their form, the major use of sectoral and economy-level macroeconometric models is for national economic forecasting and policy analysis. Diagnosis is a necessary prerequisite for policy prescription. It is as a diagnostic tool, that is to aid the assessment of past events, that macroeconometric analysis and models can contribute to policy research. Such models are, as mentioned, by their nature historical and it is by virtue of being historical descriptions that they can contribute to future directed analysis by showing what has occurred in the past. But it need hardly be stated that the derivation of policy prescriptions from this type of analysis is by no means a straightforward or simple process. In using macroeconometric methods for policy research it is absolutely crucial to pay attention to what is omitted from the analysis. Furthermore, the process of policy diagnosis must be a continuous one, and so there is a need for readily available and adaptable analytical tools such as macroeconometric models. But in the context of a continuous process of policy research these models are revised and commonly found to be "structurally unstable". The term structural change is used loosely in modelling to cover three types of change:

(i) changes in variables exogenous to the equation or set of equations which are of two broad types – non-policy (e.g., weather) and (government) policy instruments;

(ii) changes in the values of coefficients with an unchanged equation or set of equations; and

(iii) changes in equation specification – variables or functional form – and, therefore, of course, coefficients or elasticities.

From an econometric perspective it is usually only the second type of instability that is regarded as a matter of concern. In recent years much attention has been focused on the fact that single equations, used in large-scale operational models, exhibit coefficient instability and that this source of model "breakdown" apparently places severe limits on their usefulness in policy analysis. The commonly cited implication of this is that the instability arises from mis-specification of the model which in turn, it is held, may reflect the inadequacy of its theoretical basis.

A major questioning the usefulness of macroeconometric models has followed the development of the theory of rational expectations, and specifically Lucas's (1976) critique of "econometric policy analysis". There is no doubt that the "mainstream" theory and, particularly, macroeconometric models of the economy are vulnerable in many ways to the criticism deriving from the equilibrium model of the business cycle as developed by Lucas, Sargent and others (Lucas, 1981; Lucas and Sargent, 1981).[9] However, these new theories of the economy are themselves subject to questioning and debate not least because of their equilibrium foundations. A successful strike against the "mainstream" theory or economy-wide macroeconometric models does not imply that successful parts must be jettisoned. So while we clearly recognize the relevance and significance of rational expectations analysis, our selected task at this stage is not to address all the methodological issues involved in macroeconometric economy analysis and its use in policy research. Obviously these issues will have to be addressed in delineating the appropriate role for this technique in policy-making. But our concern here is with "laying down the foundations" or, in other words, with a structurally consistent macroeconometric analysis framework suitable for the Irish economy by taking into account the main behavioural and institutional features of the economy, the data constraints and previous sectoral and economy-wide analysis. For this reason we stand back in this study from

9. In simplistic terms the basic idea of rational expectations is that individuals make full use of available information or, as the Rational Expectations Hypothesis asserts "individuals do not make systematic mistakes in forecasting the future" (Begg, 1982, p. xi). There are a number of recent books providing an overview of the analysis and implications deriving from this proposition and Begg (1982), for example, has two chapters addressing the empirical research and econometric consequences.

the issues raised by rational expectations. We do so also because these are currently subject to intensive debate and the implications for structural macroeconometric economy-wide analysis are not sufficiently clear at present. For instance, Pagan (1981) argues that if expectations are fully rational the presence of these rational expectations does not necessarily imply that econometric models are unstable in the sense of (ii) above.[10]

This does not mean that model instability is not due to incorrect specification, and only refers to one frequent interpretation placed on the rational expectations critique.[11] Instead, for instance, the theoretical basis may be correct but indicate that coefficients are not constant. Alternatively, poor data are also important causes of coefficient instability.[12] Indeed, it should also be noted that the most important contribution of policy research and implementation is actually to bring about "model" instability. That is because the crucial task of policy formulation is not to accept the existing model (constraints on achieving goals), or more exactly the underlying structure, but rather to induce structural change, i.e., alter the coefficients or the relations themselves. Fundamentally, policy research is about finding the means for turning *constants* – whether coefficients or relationships – into *variables*. Policy making is akin to forming expectations, and Hahn's statement about the latter process is relevant as a perspective on the use of macroeconometric model-based research: "the transformation of observation into expectations requires the agent to hold a theory, or if you like requires him to have a model. The model itself will not be independent of the history of observations. Indeed, learning largely consists of updating models of this kind" (1982, p. 3).

10. This is demonstrated (Pagan, 1981, pp. 13-14) by means of a simple econometric model of the type outlined above. Rewriting this as a model for a firm's supply decision, we have

$$S_t = \alpha + \beta_1 P^*_t + \beta_2 C_t + \mu_t$$

where S is supply, P* is expected price for the good, and C is costs of production. Full rationality implies that deviations between expected price (P*) and actual price (P) is a random variable (θ) uncorrelated with P. Therefore, under certain conditions, discussed by Pagan,

$$P^* = P_t + \theta_t$$

and by substitution,

$$S = \alpha + \beta_1 P_t + \beta_2 C_t + \epsilon_t$$

where $\epsilon_t = \mu_t + \beta_1 \theta_t$. Thus, while the error term is altered, the structural coefficients $(\alpha, \beta_1, \beta_2)$ are not affected.

11. Nor, of course, does this view address the implications of rational expectations for policy making and indeed the derivation of policy implications from macroeconometric models.

12. It need hardly be stressed that there are many other important issues involved in the methodology of macroeconometric modelling and policy research but, as mentioned already, they cannot be examined here.

In conclusion, the macroeconometric approach in policy research must be used with caution. The derivation of policy implications from these methods is not, as mentioned above, a simple mechanical procedure. Allowance must be made for the nature of the methodology employed which circumscribes its explanatory power. The fundamental role of macroeconometric analysis is to provide estimates of the historical relationships, including, perhaps, functional form, between previously identified variables. Further than this they do not, in themselves, add to our understanding of economic behaviour in terms of the postulated relationships, identified variables, and coefficient or elasticity magnitudes.

IV. *OUTLINE OF THE STUDY*

The remainder of this study is organised as follows. In Chapter 2 we describe the system of national economic accounts which is the main data source and organising framework for macrosectoral-econometric analysis. We examine the manner in which these annual accounts for the economy are presented and show how their structure and coverage provides both guidelines and imposes constraints on attempts at empirical behavioural explanation of the actions generating the results recorded in the accounts. First, the concept of an economic accounting matrix is introduced, as a framework which summarises and integrates all the complex interdependencies among sections of the economy. The national income, product, and expenditure sub-set of these accounts, which is the data base actually available for our analysis, are shown to give only a partial picture of these interdependencies. Furthermore, the definition and measurement of accounts variables also imposes constraints and limitations which must be borne in mind when conducting and using research based on this data set. In principle a distinction can be made between theory/model and data sources but there is a circularity in practice that is unavoidable. Conceptually, at least, a theory or model can be specified and estimated by means of national accounts data. But at the same time we must, to some extent, recognize that the formulation of any macroeconometric analysis and model is influenced by the data available which are the national accounts. Second, some important economy-wide sectoral balances can be identified from the accounts and a number of these are discussed in Chapter 2. The re-organisation of the basic accounts undertaken here highlights one balance – the equality of aggregate demand and supply – as particularly relevant to our economic problem area. This provides the specific organising framework for our analysis as centered around the sources and uses of aggregate supply. Using this, we then present a schematic block framework which segregates our analysis into three areas: aggregate supply (concerned with output, imports, and supply of, and demand for, factors of production); aggregate demand (concerned with domestic absorption — consumption, investment, stocks — and foreign demand); and income distribution (concerned with wages, prices, and the role of public fiscal and monetary authorities in the distribution of incomes).

In Chapter 3 we consider a topic — the structure of aggregate production and factor demand decisions — which is vital to a correct understanding of medium-term supply issues but which has been relatively neglected in Irish empirical and theoretical analysis at the economy-wide level. The technique used for modelling aggregate supply is the Neo-classical one-good production function and we expose some of the key issues in this approach. The exposition is, of its nature, fairly technical. The issues involved are related to the measurement of capacity, production functions, technology and factor demand systems. Basically, we examine how a firm's output and demand for factor inputs (labour, capital equipment, and materials) are related in a consistent manner. Various concepts of "capacity" output and factor utilisation are examined and a clear distinction is drawn between the output level which firms decide to produce at a given point in time and what they would be capable of producing if they worked the plant according to various decision criteria. The distinctions made are important, especially in an economy in transition from labour intensive production techniques to more capital intensive techniques, and has consequences for two major problems facing the Irish economy at present, i.e., unemployment and income levels. The capital and labour demands of firms, which are usually estimated separately are shown to arise naturally as part of an interrelated system of factor demands and different methods of operationalising these are considered. Among other topics, we also examine the various possible functional forms available for production functions, and the implications of these forms for factor substitution possibilities. The implications of different assumptions concerning the malleability of capital are also examined. Problems relating to these aspects are explored with a view to selecting a suitable supply structure and representational technique for sectoral models. Finally, although becoming less common, short-term and medium-term models are still usually treated in isolation from each other and we consider two examples of important recent international work in which these two approaches have been reconciled. These are studies by Helliwell and McRae (1981) and Behrman (1977).

The material in Chapters 2 and 3 provides the building blocks for conducting a macroeconometric sectoral analysis of the economy. This stage involves designing sectoral sub-models by selecting the appropriate elements and embedding them in the institutional and behavioural context of each specific sector. We proceed, in Chapters 4-8, to deal with the three major blocks selected in Chapter 2: supply, demand and income distribution. The relationship between the supply and demand blocks was singled out for particular attention since it is in the construction of these blocks and their interrelationship that the main novelty of our macrosectoral analysis lies. Aggregate supply is analysed in Chapter 4, which covers industry and agriculture, and Chapter 5, which covers services, imports and labour supply. Aggregate demand made up of domestic and foreign components, is examined in Chapter 6. Given the factor demands arising from the supply block the remaining elements – prices, money supply and fiscal redistribution – necessary for the income distribution process are explored in Chapters 7 and 8. The latter includes the macroeconomic summary amounts including the balance between domestic absorption and domestic production, i.e., the balance of trade. Finally, in Chapter 9 we provide a brief overview of the results of this stage and an indication of future work.

The format for each of the sectors in the three blocks is largely the same. We first describe, in a stylised manner, some salient features of the sector. We then propose a sectoral modelling framework which attempts to capture, in mathematical terms, the main elements of the sector. We next provide the data and carry out equation estimation, usually within a fairly tightly specified theoretical formulation. This gives the functional forms, dynamic structure, stochastic structure, and supplementary variables and data used to estimate the individual equations and sectors. Finally, we evaluate the results in the light of the estimation and highlight those areas where statistical estimation does not provide values of coefficients and parameters which are plausible in the light of theoretical expectations. The validation procedure is that appropriate to single equation testing but, as stated, is supplemented by an examination of the empirical plausibility of the specification and results.[13] Our objective is not only to provide a technically detailed description of the structure of each block and the empirical estimation results, but also to facilitate an overall understanding of how the sectors connect with each other. The use of small flow diagrams is incorporated as an explanatory device to aid this process. In this way we hope to relate our verbal description of how we postulate the economy as working and developing over time with the more formal mathematical description of the sectors.

Before concluding this section and chapter we should note that a number of estimated equations is reported in almost all cases and make some points in this regard. The development and presentation of any large-scale macro-

13. The validation of a complete economy-wide model provides further insights into theoretical and empirical plausibility but is, in itself, a substantial task and is undertaken as a separate study (Bradley, Fanning and Wynne, 1984).

econometric analysis, including an economy-wide operational model, has to contend with two apparently irreconcilable difficulties. First, if a formal and exhaustive investigation into the economic assumptions underlying the analysis is presented there is the difficulty that a study may be too long, detailed, or technical according to some other desirable criterion. But, second, if an operational model of, say, the entire economy is simply presented then there is the difficulty of it appearing merely as a "black box" and a danger of it being misunderstood or, at best, ignored or else as something that is open to misuse. The latter results in the technique becoming a debating tool with sides chosen according to whether the "results" coincide or not with pre-determined views. Such a situation does not provide common ground for research and policy-making dialogue.[14] The fact that the empirical results were "mixed" should serve as a caution against any hasty or inflexible selection of equations as *the* model of the Irish economy or of a sector. Such results are inevitable given our approach, for example, the degree of aggregation is very severe – industrial output is produced by one big firm ("Industry") and four very different production sectors produce one good ("Output") which can be used for consumption or investment purposes at home or abroad. This limits both the theoretical analysis and empirical results that can be obtained, but is a simplification that facilitates exploring a number of issues and developing insights for economic understanding and policy making. Looking at the mixed empirical results from the point of view of the next stage of the project – the construction and use of an economy-wide operational model – suggests three options. First, a formal behavioural and structural model could be left aside in favour of a verbal (but not necessarily a less precise) approach or informal reasoning. But the verbal approach does not provide orders of magnitude, although it may encompass more subtleties, and informal reasoning is open to the dangers of assumptions being made implicitly and, perhaps, inconsistently. These are, of course, dangers which also face the formal macroeconometric approach but possibly to a lesser extent or, at least, in a manner easier for critical readers to identify. Second, any unsatisfactory results could be included in the operational model but any such equations that "misbehave", i.e., cause problems when using the model, can be overruled. This is a common, but scientifically rather dubious, approach. It raises questions about what role the estimated equations fulfil if they are not used in analysis. More seriously, the theoretical and systems validity of whatever is used in their place is unclear and, if used extensively, makes it difficult to trace and understand the system proposed as a representation of the economy. Third, and finally, plausible values could be imposed

14. This was also an important factor in the decision to present a sequence of related, but self-contained, studies.

on theoretically specified relationships. This is facilitated by having a theoretically coherent framework and, within that framework, this approach should be quite transparent in its implications.

Given the quality and availability of data and the nature of econometric analysis, as outlined above, the latter option would seem to be the best one to follow. No claim can then be advanced intentionally, or held unintentionally, that such a model reflects, or could reflect, all the real processes of an economy or that it is *the* only valid or useful representation of the entire economy or sector of the economy. We do not follow this approach here. The equations estimated and the presentation of mixed results is a necessary exploratory exercise and identifies areas where values have to be imposed rather than freely estimated from the data. It shows the results of applying data to the NK specification for an economy without the researcher's intervention in this regard.[15] Nor is it scientifically appropriate in this context to report only a single "best" result. As likely as not such an equation would simply be one that happened to "work", i.e., fit best according to some simple statistical criterion. But a proper interpretation and appreciation of empirical analysis requires that a representative range, at least, of the alternative equations estimated must be reported. The multiple satisfactory, or unsatisfactory, results demonstrates the crucial *caveat* that even within the constrained range of just one relatively narrow paradigmatic framework, the NK specification, there are still indeterminancies to be faced. In other words, choices have still to be made, about functional forms, particular variables and even behavioural specifications.

In conclusion, the distinction between an operational economy-wide system of equations and a particular selection of equations estimated within a consistent analytical framework, such as the NK specification, is important in conducting macroeconomic research. A macrosectoral analytical framework of the economy is a method for bringing together and organising diverse pieces of analysis and not just compatible or supporting analysis and results. An operational macroeconometric model simplifies and omits. So it is important for appreciating results, and, therefore, for improving the construction and use of macroeconometric models, that it be confronted with conflicting evidence. Formulating an operational model involves the intervention of the modeller, but until that stage of a research project is undertaken there is no need for imposing values. Nor would it be appropriate to do so. The aggregate sectoral approach and data problems makes the research task difficult but it is required by the integrity of a research report that such

15. One area where we have intervened, when we thought it necessary to obtain reasonable statistical results, is to correct for autocorrelation among the errors of econometric equation the presence of which are commonly taken to imply mis-specification in a model or equation.

difficulties be explicitly stated. Our main concern in this report is to lay down a consistent overall structure for macrosectoral analysis of the Irish economy over a medium-term horizon. This is intended to serve a dual role. It provides a core which is capable of being extended and contracted to meet particular needs and it brings together and extends, within this framework and with an integrated data base, a large amount of macroeconometric research on the Irish economy.

Chapter 2

THE MACROSECTORAL DATA FRAMEWORK

I. *INTRODUCTION*

The economy is an interconnected network of flows between the various units – households, business enterprises and other organisations – that comprise the economic system. The myriad of interactions between firms themselves, and between firms and final users and factor suppliers, results in a highly complex system of interdependencies. There is a need to organise these flows in a simplifying way which, nevertheless, still facilitates a quantitative understanding of overall and sectoral economic activity. The method used to provide a compact and coherent summary, varying in coverage and comprehensiveness, is national economic accounting. These accounts present the historical record in an internally consistent framework. However, to understand the economy and its various subsectors there is a need for more than accounting balances. Relationships between the flows, based on behavioural, institutional and technical aspects of the economic system must be identified. Then the accounting balances ensure that the individual elements are mutually consistent. In other words, to understand the economy or subsectors of it we must use an integrated macro-framework encapsulating behavioural, technical and institutional relationships. In the case of the analysis presented here this takes the form of a macroeconometric study based on data from the National Income, Product and Expenditure Accounts. The subject matter of this chapter is an exposition of the data organising framework and its relationship to the sectoral organisation of the analysis to be carried out in this study.

This exposition serves a number of related purposes. Macroeconometric analysis is heavily dependent on the data set utilised and it is essential to highlight the manner in which, for example, the sectoral detail of the analysis is constrained by the coverage and content of the available data. This is done in the next subsection. The data set actually used and the organising framework followed is that of the standard macroeconomic, i.e., national income and expenditure, accounts and a brief outline of these is presented in Section III. The basic accounting balances are then used in Section IV to provide different perspectives on the economy as a whole (i) in order to select the one most suitable for our analytical purposes and (ii) for presenting, in the context of these different perspectives, historical information on the main trends in the Irish economy over the period of interest to us. In Section V which deals with some aspects of the relationship between accounting balances and behavioural analysis, two particular points are emphasised. First, there is an interdependence between theoretical analysis of the economy and the macroeconomic accounts which must be recognised. Second, the accounts themselves are fundamentally flow measures in nominal values, and any data beyond these are constructed "artificially" from these on the basis of national accounting assumptions, e.g. "real" output. Both aspects have an important bearing on the type of analysis which can be conducted when using these data. Finally, in Section VI, there is a brief discussion of the particular accounting framework selected as appropriate for our analysis.

It should be noted at the outset that this chapter is not concerned with the details of the Irish national accounts and data *per se* and reference is only made to these to make particular points relevant to the above themes. To the extent that details of the Irish accounts are necessary for our analysis they are covered primarily in Appendix 2.2: Data Sources and Notes. Our focus here is with a few simple but fundamental principles of the data organising framework and with their relationship to our analysis. The presentation of Irish data is only intended to be illustrative of the main trends occurring during our sample period and of the arrangement or re-arrangement of the national accounts data to reflect the different perspectives of looking at the economy.

II. *DATA ORGANISING FRAMEWORK*

The complexity resulting from interdependencies among economic units requires a summary view for analytical purposes. Obviously if this were attempted in terms of the physical flows of goods and services between all the individual units it would not be a simplifying or summary view but a complete description of the economy. Such activity is made up of producing and selling a highly heterogenous collection of goods and services among a vast array of agents and units. Two approaches are adopted to organise these activities into a compact framework. First, in any market economy, goods are exchanged at different relative prices and there is one good – money – which provides a unit of account. The prices of goods are stated relative to this *numeraire* which provides the basis for aggregating the heterogenous collection of commodities. Second, the vast number of agents and units in the economy is reduced to a manageable size by aggregating in terms of markets and broad categories of goods and services based on some common characteristics, e.g., consumption goods purchased by private households. Thus, the economic accounting framework is based on:

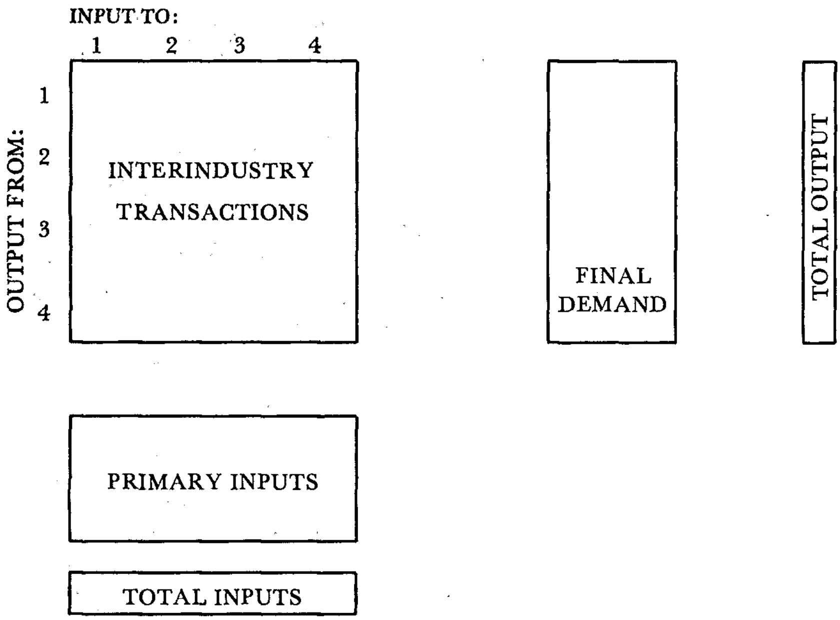
(i) the accounting summation of money values of goods and services;
(ii) and an aggregation of decision-making units of the economy into broad categories.

This framework is illustrated schematically in Figure 2.1 in an example with four production sectors.[16] This is the data organising framework for sectoral and economy-wide analysis and is referred to as the Economic Account Matrix (EAM) or Input-Output table.

The arrangement of the economic accounting matrix implies balance equations between the supply of, and demand for, the products of each of the nine producing sectors. Demand for the output of each of these sectors (along the rows) includes the demand for use as intermediate inputs by these sectors themselves. The remainder of domestic availability is allocated among the categories of final demand. The total of these two broad sets of uses equals the total gross output of each sector.

A major constraint on using input-output accounts data is that such data are usually only available for occasional and rather few years. Currently the

Figure 2.1: *Diagrammatic representation of intersectoral flows for an economy at a four branch level of aggregation*



16. A corresponding set of Irish economy accounts for one year is presented in Appendix 2.1. The currency unit for all data in this study is £ Irish.

Central Statistics Office has published only three tables – 1964, 1969 and 1975.[17] This means that the sectoral production and demand relationships would be estimated on the basis of extremely small samples. Furthermore, the time lag involved in publication of such tables is substantial – the above three tables were only published in 1970, 1978 and 1983, respectively. The data constraint is lessened if analysis is conducted on the basis only of the final demand and primary inputs blocks of the EAM. These data are available annually, albeit with up to a two-year time lag, still subject to significant revisions (Ruane, 1975), and in a highly aggregated format in the National Income, Product and Expenditure Accounts (NIPEA). Although it is a subset of EAM in terms of coverage, the NIPEA data are organised along somewhat different lines which further limit the analysis options available. First, these data – and related data from other sources – broadly permit only a four-sector breakdown for production activity: public administration, agriculture, industry and services. These provide the basic quantitative framework for the sectoral analysis conducted here. A corresponding four sector EAM is given in detail in Appendix 2.1. Second, using only NIPEA aggregate data mean that inter-industry transactions cannot be included in the analysis. The omission of inter-industry transactions amounts to the crucial assumption that such activity can take place automatically in response to increases in final demand, i.e., that there are no bottlenecks, due to financial, material, primary inputs shortages and so on, in this area of the economy's activity. This is an important assumption as the gross value of transactions is substantially more than net output. An indication of the importance of omitting inter-industry transactions is indicated by the data in Table 2.1 on intermediate inputs as a proportion of gross outputs for a three sector grouping. The sectors show intermediate inputs increasing rapidly as a proportion of

Table 2.1: *Intermediate inputs as a proportion (%) of effective production in Ireland, 1969 and 1975*

	1969	*1975*
Agriculture	44.5	42.0
Industry	60.7	69.4
Services[a]	32.8	35.0

Source: Data on which calculations are based are from *Eurostat* (1981); and *Eurostat* (1983) for 1969 and 1975 respectively.

Note: a Includes Public Administration.

17. A number of input-output tables for other years have been published by E. Henry of The Economic and Social Research Institute (Henry 1976, 1980), for the years 1968 and 1976; McGilvray (1964/65) gives a table for 1956; Geary (1963/64) gives a table for 1960.

total output in the case of industry between 1969 and 1975. Agriculture appears to have remained stable at just over 40 per cent between 1969 and 1975, while services show a small increase (to 35 per cent). These trends are experienced in all industrialising countries and are symptomatic of the increasing complexity and interconnectedness of sectors which is part of the development process. Therefore, when the present national accounts (which provide data only for added value) are used as the source of data, an increasing proportion of overall economic activity is excluded from the analysis.

Third, and finally, the degree of detail for final uses or primary inputs does not correspond to that of the Economic Accounting Matrix (EAM). For example, the final demand variables are not the final use of each sector's output by type of use but, rather, are the standard aggregate consumption expenditures by households and governments, gross fixed capital formation, changes in inventory stocks and exports. Therefore, the *National Income and Expenditure* (NIE) organising framework for economy-wide macro-econometric analysis of the type reported here is the GNP subset of the overall EAM accounts. This familiar subset, showing the total supply (at cost production) and total expenditures on final goods, is illustrated in Figure 2.2 and is discussed briefly in the next section.

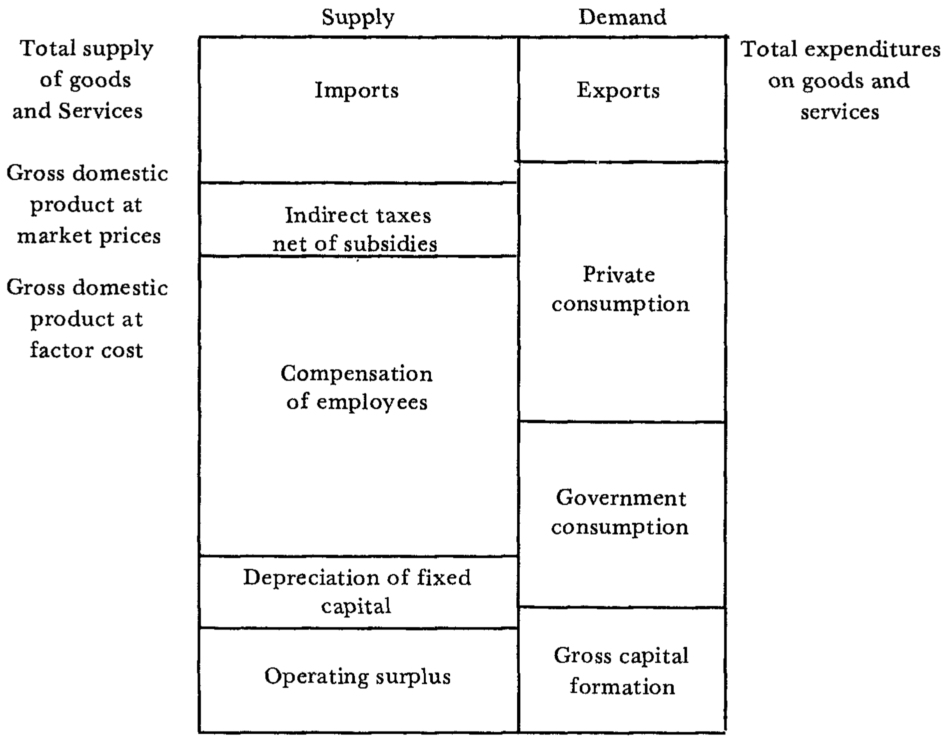
III. *THE MACROECONOMIC ACCOUNTS*

The starting point for national income, product and expenditure accounting is an attempt to get some measure of the overall income accruing to factors of production as a result of current production activity. Corresponding to the *national income*, measures of the value of *national product* – the goods and services produced by that activity – and *national expenditure* – the spending incurred on the national output – are defined and estimated.[18] The central concept of the macroeconomic accounts is gross domestic product in value terms and the accounts are organised around the three approaches mentioned. The definitional equivalence of the three measures provides the fundamental identity for historical macroeconomic accounting.

The incomes, or factor payments, approach involves adding up all the factor incomes earned during the accounting period. With the usual national income accounting conventions, gross domestic product at factor cost by

18. In this section we do not attempt to deal with details of national accounting for the Irish data. Information relevant to the construction of the model data bank is given in Appendix 2.2: Data Sources and Notes. There are, unfortunately, no comprehensive or recent analyses of the national economic accounts in Ireland. Of the few available, the best, although somewhat dated by revisions to the Accounts, are still the brief descriptions by O'Mahony (1964a, Chapter 8), McGilvray (1968, Chapter 6), and Kirwan and McGilvray (1983, Chapter 6). Specific aspects of how the accounts are actually calculated may differ from the general principles outlined here.

Fig. 2.2: *Schema for consolidated macroeconomic accounts*



incomes (GDY) comprises all the production costs paid, i.e., all incomes earned including profits. Broadly, its components are:

$$GDY = YW + YSE + YPRO + YR$$

where YW is income of wage and salary earners;
YSE is income of self-employed;
YPRO and YR are profits and rental incomes.

The output or value added approach is the summation of that part of the value of final output produced by each production unit in the economy. This, of course, is just the difference between the production value of its output and the cost of intermediate goods and services used by the unit to produce that output. The intermediate purchases by each production unit are excluded so that the resulting magnitude, conceptually at least, corresponds to that estimated by the incomes approach. This gives gross domestic product at factor cost (GDPFCV) for the four sectors of origin as:

$$GDPFCV = OAFFV + OIV + OSV + OPAV$$

where OAFFV is value added by agriculture, forestry and fishing;
OIV is value added by industry;
OSV is value added by services; and
OPAV is value added by public administration.

The third method of calculating an equivalent aggregate measure is the expenditures approach whereby all final expenditures for consumption and investment purposes in a particular accounting period are added together to give gross domestic product at market prices by expenditure, GDEV. The final uses of domestic output are consumption or current uses by the household and State sectors, fixed investments and net changes in stock holdings, and exports to meet demand from abroad for domestically produced goods and services. However, goods and services are also imported, i.e., there is domestic demand that is not matched by domestic output. Since such expenditures are already included in the previous items, these imports must be netted out to maintain the balance between domestic output and expenditure on domestic output. Thus, the breakdown by how the national product is used is:

$$GDEV = CPERV + IFV + CGV + XGSV + IIV - MGSV$$

where CPERV is the value of consumer personal expenditures;
IFV is the value of gross fixed capital formation;
CGV is the value of current government expenditure;
XGSV is the value of exports;
IIV is the value of changes in stocks; and
MGSV is the value of imports.

The two measures of GDP at factor cost have to be adjusted by other costs (ADJV) that occur in order to equate the estimated magnitudes with GDEV.[19] The definitional equivalence of the three measures, i.e., the circular flow of income, is the fundamental identity of macroeconomic accounting and provides the framework for summarising and ensuring internal consis-

19. These other costs are factor cost adjustment (indirect taxes net of subsidies), capital consumption allowances and adjustment for financial services. We have only been concerned with the broad conceptual framework of the accounts and have not identified these separately here. The expenditure items, because they are at market prices, already include indirect business taxes net of subsidies, etc.; and it is to make the magnitudes derived by the other approaches equivalent to that derived by the expenditure method that these adjustments mentioned must be made. The letter V indicates nominal values, M is used for indicating market prices where necessary. In official national accounting statistics there is usually a further "statistical discrepancy" due to measurement errors.

tency in the derivation of GDP at market prices (GDPMV):

$$GDY + ADJV = GDPFCV + ADJV = GDEV = GDPMV$$

This is the NIPE data organising framework for macroeconomic analysis which seeks to explain the various sub-components, in different degrees of detail, of these flow measures of activity. The most frequently used and comprehensive measure of income is gross national product which is simply GDPMV to which is added net factor incomes from abroad (YFN):

$$GNPV = GDPMV + YFN$$

Net factor income from abroad is mainly dividend, interest and labour income accruing to domestic residents from abroad or paid abroad by domestic residents.

IV. *SOME IMPORTANT SECTORAL BALANCES*

The basic macroeconomic accounts set out in the last section can be used to develop a further sequence of identities which are useful for analysing economic activity. However, these are accounting balances which hold by definition and deal with the historical record. They do not imply any particular cause and effect or behavioural (*ex ante*) view of the economy. Nevertheless, they provide important insights since they identify sectoral balances which must hold *ex post*. To the extent that they, just like their underlying macro-accounts, refer to decisions they record the net outcomes of past decisions.

Total Supply and Total Demand

Re-organisation of the basic macroeconomic accounts to show the source of total supply and the overall uses to which it is put provides the basic starting point for structural analysis. Gross domestic supply at market prices (GDSV) is made up of domestically produced goods and services plus imported goods and services (MGSV):

$$GDSV = GDPMV + MGSV$$

The uses to which this is put are, as we have seen, made up of domestic use plus exports, so gross final demand (GFDV) is:

$$GFDV = CPERV + IFV + CGV + IIV + XGSV$$

From the original accounting identity the total value of output supplied must balance with the total value of expenditures on that output so that:

$$GDSV = GFDV$$

In an economy open to trade, consumption, investment, and government spending is total domestic spending on all goods available in the economy, irrespective of origin, i.e., whether produced domestically or abroad. Such spending can be consolidated by defining GDAV as the value of aggregate domestic absorption (which in terms of the account includes domestic expenditure by foreign tourists) such that:

$$GDPMV - GDAV = XGSV - MGSV$$

The term on the right hand side is the trade account balance and the overall relationship shows the macroeconomic nature of this external imbalance. A surplus, net exports, implies that domestic spending is less than domestic production. Using this accounting balance as an organising framework, data for the Irish economy for selected years are presented in Table 2.2. On the supply side, the main trends show for domestic production, a substantial decline in the share of agriculture and increases in industry and services while, for foreign supply, the share of imports has increased. On the uses side, personal consumption declined; government consumption increased slightly, as did investment expenditures. The share of exports also increased, but not sufficiently to overcome the relative increase of imports, so the deficit on the trade account increased by a substantial amount.

Domestic Production and Domestic Income

Up to now we have focused on gross domestic product as the central concept of macroeconomic accounting. This is the basic magnitude in evaluating a nation's output, i.e., the value of output domestically produced or income domestically earned, and is the major source of national income. However, domestic production is not the only source of income, nor does it mean that income so earned is retained domestically. There is also, as we saw above, net factor incomes which is the difference between income received for productive activity, whether at home or abroad, by domestic residents (GNPV) and the value of domestically produced output at market prices (GDPMV). These net payments have now become significantly negative as the data in Table 2.3 record. This is the combined result of:

(i) domestic production with the significant involvement of external

Table 2.2: *Total supply and final demand in Ireland for selected years, £m. at current prices, and percentage shares of respective totals (in parentheses)*

		1960		*1970*		*1979*	
Supply							
Agriculture	OAFFV:	140.0	(16.2)	232.9	(9.9)	970.0	(7.7)
Industry	OIV:	167.9	(19.4)	500.0	(21.3)	2528.0	(20.1)
Services[a]	OSV:	254.7	(29.4)	686.7	(29.2)	3655.0	(29.0)
Adjustments[b]	ADJV:	68.7	(7.9)	200.6	(8.5)	312.0	(2.4)
Domestic Production	GDPMV:	631.3	(72.9)	1620.2	(68.9)	7465.0	(59.2)
Imports	MGSV:	235.2	(27.1)	728.5	(31.1)	5135.0	(40.8)
Total Supply	GDSV:	866.5	(100)	2348.7	(100)	12618.0	(100)
Demand							
Personal Consumption	CV:	483.4	(55.7)	1115.9	(47.5)	4696.0	(37.2)
Government Consumption	CCV:	78.6	(9.1)	237.4	(10.1)	1437.0	(11.4)
Gross Fixed Investment	IFV:	91.1	(10.5)	361.6	(15.4)	2368.0	(18.8)
Stock changes	IIV:	12.4	(1.5)	34.9	(1.5)	146.0	(1.2)
Domestic Absorption	GDAV:	665.5	(76.8)	1749.8	(74.5)	8647.0	(78.6)
Exports	XGSV	201.0	(23.2)	598.9	(25.5)	3953.0	(31.4)
Total Demand	GDDV:	866.5	(100)	2348.7	(100)	12600.0	(100)
Trade Balance							
Domestic Production	GDPMV:	631.3		1620.2		7465.0	
minus							
Domestic Absorption	GDAV:	665.5		1749.8		8647.0	
equals							
Balance on Trade Account	BPGSV:	-33.8		-129.6		-1182.0	

Source: Ireland, *National Income and Expenditure (1977, 1978, 1979),* Stationery Office, Dublin, (1979, 1980, 1981)

Notes: a Services includes Public Administration.
b Adjustments for financial services and indirect taxes net of subsidies.

factors, e.g., foreign portfolio and direct investment;

(ii) a substantial foreign borrowings element in State sector financing of current spending and capital spending; and

(iii) Irish owned factors abroad returning insufficient amounts to offset the outflow.

The consequence of these is that GNPV is now less than the value of domestically produced output, i.e., we must relinquish abroad purchasing power over output, since GNPV is defined as:

$$GNPV = GDPMV + YFN$$

and YFN is, as Table 2.3 shows, significantly negative.

Table 2.3: *Net factor income, Ireland 1972-1982, £m at current prices*

	Net non-government factor payments	*Government interest payments abroad*	*Net factor income*
1972	40.2	-10.6	29.6
1973	36.4	-12.9	23.5
1974	50.1	-16.6	33.5
1975	58.1	-37.1	21.0
1976	64.4	-62.7	1.7
1977	64.6	-96.1	-31.5
1978	62.8	-131.0	-68.2
1979	85.2	-153.9	-69
1980	105	-225	-120
1981	105	-315	-210[a]
1982	105	-575	-470[b]

Source: P. Bacon, *et al.*, May 1982, p. 27.
Notes: a estimate
b forecast

Following from the definition of the value of gross national product a number of further income identities, which provide different insights into the state of the economy, can now be derived. First, a certain portion of income has to be put aside to maintain capital assets, i.e., production capacity, and so is not available for current use if production capacity is to be maintained. Thus, a capital consumption allowance is deducted to cover depreciated capital stock, to give net national product at market prices (NNPMV) and this is *conceptually* a better measure of the economy's claim on new goods and services than GNPV:

$$\text{NNPMV} = \text{GNPV} - \text{CCAV}$$

By further deducting indirect taxes (TI) net of subsidies (SUB), neither of which constitute income to persons, national income (Y) is derived:

$$\text{Y} = \text{GNPV} - \text{CCAV} - (\text{TI-SUB})$$

A further development of this shows the position of the private and personal sectors of the economy. By adding transfer incomes (YTR) – including national debt interest – and deducting adjustment for stock appreciation (YASA) and public authorities net trading and investment income (YGTIN), private income (YP) is derived:

$$\text{YP} = \text{Y} + \text{YTR} - \text{YASA} - \text{YGTIN}$$

The amount persons receive, personal income (YPER), is derived by deducting undistributed company profits (YCU) so:

$$YPER = YP - YCU$$

Then what they actually have to spend, personal disposable income (YPERD), is obtained after all direct personal income taxes (TYPER) and social insurance contributions (SOC) have been deducted:

$$YPERD = YPER - (TYPER + SOC)$$

Data according to this organisation of the national accounts are given in Table 2.4 for selected years.

Savings and Investment

An alternative perspective on the total supply-final demand and domestic production-income relationships is given by another important balance, namely, the equality between savings and investment which is implicit in the GDPMV and GNPV identities. The uses to which savings are put are fixed investment and investment in inventories. Using national accounts data we can isolate the sources of saving into domestic components and the foreign contribution. Taking the domestic component there are two broad means of financing investment: depreciation funds and net national savings over and above depreciation. The first of these, as we saw above, is deducted from gross national product at market prices, the income from productive activity, to give net national product at market prices, which is a measure of the income from productive activity which is available for disposal after allowance has been made to maintain the capital stock. By further appropriate adjustment, outlined above, national income, private income, personal income and personal disposable income (YPERD) can be derived from net national product at market prices. Personal disposable income is then the source for the personal (or household) part of net national savings. Personal savings (SPER) is then, by rearrangement of the basic accounts:

$$SPER = YPERD - CPERV$$

where CPERV is personal expenditure on consumers' goods and services. The company sector contribution to net national savings is simply retained profits (YCU) less taxes paid:

$$SC = YCU - (TYCU + TPC)$$

Table 2.4: *Macroeconomic accounts, Ireland, selected years, £m at current prices*

			1960	*1965*	*1970*	*1975*	*1979*
	Gross Domestic Product at market prices[a]	GDPMV:	631.3	958.9	1620.2	3728.4	7465.9
plus	Net Factor Income from abroad	YFN:	15.8	25.5	28.3	21.0	-69.0
equals	Gross National Product at Current Market Prices	GNPV:	647.1	984.4	1648.5	3749.4	7396.0
less	Capital Consumption Allowance	CCAV:	39.3	68.2	122.4	73.2	148.0
equals	Net National Product at Market Prices	NNPMV:	607.8	916.2	1526.1	3676.2	7248.0
less	Indirect Taxes net of Subsidies	(TI-SUB):	79.9	123.6	235.6	477.9	896.0
equals	Net National Product at Factor Cost or National Income	Y:	527.9	792.6	1290.5	3198.3	6352.0
plus	Transfer Incomes	YTR:	76.2	118.9	249.1	735.2	1537.0
less	Adjustment for Stock Appreciation and Public Authorities Net Trading and Investment Income	YGTIN:	16.2	23.3	39.8	77.7	206.0
equals	Private Income	YP:	587.9	888.2	1499.8	3855.8	7683.0
less	Undistributed Company Profits	YCU:	32.3	52.0	75.4	153.9	463.0
equals	Personal Income	YPER:	555.6	836.2	1424.4	3701.9	7220.0
less	Direct Taxes on Personal Income	TYPER:	31.3	62.8	143.3	485.0	1106.0
equals	Disposable Personal Income	YPERD:	524.3	773.4	1281.1	3216.9	6114.0

Source: Ireland, (*National Income and Expenditure (1977, 1978, 1979)*), Stationery Office, Dublin, 1979, 1980, 1981.

Note: a Arrangement follows O'Mahony (1964a, p. 148).

where TYCU and TPC are corporation tax and corporation profits tax revenues.[20]

The contribution of public authorities to net national savings is simply total income from taxes (TREV), net trading and investment income (YGTIN), and current transfers from the rest of the world (TRGL) less total expenditures, which comprises current expenditure on goods and services net of some receipt items and includes part of public authorities' depreciation (CGV) subsidies (SUB) and government transfers, including transfers abroad, (GTR) and national debt interest (GDI):

$$SG = (TREV + YGTIN + TRGL) - (CGV + SUB + GTR + GDI)$$

Re-organising the savings-investment identity shows that any deficit between domestic resources (net national savings plus depreciation) is made up by the contribution of foreign dissavings (or net foreign disinvestment) which, in turn, is made up of the trade balance (BPTV), net factor income from abroad (YFN), and net transfers from abroad (TRLN) i.e.:

$$CCAV + (SPER + SC + SG) - IFV + IIV = (BPTV + YFN + TRLN)$$

where IFV is total fixed investment and IIV is total inventory investment. The right hand side term is the deficit on the foreign current account (BPV) which is therefore identically equal to the excess of domestic investment over private sector plus public sector saving. This source of investment financing has a counterpart in the balance of payments capital account which shows how a current deficit is financed. Data for Ireland organised according to accounts of this type, which show the sources of investment financing, are presented in Table 2.5 for selected years. The dissaving of the public sector since 1971-75 and the significant contribution of net foreign investment in the Irish economy, stand out.

The flow of savings (inclusive of depreciation and net national savings and foreign savings) in the economy links the "real" (income-expenditure) with financial-monetary sector flows and accounts for the economy. Taking the financing aspect first, if an extreme assumption were made, i.e., unlimited

20. In this section here we are only isolating out the main source of savings to match against the total investment use of those funds. Depreciation is not available by this sectoral breakdown in the *National Income and Expenditure* Volumes. No attempt is made to match these against sectoral investment. Vaughan (1978) made estimates of investment and sources of financing for the company sector. Furthermore, the term private is the National Accounts designation and includes public sector components in personal incomes and company profits etc.

Table 2.5: *Investment financing from domestic and foreign sources, Ireland, 1961-1980*

	1	2	3	4	5	6	7	8	9
Years	*Depreciation*	*Net national savings (unadjusted)*[a]			*Adjustment for stocks ap.*	*Net national savings*[b]	*Total domestic financing*[c]	*Investment incl. inventories*[d]	*Net foreign saving*
		Personal	*Company*	*Public auth.*					
1961-1965	297.7	341.5	124.8	3.8	−27.0	443.1	740.8	892.4	151.6
1966-1970	527.2	572.9	195.6	80.0	−62.5	786.0	1313.2	1420.7	107.5
1971-1975	1111.4	2174.7	394.4	−305.7	−428.0	1835.4	2946.8	3434.7	487.9
1976	363.9	824.1	174.0	−181.4	−199.3	617.4	981.3	1138.4	157.1
1977	458.8	1003.9	270.9	−197.1	−158.7	919.0	1377.8	1533.0	155.2
1978	588.4	1242.7	279.4	−344.9	−117.4	1059.8	1648.2	1848.5	200.3
1979	700.0	1418.0	332.0	−464.0	−199.0	1087.0	1787.0	2514.0	727.0

Source: Ireland, *National Income and Expenditure, (1977, 1978, 1979)*, Stationery Office, Dublin, 1979, 1980, 1981.

Notes: a The sum of Columns 2, 3, 4 represents net national savings unadjusted for stock appreciation.

b Column 6 represents net national savings adjusted for stock appreciation.

c Column 7, total domestic financing, is the sum of Column 1 (depreciation) and Column 6 (net national savings adjusted).

d Column 9 is the sum of Columns 8 and 7. It represents the total available for investment in domestic physical capital formation.

borrowing and lending opportunities available at an externally determined interest rate and perfect financial intermediation, then the structure of the flow of funds (i.e., uses and sources of financing) between sectors in the economy and with the rest of the world, would be of no consequence (Honohan and Dunne 1982). However, in a real world situation, such assumptions do not hold and hence funds generated by the savings of surplus/lending units in the economy may be relevant to the cost and availability of borrowed resources to deficit/borrowing units, and the precise pattern of borrowing and lending becomes important. To investigate such issues requires the systematisation of the entire body of financial data in such a way as to permit financial developments to be perceived in the context of the *National Income and Expenditure* accounts.[21] Because the account for each sector of the economy reveals the sources of funds (income or borrowing) and all the uses (spending or lending), this way of looking at transactions in their entirety has come to be known as the flow-of-funds approach. One limited element of this approach is already incorporated into the economic accounting matrix and national income and product accounts, i.e., the balance of payments is concerned with the net transactions between residents and foreigners. The flow-of-funds accounts extend the same approach to the transactions between different domestic sectors.

In the above savings-investment identity we are concerned with goods and services and transfer payments. The bridge between this identity and the flow-of-funds analysis, which is concerned with the acquisition of financial assets and the contraction of debt, is savings. Savings are determined in one account as the excess of income over outlay, and in the other, as the difference between increases in financial assets and the increase in liabilities, i.e., net financial acquisitions or investment. The relation between the savings, capital formation and changes in financial assets and liabilities of any sector of the economy, which shows the equality between the sources and uses of funds may be summarised as follows:

Gross savings + Increase in liabilities (sources of funds)

equals

Gross domestic capital formation + increase in financial assets (uses of funds)

i.e.,

Gross savings = Gross domestic capital formation + net financial investment

21. The initial work in this area for Ireland is the study by Dowling (1973/74) and the recent estimates by Honohan and Dunne (1982) for the period 1972-1977.

For the economy as a *whole*, income equals expenditure and savings equals investment plus net increase in foreign assets, since the changes in domestic financial assets and liabilities of the various sectors cancel out. Hence, in the usual consolidation of the accounts of all domestic sectors, only the debts between residents and foreigners remain. Since one sector's payments become another sector's receipts, when all these individual sector statements are put together one obtains a flow-of-funds matrix for the whole economy as an interlocking grid that reveals financial relationships among all sectors. This is referred to as the financial accounting matrix (FAM) and provides a method for organising recorded data concerning financial transactions which is equivalent to the economic accounting matrix for product transactions.

Concerning the second, monetary aspect, savings is the link between the foreign savings or net foreign investment and the monetary sector of the economy. The money stock is the liability of the consolidated banking system. The assets are net foreign assets and net domestic assets. The savings-investment balance brings out an important aspect of the current account, namely, that it indicates the rate at which the economy is adding to its net external assets. When spending is less than income, claims on the rest of the world are being accumulated and vice versa in the case of a balance of payments current account deficit. If we ignore changes in the value of existing holdings of foreign assets, we can say equivalently that the current account balance equals the change in net official assets plus the rate of capital inflow or outflow or the rate of change of private claims on the rest of the world. Together the latter comprise the change in net foreign assets (ΔNFA). Hence,

$$BPV = \Delta NFA$$

Therefore, substituting into the previous balance and consolidating net national financing, savings, stock appreciation adjustments and depreciation sources of investment into private and government savings, we have

$$(SP - IP) + (SG - IG) = \Delta NFA$$

This links net saving to asset acquisition. Private sector net savings (SP - IP) plus public sector net saving (SG - IG) equals the acquisition of foreign claims. If the private sector component was in balance, i.e., SP = IP, then the budget deficit is externally financed through a decrease in net claims on the rest of the world. This could take the form of an increase in external public debt or a decrease in official reserves. Also net private foreign assets might decrease – although savings equal investment – with no change in official foreign assets. Domestically, this would mean an increase in public sector debt held by the private sector. Looking at money supply (MON) in terms of its asset counterparts the balance sheet identity can be written in incremental terms, as

$$\Delta MON = \Delta NDA + \Delta NFA$$

where NDA is net domestic assets and NFA is net foreign assets. This provides the overall structure for the monetary aggregates accounts which are not considered further as they are not a major focus for analysis in this study.

V. *ACCOUNTING BALANCES AND BEHAVIOUR*

It is important to note that sectoral balances simply impose consistency between the sectors and do not imply any particular cause and effect relationship. For example, if we look at one sectoral balance, such as a current account deficit, we cannot say that it is determined by any one of the other sectoral balances. A certain relationship must hold between them, and this provides useful information. It is this type of information which is summarised in the economic accounting and financial accounting matrices for the economy. To analyse causation we must look at the determinants of the components of the various sectoral balances and trace out possible links between them. In the case of the last balance discussed above, for example, the three sectoral balances are all simultaneously determined by the general interdependence of income, output and prices. To understand these balances we, therefore, have to consider the underlying decision-making and economic behaviour which results in the respective balances. In other words, these accounting balances provide quantitative data and an organising framework while economic theory provides an explanatory framework. In principle there is a distinction between the analytical framework suggested by theoretical reasoning and the source of the data used in quantitative analysis based on that theory. However, in practice, there is a circularity as the availability of data and the organisation of the accounts influence, to some extent at least, the analysis itself and the formulation of sectoral and economy-wide models. The preceding discussion of the accounting framework and the available data identified a number of constraints that have to be accepted and, therefore, they influence the analysis. As the economy-wide analysis undertaken here is explicitly executed in the context of the framework provided by the NIPE accounts, there is a need to examine further two specific aspects of these accounts in terms of their relationship to the conduct of macroeconometric analysis of economic behaviour.

The accounting balances were in terms of current value or nominal magnitudes and they referred to flow magnitudes per period of time as distinct from stock magnitudes measured at a given point in time. Thus, for example, the output of the industry sector was measured in terms of the current value during some specific accounting period. Taking the current value aspect first, it means that the magnitude involved may change entirely or partially due to changes in prices which may not reflect changes in real activity or quantities. In many areas of economic activity it is the latter which are of importance. Therefore, it is necessary to control for price change effects without falling back on the completely disaggregated stage of listing the physical amount of every type and variation of good. Accordingly, in order to retain the benefit of aggregation and summary data, it is necessary to construct "real" output flows. To control for the impact of price changes, and to isolate such changes for analysis themselves, the nominal magnitudes are deflated by the most appropriate price indices or implicit deflators available. The derived magnitude, for example, output of industry revalued at constant, i.e., base year, prices, is regarded as the "real" output of the sector. The validity of such an assumption is affected by the appropriateness of the deflation procedure and by the aggregation of diverse products. Thus, the real output measure emerging from the national accounting procedure is total value-added over all goods and all stages of the production process deflated by an index of industry sector goods prices.[22] While this is obviously an artificial construction and its limitations at the aggregate level are important, nevertheless, it is a widely used method of introducing *real* measures of economic activity into the analysis. Much of economic analysis is in terms of these *real* magnitudes, on the one hand, and in terms of prices, on the other hand. Combining both aspects in identities allows the derivation of the "value" balances discussed above. A crucial assumption involved in this approach is that this single good, "output" of industry, can be put to a variety of uses, i.e., consumption of non-durables and durables, investment in fixed assets, government consumption, by both domestic and foreign users. The implication of such an assumption is that compositional changes taking place within an aggregate variable are held to have no important consequences for the issues being analysed. There is thus no distinction between capital goods- and consumption goods-producing sectors in terms of how their behaviour is modelled. Output is just one malleable output.

The second aspect is the suitability of flow magnitudes, and the possible

22. Deflation procedures must be applied to a wide range of variables, such as consumption expenditures. We do not go into the details of these here as they are discussed in textbooks such as those by McGilvray (1968) and O'Mahony (1964a) mentioned in footnote 17 above, as well as in the *National Income and Expenditure* volumes. Information on data sources and adjustments we have made to official data, etc., is outlined in Appendix 2.2: Data Sources and Notes.

need to complement these with stock variables. There are three major topics of interest in the present analysis: employment and output, inflation, and incomes. In a capitalist market economy, production of output and the employment of labour takes place in response to profitable opportunities to meet demand. Thus, employment is related to demand and the profitability of output, which are flow variables. The rate of change of prices is also related, to some extent at least, to flow variables such as productivity growth. Finally, incomes are obviously a flow variable, and although not unrelated to the stock of wealth or capital, they are themselves important as an indication of the new production activity of the economy and, after allowing for capital consumption, of what may be consumed (or invested) without reducing the economy's production capacity. The economic variables central to the analysis are therefore flows, or largely related to flow variables, and so the NIPEA framework provides a suitable core for quantitative macrosectoral analysis. This does not, of course, deny the importance of stock variables. Variations in stocks occur via flows and flows enter and exit from stocks so that the interaction between these is clearly a significant aspect of the behaviour of economic agents. A particularly important example of such a relationship, in the context of a medium-term analysis of output, is the connection between investment in fixed asset flows and the resulting capital stock, which is central to the economy's production capacity. The measure of capital stock constructed from NIPEA data on investment flows is an artificial measure intended to represent the stock of productive plant and equipment. It is the accumulated investment expenditure on fixed assets vaued at historical costs by means of price deflation, and adjusted by some estimate of wear and tear. This is the "quantity" of capital and is just one example of the type of real and stock data which have to be "manufactured" in order to obtain a representation of necessary economic variables.[23]

VI. *FRAMEWORK FOR MACROSECTORAL ANALYSIS*

In the preceding sections we have considered the sources of data for macrosectoral analysis and the organisation of these as sectoral and economy-wide accounts. In this final section we avail of this accounting framework to set out the overall macrosectoral structure for the analysis to be carried out. Sectoral analysis, or sector models, as well as economy-wide models are by their nature simplifications or abstractions as the very term model constantly reminds us. Nevertheless, they are a compact method for organising the

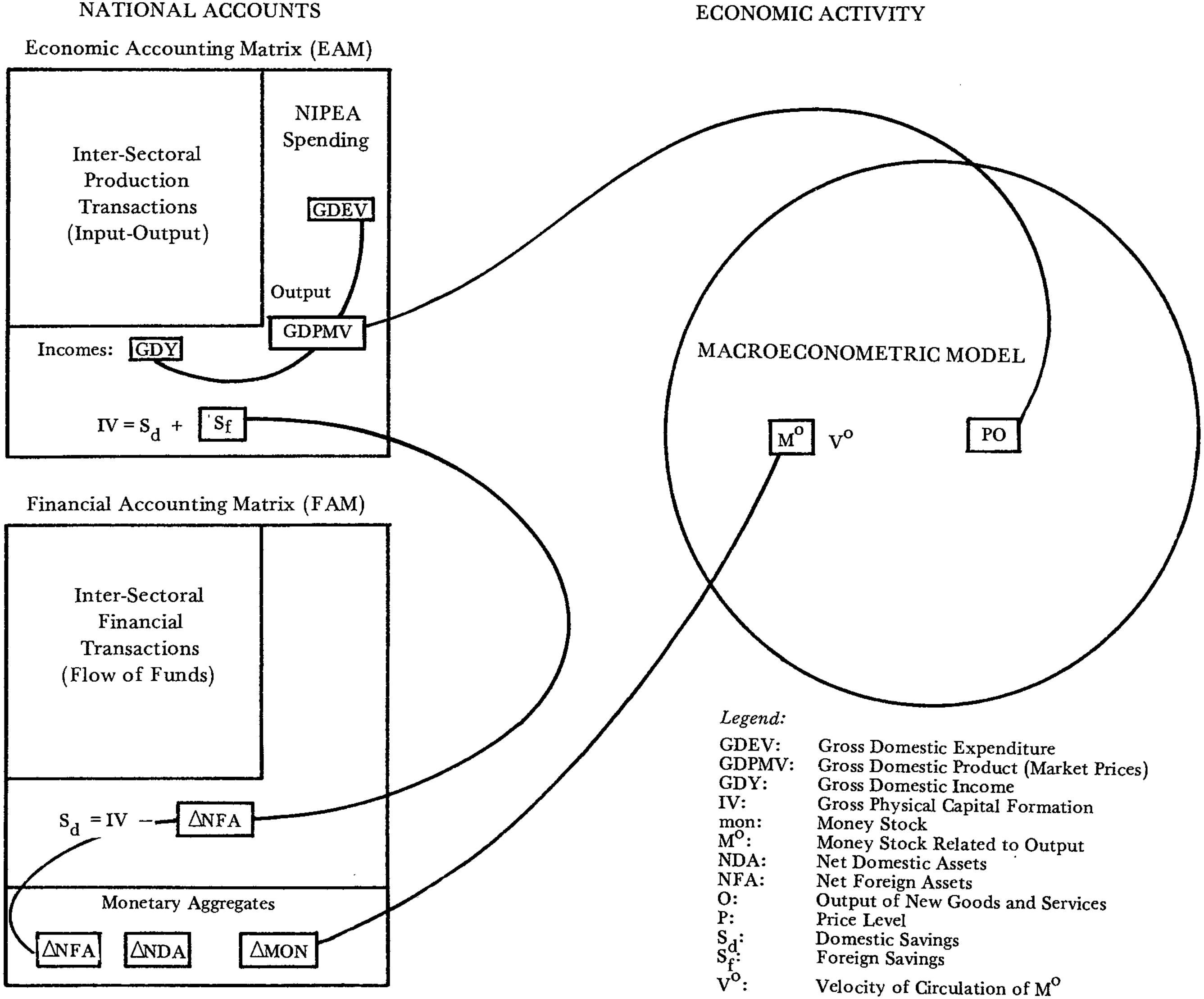
23. Other variables requiring similar treatment are measures of capacity output, full employment, and technical progress. These, including capital stock, are discussed briefly in Chapter 3, while the derivation of a number of other variables and specific sources is outlined in Appendix 2.2: Data Sources and Notes.

complex interdependencies constituting sectors of an economic system and summarising an extensive range of historical information. They do so by formalising behavioural, institutional and technological detail in a system of summary relationships within an organising framework that ensures overall consistency. The starting point for quantitative macrosectoral analysis is therefore the entire, or some part of, the national economic and financial accounts discussed in the preceding sections. These, as we have seen, can be organised so as to emphasise particular aspects of macroeconomic activity and, by so doing, a structural framework can be developed. By simplifying the analysis for expository convenience, down to one sector, or model, the relationship of the analysis to the accounting framework — more specifically the four elements discussed in this chapter — can be shown schematically as in Figure 2.3. The four elements are: (i) Inter-sectoral Production Transactions, (ii) National Income, Product and Expenditure Accounts (both of these composing the Economic Accounting Matrix), (iii) Flow-of-Funds, and (iv) Monetary Aggregates (both of these composing the Financial Accounting Matrix).

The income, product, and expenditure flows summarised in the NIPE accounts are the combined result of a subset of real — production and spending — activities and price determination mechanisms of the entire economy. These may be represented, for example, in an economy-wide macroeconometric model. Corresponding to these components of overall economic activity are the processes of financial intermediation between the sources and uses of funds as well as of monetary expansion which are summarised in the financial accounting matrix. The behavioural and accounting (budget constraint) relations between the real and the financial/monetary processes, and therefore the flows between the different sets of accounts, are relatively rudimentary in our study.[24] Thus, the economic analysis must be seen in its proper context as a partial analysis of activity, represented in Figure 2.3 by the circled area. The role of macroeconometric analysis is to endogenise the determination of the overall accounting aggregates of output, income and spending by means of relationships representing the determination of their components in real terms and their prices. The connection between the monetary aggregate accounts and the income-expenditure aggregates is illustrated by means of the alternative global accounting identity which states that the total outlay or spending on an economy's final output is identically equal to the volume of monetary instruments needed for making payment on this output. The exact relationship between changes in

24. This is not due entirely to data limitations but, as in the case of the monetary sector discussed in Chapter 8, also reflects the broad features of the interrelations during the sample period of the analysis here.

Figure 2.3: *Relationship between accounting frameworks and macroeconometric analysis.*



Legend:

GDEV:	Gross Domestic Expenditure
GDPMV:	Gross Domestic Product (Market Prices)
GDY:	Gross Domestic Income
IV:	Gross Physical Capital Formation
mon:	Money Stock
M^o:	Money Stock Related to Output
NDA:	Net Domestic Assets
NFA:	Net Foreign Assets
O:	Output of New Goods and Services
P:	Price Level
S_d:	Domestic Savings
S_f:	Foreign Savings
V^o:	Velocity of Circulation of M^o

the monetary aggregates and the income-expenditure aggregates is a matter for the behavioural specification of a model of the economy. This is also the case with the other relationships, such as the uses and sources of funds, which were identified in the preceding discussion of sectoral balances.

Turning to the problem of selecting a particular framework for organising our analysis, the overall structure that is most appropriate for medium-term macrosectoral analysis is the set of balances which concentrate, in an aggregate manner, on the sources of output and the claims on it. Thus, the total supply and total demand balances of the NIPEA part of the economic accounting matrix is selected because first, the production activities of the economy are of particular importance in themselves for an analysis of output and employment and, second, the present inadequacy and limitations of the inter-industry transactions and flow-of-funds accounts severely constrains the use which can be made of such data in analysis of the type to be presented here.

The sectoral analysis, following the overall framework selected, can therefore be structured into three blocks as follows:

I The Supply Block
II Domestic Absorption and Balance of Payments Block
III Income Distribution Block

The supply block analyses the supply of output according to the aggregate sectors of origin:

$$GDSV = OIV + OAFFV + OSV + OPAV + MGSV$$

The four sectors actually analysed in this block are industry, agriculture, services, and the imported supply of goods and services. Supply of labour, i.e., the demographic, participation and migration aspects of labour supply, are also included in the supply block. The domestic absorption block is based on the components of aggregate spending:

$$GFDV = CPERV + CGV + IFV + IIV + XGSV$$

The first four items comprise domestic absorption, i.e.,

$$GDAV = CPERV + CGV + IFV + IIV$$

which, as we saw earlier, plays a key role in determining the balance on the external account. The third block – income distribution – examines the behaviour of factor and product prices, the redistribution process via the public authorities taxation, expenditure and credit policy, and sets out a set of overall macroeconomic accounts and related balances for the economy. In Appendix 2.3 we briefly examine a range of empirical studies of the Irish economy within the above framework.

VII. *CONCLUSION*

In this chapter we have looked at how the organisation and scope of the national economic accounts influences the manner in which an overall macro-sectoral framework is formulated for quantitative analysis. An appropriate framework is identified and is based on a three-block structure which isolates domestic supply, domestic absorption and income distribution. These are the subject of theoretical and empirical analysis in Chapters 4-8 following. While these three blocks are examined separately they cannot be considered in isolation from each other because they are subsectors of the interrelated system that is the economy. Therefore, in conducting a structural macro-economic analysis it is necessary to take into account the interrelationships between subsectors as well as those within sectors. The controlling framework for this is provided by the national income, product and expenditure accounts discussed in this chapter.[25]

25. Because they are subsectors of the entire economy the three blocks can be brought together to make up an integrated system, i.e., an economy-wide macroeconomic model. In Chapter 9 we consider some aspects of this and the actual assembly and operation of a complete model system will be presented in a subsequent study.

Chapter 3

PRODUCTION FUNCTIONS, TECHNOLOGY AND FACTOR DEMAND SYSTEMS

I. *INTRODUCTION*

The discussion in the previous chapter of output and capital stock leads naturally into the main topic of this chapter, namely, the relationship between output and the capital, labour and material inputs, known as the production function. The problem of estimating production functions, and explaining employment, capital and material input decisions lies at the heart of most approaches to medium-term macroeconometric analysis. In approaching the problem of the analysis of the economy in the medium term, we considered that this area of economic methodology could usefully be separated and treated prior to the applied analysis of later chapters. In this way certain techniques can be isolated which assist in gaining further insight into some of the important economic mechanisms operating in all the production sectors of the economy. In presenting this material we hold the view that to get to the heart of what determines the growth rate, and variation in the growth rate, of an economy requires the synthesis of many areas in economics which have become artificially separated. Methods used to date in Ireland to study medium-term growth have tended to be "data-intensive", in the sense that data have been examined, often in great detail, using only relatively simple models of behaviour. Such models are often of a "reduced form" variety. The Verdoorn relationship between labour productivity and output used by Kennedy (1971) and Kennedy and Dowling (1975, pp. 72-74) is one example, as is also their use of the ICOR (incremental capital-output ratio) in the study of investment behaviour. If one accepts the view, as we do, that such reduced-form models arise from underlying structural behavioural models and are best interpreted in these terms, then the reduced-form models may become unreliable when their structural underpinnings are changing. Any period of economic upheaval, such as the recent past, tends to cast doubt on the validity of reduced-form models. In practice, of course, both types of model are complementary and the possible existence of stable reduced-form relationships is a spur to develop underlying structural theoretical explanations. We have chosen a range of topics for examination in this chapter, and Sections 3.II to 3.V can be viewed as building blocks for the theoretical and empirical work used in the later analysis of output supply and prices. In Section 3.II we formulate some basic material from the Neo-classical factor demand literature, material which will be used in an empirical application in Chapter 4 to determine employment and investment. Since our applied work will make use of fairly simple production functions (Cobb-Douglas and CES), we examine how the concept of technical progress is incorporated in these production functions in a way that permits fairly easy generalisation to more complex production functions. Since estimating factor demand equations involves, essentially, estimating the values of key production functions parameters, we briefly examine alternative methods which do not involve factor demand systems. Finally, recent movements in factor prices have rendered it advisable to extend the familiar two-factor value-added production functions (capital, K and labour, L) to include such additional inputs as energy, E and materials, M. While data limitations may prevent such extensions to Ireland at present, the issues raised are, nevertheless, of vital importance in order to be able to adjust for bias in the two-factor applications and to be prepared for empirical extensions as more, and better quality, data become available.

In Section 3.III we examine some ways in which the concept of "capacity" or "potential" output may be defined. Since in the medium term firms plan investment geared to some measure of "capacity" output, it is important to formalise such concepts. Our approach is two-fold. Based on work of Hickman and Coen (1976) we first concentrate on the conceptual or theoretical issues involved. We then examine some more operational empirical approaches, in particular the method of "linked-peaks".

Central to any attempt at modelling supply and factor demands is the issue of the malleability of the capital stock. In simple terms, the malleability of the capital stock refers to the possibility of substituting capital and labour before, during or after, the physical installation of the actual equipment. To date, the "putty-putty" model of capital stock has tended to be used in empirical work since it is both analytically simpler to handle and makes fewer demands on the data. Within this assumption, capital and labour are substitutable at all stages of the life of the equipment, an assumption which may be quite unrealistic in certain real world situations. In Section 3.IV we briefly examine some alternative malleability assumptions and their empirical implications.

Finally in Section 3.V we consider two major recent approaches to using the Neo-classical production function methods in empirical macro-analysis. The first approach, due to Behrman (1977), attempts to integrate the short- and medium-term aspects of supply and demand models, within a two-factor value-added framework. The second approach, of which the work of Helliwell and McRae (1981) is an example, tackles the issue of supply modelling using gross output and three inputs; capital, labour and energy. Our own sectoral macroeconometric analysis has been strongly influenced by the recent international work along these lines.

II. *PRODUCTION FUNCTIONS AND FACTOR DEMAND SYSTEMS*

Factor Demand Systems

A production function is a complex analytical tool which describes the maximum output that can be obtained from a given set of inputs in the existing state of technology. If specific assumptions about market behaviour are introduced, the production function constitutes a central part of Neo-classical growth theory and the marginal productivity theory of employment and income distribution. The parameters contained in the production function represent and reflect features of the prevailing technology whereby given inputs are transformed into output.

A general two-factor (value added) production function is written as

$$Q^* = f(K^*, L^*) \tag{3.1}$$

where Q, K and L represent (value added) output, capital input and labour input, respectively, and the "*" indicates that this is a long-run, or equilibrium, relationship which may not hold in the immediate short term. Considering only production processes of single period duration (generalisations are fairly straightforward) if c^* and w^* represent the cost of capital and labour, respectively, then

$$C^* = c^*K^* + w^*L^* \tag{3.2}$$

represents the cost, C^*, of producing Q^*. If the desired output, Q^*, is determined outside the firm and is not subject to its influence or control, then an efficient firm will wish to determine its required inputs of labour and capital such that C^* is minimised, i.e., it will attempt to solve the optimisation problem of form

$$\begin{aligned} &\text{minimise } C^* = c^*K^* + w^*L^* \\ &\text{such that } Q^* = f(K^*, L^*) \end{aligned} \tag{3.3}$$

It is shown in Appendix 3.1 that the resulting capital and labour demand schedules are of form

$$K^* = g(Q^*, \frac{c^*}{w^*}) \tag{3.4}$$

$$L^* = h(Q^*, \frac{c^*}{w^*}) \tag{3.5}$$

i.e., the demand for factor inputs is a function of the (externally determined) level of output, Q^*, and the relative price of capital and labour (c^*/w^*).

An alternative situation is one where the level of output, Q^*, may be set by the firm and the criterion now becomes one of profit maximisation, where profit is defined as

$$\Pi^* = p^*Q^* - (c^*K^* + w^*L^*) \tag{3.6}$$

It is shown in Appendix 3.1 that this results in factor demand equations of general form

$$K^* = g(\frac{c^*}{p^*}, \frac{w^*}{p^*}) \tag{3.7}$$

$$L^* = h(\frac{c^*}{p^*}, \frac{w^*}{p^*}) \tag{3.8}$$

and an output equation of form

$$Q^* = k(\frac{c^*}{p^*}, \frac{w^*}{p^*}) \tag{3.9}$$

i.e., factor inputs and output are functions of the real, or product, price of capital and labour.

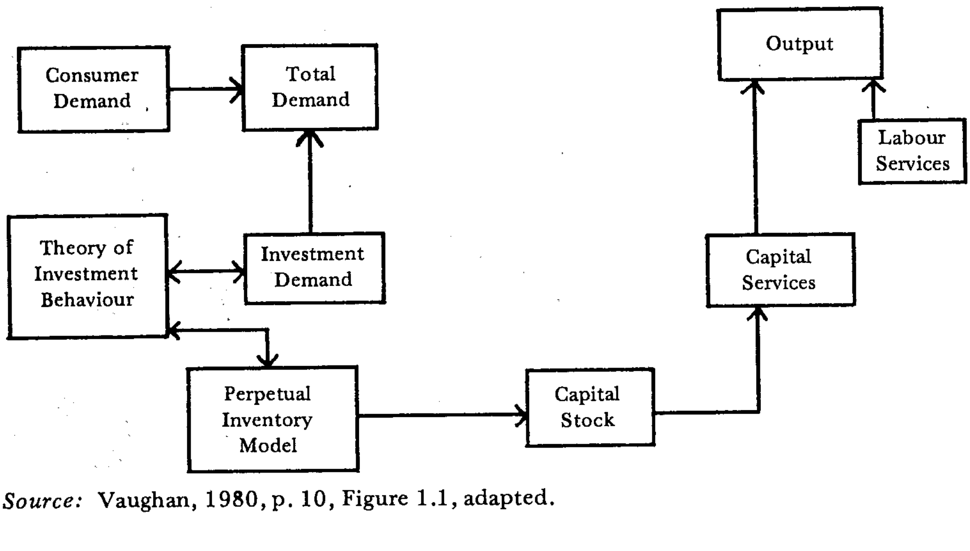
The exact form taken by the factor demand equations and the output equation depend, of course, on the particular form of production function chosen. In Appendix 3.1 we present the details for two commonly used functions, the Cobb-Douglas (CD) and the Constant Elasticity of Substitution (CES). In addition, we show how the long-run, or equilibrium, equations can be related to the short-run, or disequilibrium, situation described by data. In the derivations described in Appendix 3.1 it is clear that the factor demand equations, such as (3.4) and (3.5) above, are not independent of each other but both contain common parameters from the underlying production function. Hence, statistical estimation must take cognizance of this fact if the factor demand equations are to be interpreted in terms of a specific underlying technology. Finally, the above treatment can be readily generalised to production functions involving more than two factor inputs. However, the algebra of the derivations very quickly becomes complex and intractable.

From a more practical point of view, we now look briefly at the type of data needed to estimate factor demand systems of the above type.

(i) *Output:* If the model were applied to the industrial and services sectors, then industrial product (OI) and services product (OS) would be used as measures of Q.

(ii) *Capital Inputs:* Vaughan (1980) has pointed out some important difficulties in this area if official, or other published, capital stock series are simply taken as data. The most common mistake is to assume that replacement investment is proportional to the capital stock, whereas the capital stock itself has been generated on the basis of entirely different depreciation assumptions. Vaughan's illustration of the conceptual relationships concerned with the method of generating the capital stock (the perpetual inventory method, PI, here) is reproduced below in Figure 3.1. As Vaughan (1980, p. 11) points out using this conceptual scheme for a simple economy "one cannot choose independently any of the bases linked directly by arrows . . . ; i.e., a theory of investment behaviour implies a given PI model (or alternatively that a choice of a given PI model implies a given theory of investment behaviour). A given PI method implies a given capital stock (although not inversely)." We are inclined to accept the simpler interpretation of the "capital stock" variable as a

Figure 3.1: *Conceptual relationships between the perpetual inventory method, estimation of capital stock, and theory of investment behaviour*



Source: Vaughan, 1980, p. 10, Figure 1.1, adapted.

special case of a general economic model in which the cumulation of a particular variable over time (in this case, investment), influences current economic actions, thus avoiding a number of criticisms usually attached to a capital measure.

Hence, we generate our capital stock measure according to an exponential depreciation scheme:

$$K_t = I_t + (1 - \delta)K_{t-1} \quad 0 < \delta < 1$$

where I_t is real gross investment and δ is the annual rate of depreciation. A value of δ is assigned taking into account any available data on asset lifetimes.

(iii) *Labour Input:* Labour input should ideally be measured in man hours rather than numbers employed since average annual hours worked shows a slight downward trend over the past twenty or so years.

(iv) *Wage Rates:* The wage-rate measure is taken as average annual earnings in the relevant sector, where employers' social insurance contributions are included.

(v) *User Cost of Capital:* Using the appropriate investment deflator, we can base our user cost of capital index on the work of Geary and McDonnell (1979), Ruane (1982), Flynn and Honohan (1982). Actual empirical details are given in Chapter 4 below, and in the data Appendix 2.2.

(vi) *Expectations:* The variables entering the factor demand equations are not actual *but* expected output and relative factor prices. If the "*" is simply dropped, we have the case of static expectations. Expectations could also be proxied by weighted averages of current and past values of the variables. Alternatively, separate expectations mechanisms could be postulated using, say, autoregressions of actual values.

Technical Progress

One of the many problems that beset empirical applications of production functions is that conventional statistical measures of factor inputs fail to reflect possible alterations in their quality. For example, factors influencing labour inputs include such items as shorter working hours, changes in the age and sex composition of the work-force, and developments in technical education and training. In the case of capital inputs, these are affected by technical improvements in the design of capital equipment and (particularly in a small open economy) changes in the proportion of domestically produced to foreign produced capital equipment.

Two broad approaches have been used to deal with the problem of technical progress. On the one hand, attempts have been made to "correct" the statistical measures of factor inputs for changes in their quality.[26] Alternatively, factors can be incorporated into the production function which attempt to adjust for changes in the quality of inputs. To illustrate the relationships among the parameters of a production function in the presence of technical change, consider a general production function which admits factor augmenting innovation.

$$Q_t = F(A_t \cdot L_t, B_t \cdot K_t) \tag{3.10}$$

where Q is output, L(K) is labour (capital) services, F is linear homogeneous and A and B are measures of input efficiency. If labour and capital efficiency change at the constant rates λ_L and λ_K, then we may write

$$\begin{aligned} A_t &= A \exp(\lambda_L t) \\ B_t &= B \exp(\lambda_K t) \end{aligned} \tag{3.11}$$

Three types of technical change can be defined:

(i) *Hicks neutral:* Technical change is Hicks neutral if $A_t = B_t$;

(ii) *Harrod neutral:* Technical change is Harrod neutral if it is completely labour augmenting, i.e.,

$\lambda_L \neq \lambda_K = 0$; and

(iii) *Solow neutral:* Technical change is Solow neutral if it is completely capital augmenting, i.e.,

$\lambda_K \neq \lambda_L = 0.$

The incorporation of technical change proxies into the production function has important implications for the form of the factor demand equations. The omission of, or the inclusion of an inappropriate form of, technical change may result in serious bias in estimated parameters and wrong conclusions about the size and sign of output and relative price elasticities. In Appendix 3.1 we illustrate these issues using the CES two-factor production function.

26. An example applied to US data has been given by Christensen and Jorgenson (1970).

Other Approaches to Estimating Production Function Parameters

Three broad interrelated methods of estimating production function parameters can be distinguished: indirect estimation via factor demand equations (treated above and in Appendix 3.1); direct estimation, and indirect estimation via duality theory. We briefly examine the last two methods below and comment on some problems with the first method.

Direct Estimation

Given data on employment and capital stock, one can always attempt the direct estimation of the parameters of the production function. While apparently very simple, this approach is fraught with practical problems.

The production function is more correctly interpreted as a planning relation between expected long-run output (Q^*), employment (L^*) and capital stock (K^*). Assuming a Cobb-Douglas technology and neutral technical progress, the production function is of the form

$$Q_t^* = Ae^{\gamma t} (K_t^*)^{\alpha} (L_t^*)^{\beta} \qquad (3.12)$$

However, the corresponding short-run production function is of form

$$Q_t = Ae^{\gamma t} (k_t K_{t-1})^{\alpha} (l_t L_t)^{\beta} \qquad (3.13)$$

where k_t and l_t are indices of the intensity of use of the observed inputs K_{t-1} and L_t and where output is measured at its actual current level.

Hence, empirical estimates using actual data for output, employment and capital must be adjusted for utilisation rates of labour and capital and deviations between actual and long-run output. If these adjustments are not made, the parameters of the production function will be difficult to identify when there is slack capacity. An example of this problem is given by O'Reilly and Nolan (1979).

Furthermore, the nature of the technical progress assumed is important (e.g., whether disembodied or embodied) and makes it difficult to interpret the parameters on K and L. This, of course, holds no matter what method is used for estimation.

Finally, K and L are often almost collinear, rendering estimation difficult. Imposing constraints on the production function can sometimes alleviate this problem, provided the constraints are correct. For example, if in the Cobb-Douglas function

$$Q_t = Ae^{\gamma t} K_t^{\alpha} L_t^{\beta} \qquad (3.14)$$

we impose constant returns to scale ($\alpha + \beta = 1$), we can estimate the function as a labour productivity relation, i.e.,

$$\left(\frac{Q}{L}\right)_t = Ae^{\gamma t}\left(\frac{K}{L}\right)_t^{1-\alpha} \tag{3.15}$$

Indirect Estimation via Cost Functions

This method attempts to use the well-known duality relationship between production functions and cost functions. The advantage it has over methods which work directly with the production function is that the structure of the cost function and associated relations (such as budget share equations) is usually considerably simpler than the often highly non-linear factor demand equations. Three recent examples using Irish data are provided in Higgins (1981), Boyle (1981), Boyle and Sloane (1982). However, such methods are known to have problems due to there being no unique correspondence between the mathematical forms of the cost and production functions (Geary and McDonnell, 1980). They provide, however, quite powerful techniques for testing the restrictions of neo-classical production function theory and have normally been used in such a context rather than as methods of estimating factor demands.

Indirect Estimation Via Factor Demand Equations

In Appendix 3.1 we have shown for selected production functions how the coefficients of the factor demand equations consist of the production function parameters, and hence provide a powerful method for indirect estimation of these parameters. Estimates along the above lines are presented in Waelbroeck and Dramais (1974), for the nine-member EEC. The method failed to give reasonable results in the case of the Irish model. Application to the industrial sector has been made in Fanning (1979). However, as with the dual approaches, there are many problems with this indirect estimation methodology. For example:

(i) It is necessary to carry an elaborate series of maintained hypotheses.
(ii) There may be identification problems with the factor demand equations since different production functions and adjustment mechanisms could yield similar estimating equations.
(iii) The "putty-putty" technology used is by no means the only possible one. Alternative assumptions concerning the malleability of the capital stock yield radically different estimating equations as will be considered in Section 3.4.
(iv) The exogeneity assumptions concerning the demand for output and

factor prices may give rise to simultaneity bias in estimation if output and prices are not truly exogeneous.

Multifactor Production Functions

In using production functions as a tool for econometric analysis, three basic issues must be addressed. These are related to the number of factor inputs to be used and the separability of these factors; the definitions to be employed in measuring output; and the functional forms to be employed.

In applications dealing with two-factor production functions, an implicit assumption is made that factor inputs other than labour and capital (say, energy and raw materials) are used in amounts directly proportional to output. For example, in a simple three-factor Cobb-Douglas production function (where M denotes materials),

$$Q_t = Ae^{\gamma t} K^{\alpha} L^{\beta} M^{\delta} \quad \alpha + \beta + \delta = 1 \tag{3.16}$$

if one assumes that M = kQ, then the function can be rewritten in the standard two-factor form

$$Q_t = A'e^{\gamma' t} K^{\alpha'} L^{\beta'} \quad \alpha' + \beta' = 1 \tag{3.17}$$

However, a major conclusion of recent literature on the subject indicates that it has become important to include such factors as energy and raw materials explicitly in order to deal with the implications of massive shifts in relative factor prices (Berndt and Field, 1981).

To assist with and simplify empirical applications, it is useful to examine whether certain factors can be combined into "bundles" by the imposition of constraints on factor substitution possibilities. For example, in a three-factor production function,

$$Q = g(K, L, E) \tag{3.18}$$

one could consider such bundles as

$$Q = g(f(K, L), E) \tag{3.19}$$

or

$$Q = g(f(K, E), L) \tag{3.20}$$

In estimating the first production function, the inner bundle production function, f(K, L), can be estimated using standard national accounts "value-added" data, and the energy statistics are only needed at the second, or outer, stage of estimation. Such a desirable situation does not hold in estimating the second type, an example of which has been used by Helliwell and McRae (1981) where the inner (K, E) bundle is assumed to be CES and the outer bundle is Cobb-Douglas.

The separability issues can be tested empirically by considering a general unconstrained production function with capital (K), labour (L), energy (E) and materials (M),

$$Q = f(K, L, E, M) \tag{3.21}$$

Suppose value-added separability is assumed, i.e.,

$$Q = f(g(K, L), E, M) \tag{3.22}$$

where value-added, V, is given by:

$$V = g(K, L) \tag{3.23}$$

i.e., the value-added relationship normally used between capital and labour when choosing the optimal capital-labour ratio as (say) a function of the relative wage-capital factor prices, unaffected by the availability or price of E or M. The formal conditions for value-added separability to hold are that the marginal rate of substitution between K and L is independent of E or M, i.e.,

$$\frac{\partial}{\partial M}(f_K/f_L) = \frac{\partial}{\partial E}(f_K/f_L) = 0 \tag{3.24}$$

Berndt and Wood (1975) provide some operational empirical tests of the separability conditions. However, empirical studies using US data seem to reject value-added separability, but do not reject capital-energy separability. The results, nevertheless, are not very conclusive.

When dealing with two-factor production functions the Cobb-Douglas and CES functional forms are commonly used in situations where the trade-off between simplicity and generality comes down in favour of simplicity. However, in extending to the use of more than two input factors it is necessary to avoid simple generalisation of CD or CES if it is felt inappropriate to constrain the partial elasticities of *all* factors to be the same. Nevertheless, one still requires functional forms which are relatively simple to estimate and two such forms are commonly used in the literature.

(i) The nested CES function (Sato, 1967): An example of this function where capital and energy are bundled, is as follows:

$$KE = \alpha\ [\beta K^{-\xi} + (1 - \beta)E^{-\xi}]^{-1/\xi} \tag{3.25}$$

$$Q = \gamma\ [\delta KE^{-\rho} + (1 - \delta)L^{-\rho}]^{-1/\rho} \tag{3.26}$$

As a special case, either function could be CD. The estimation can be broken down into two separate CES estimations. However, it is important to first check that the relevant separability conditions hold.

(ii) The Mukerji function (Mukerji, 1963): The general function form is as follows:

$$Q = \gamma[\Sigma_i\ Y_i^{-\rho_i}]^{-1/\rho} \tag{3.27}$$

where Q is gross output and Y_i is the ith factor input. The advantages of the Mukerji function are that it allows for different pairwise partial elasticities of substitution between factors and estimation can be performed using linear techniques. However, the individual partial elasticities of substitution are functions of the factor shares and vary over time.

III. *CAPACITY OR POTENTIAL OUTPUT*

Fundamental to the development of an understanding of how an economy functions in the medium term is the concept of potential output. Such a concept has many different meanings and terms like capacity output, full-employment output, etc., are often used loosely as synonyms. The purpose of this section is to examine the precise differences between the various possible measures of capacity/potential output.

Two broad approaches are discernible in the literature. The first approach deals with stylised theoretical models of the behaviour of firms in an economy and defines various types of "potential" output in terms of these models. A major work in this area is by Hickman and Coen (1976) and we draw on their treatment in what follows. The second approach is more empirical and defines potential output using fairly simple operational rules. A widely used technique is the familiar "linked-peaks" method (Klein and Preston, 1967).

The Theoretical Approach

This approach starts from the long-run desired factor demand system which gives the demand for labour and capital as functions of long-run expected output and expected factor price ratios. Simple models of disequilibrium are then introduced to relate long-run and actual variables. If one then assumes that the level of factor utilisation is proportional to the degree of disequilibrium, various measures of capacity utilisation drop out of the model. In Appendix 3.2 we derive four measures of capacity/potential output:

(i) *Capital Constrained Capacity Output* – the output which could be produced if the *existing* stock of capital were operated with the optimal input of labour, for existing techniques and factor prices.
(ii) *Labour Constrained Capacity Output* – the output which could be produced if the *existing* employed labour were used with the optimal input of capital for existing techniques and factor prices.
(iii) *Potential Output* – the output which could be produced with existing technology, if the *full employment* supply of labour were combined with the existing capital stock, irrespective of cost conditions.
(iv) *Full-employment Output* – the output which would have to be *demanded* in order to induce employers to hire the full employment labour supply at existing factor prices.

The above four definitions shed light on the differing attitudes to capacity/potential/full-employment output. Employers will favour definition (i), and will seek continually to trim down the labour force to its cost-optimal level, a process which will, of course, usually coexist with changing techniques and factor prices. Unions would probably favour definition (ii) and, in the face of employers' attempts to cut costs by shedding labour, will call for greater investment in order to reduce unit costs of production. Politicians may favour definition (iii), and this definition encapsulates the idea of "putting idle people to work", where cost considerations are left to be worked out by others. The ideal situation is stated in definition (iv) but, particularly in a small open economy, the ability of governments to bring about the appropriate demand by expansionary policies is heavily circumscribed.

The theoretical approach is useful in order to be able to state precisely different definitions and concepts. Its empirical application, however, is limited by data and other considerations. In order to have empirical measures of capacity output one must turn to simpler, less precise methods.

The Empirical Approach

While the above definitions of potential output are based on optimising behavioural assumptions and the explicit use of production functions, three methods can be isolated that do not make use of such concepts. These are:

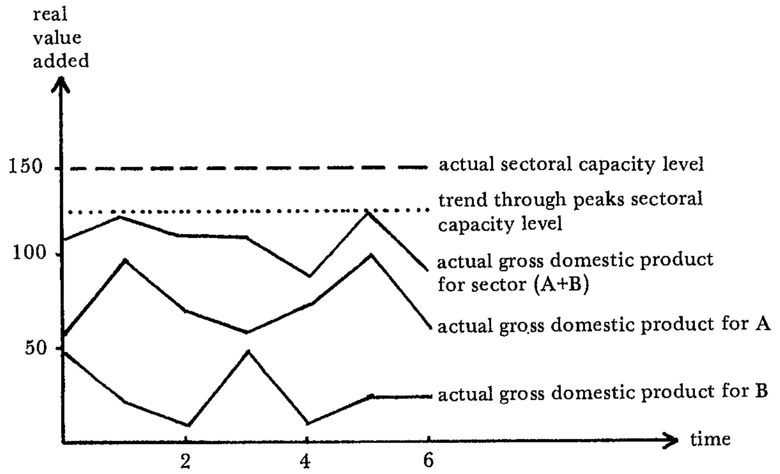
(i) business survey methods;
(ii) the Wharton (or trend-through-the-peaks) method;
(iii) the growth rate deviation method.

The first two methods have been studied in the Irish context by O'Reilly and Nolan (1979), and in an earlier work of McMahon and Smyth (1974). We make no further use of the survey based methods mainly because of inherent difficulties in using surveys to derive quantitative measures and because of the lack of empirical success with such methods (O'Reilly and Nolan, 1979, p. 55).

The "linked-peaks" method (Klein and Preston, 1967) involves the construction of a series for "capacity" output by selecting peaks in the actual output series by means of simple rules,[27] and taking these peaks to represent full capacity output. Interpolation methods yield capacity output for all intervening years. The ratio of actual output to capacity output gives a measure of capacity utilisation. While there are severe difficulties with using this approach, nevertheless, the Wharton method has been quite fruitfully implemented in a wide range of countries and studies, including Ireland. O'Reilly and Nolan (1979) applied it to the aggregate manufacturing sector using quarterly data. It has been used by Behrman (1977) as the basis for a supply sector model, discussed in Section 3.5 below. Some of the well-known problems with this method are:

(i) an aggregation problem since, even at a sectoral peak, some sub-components may not be operating at their peak level. The problem is illustrated below in Figure 3.2;

Figure 3.2: *Capacity output by trend-through-peaks and aggregation bias*



Source: Behrman (1977, p. 144), Figure 4.3.

27. For example, Q_t is defined to have a "peak" at t when $Q_{t-1} < Q_t > \max(Q_{t+1}, Q_{t+2})$.

(ii) aside from the aggregation problems, there is no reason to believe that every peak represents full capacity utilisation in the same (or any) sense. Hence, a downward bias may result;

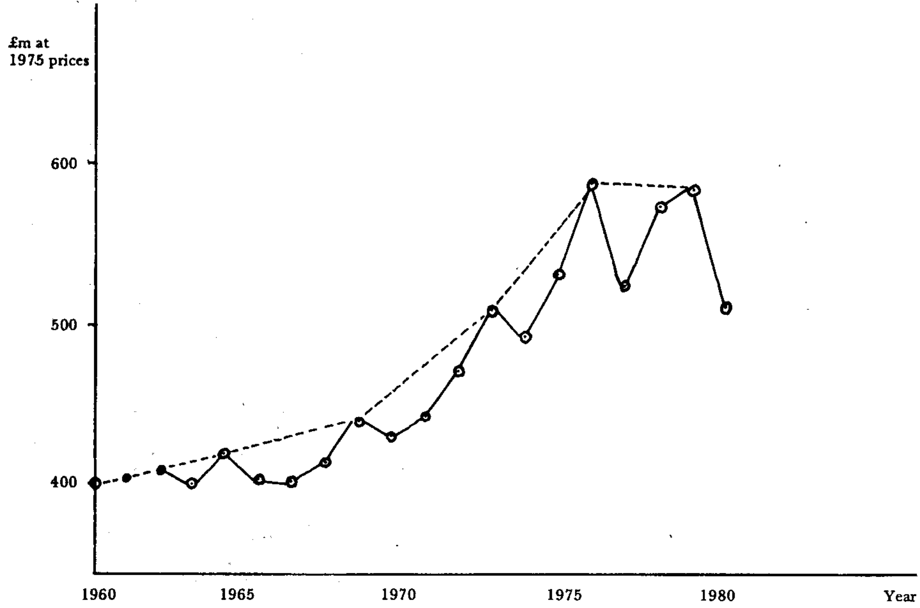
(iii) the efficiency implications of the method are unclear, i.e., the relation between capacity as defined by the method and any particular point on the long-run average cost curve;

(iv) the method of extrapolation often used for *forecasting* future capacity is very crude;

(v) inconsistencies may arise due to time aggregation — monthly, quarterly, or annual data may not provide compatible series.

Despite these difficulties, the method does represent an eminently practical and simple approach to an obviously difficult measurement and data problem. The "linked-peaks" method is appropriate either for sub-annual data or for long series of annual data which exhibit cycles of behaviour. In Figure 3.3 below we illustrate this method using the data for gross-agricultural product for the period 1960 to 1979. Five sub-peaks are clearly identified, and the method of linked-peaks leads to a series for capacity output in agriculture.[28]

Figure 3.3: *Actual and capacity product in Irish agriculture, 1960-1980*



28. The years 1975 and 1979 were peaks because of the sale of accumulated stocks of cattle in these years.

However, the corresponding data for annual industrial product exhibits only one peak in the period 1960-79 (in the year 1974). Hence, the linked-peaks method cannot be used with these data to derive a good series for capacity output for the period 1960-1979. One can, of course, use sub-annual (quarterly) data for manufacturing industry (as in O'Reilly and Nolan, 1979) and annualise the resulting capacity output measure, an approach which we will use in Chapter 4.

A simple method of obtaining a measure of capacity output is to estimate the (exponential) growth rate of, say, industrial product (OI) over a period (1960-79), and use this growth rate to define "trend" output, OI_{trend}, e.g.,

$$\log (OI_{trend}) = 6.054 + 0.05426t$$

where t = 1 for 1956. Taking 1973 as the peak capacity year, we define capacity output, $\hat{OI}$, as

$$\hat{OI}_t = 1203.7 \exp [0.05426 (t - 18)]$$

The measure of capacity utilisation becomes

$$CURI_t = \frac{OI_t}{\hat{OI}_t}$$

This simple measure is broadly in line with the more sophisticated measures used by O'Reilly and Nolan (1979) for quarterly disaggregated data. Clearly, the assumption of a single constant growth rate is restrictive. However, the introduction of dummy variables could handle any structural change in the growth rate. No such change was detected over the period 1960-1979.

Empirical factor based utilisation rates could also be estimated. For example, the unemployment rate, UR, is a measure of the utilisation rate of labour, but would be of less use in an economy with an open labour market. Similarly, O'Reilly and Nolan (1979) have used the linked-peaks method with electricity output and, on the assumption of an electrically-based capital stock, obtain measures of capital stock utilisation.

IV. *MALLEABILITY OF THE CAPITAL STOCK*

In the above sections we have used the concept of capital stock. In this section we examine briefly one aspect or attribute of the capital stock, namely, its malleability. In relation to the capital input, various different "malleability" assumptions can be made. The simplest assumption is that the capital stock is homogeneous over time and is not characterised by "vintages" which have different factor substitution possibilities, i.e., capital and labour can be substituted (in response, say, to changing factor prices) even after the capital equipment is installed.

The "vintage" capital approach attempts to disaggregate the capital stock into vintages which are characterised by different fixed production coefficients. While there are no substitution possibilities for a given vintage, changes in factor proportions will occur as new vintages are introduced.

Two vintage models are commonly used:

(a) *Putty-Clay:* There are no substitution possibilities for the capital equipment already installed. The impact of shifts in relative factor prices is confined to changes in the capital stock (i.e., gross investment) and associated movements in other factor inputs.
(b) *Clay-Clay:* Factor proportions on both new *and* old equipment are only influenced by technical factors and are independent of movements in factor prices.

The major implication of the difference between *ex-ante* and *ex-post* substitution possibilities for putty-putty and putty-clay is that the putty-putty model involves a faster impact for relative prices than does a putty-clay model. This is because factor proportions can be changed immediately (subject to the usual investment lags) in response to price changes in a putty-putty environment. Where there is no *ex-post* substitution (putty-clay), the switch in factor proportions must await the appearance of gross investment caused by growth of desired output or depreciation.

The vintage capital approach has major advantages from a theoretical point of view.

(a) Different types of technical change can be introduced in a more satisfactory way.
(b) Potential output becomes easier to define in terms of the vintage capital stock.
(c) The manner in which relative factor prices may affect actual and potential output is explained more satisfactorily.

However, there are many conceptual and technical problems, mainly connected with the determination of the oldest "vintage" of capital to be maintained in use. Some of these issues are examined in Appendix 3.3 where the data demands are shown to be heavy and the problems of aggregation very great. Some recent methods for overcoming these difficulties are proposed by d'Alcantara and Italianer (1982) and have been applied to the Irish manufacturing sector by Bradley and Wynne (1983). In Appendix 3.3 we examine a "heuristic" approach being used by the OECD in a medium-term modelling project (OECD, 1981a). Using this approach, the firm's factor demand decisions are shown to be made in hierarchical order. The long-run investment decisions take full account of factor price movements. Relative factor prices also affect energy demand but only at the margin if one excludes the possibility of changing the energy-capital ratios on *installed* equipment (the putty-clay assumption). The demand for labour only enters decisions in the very short run and relative factor prices play no role in the employment function unless, say, it is assumed that price movements influence the adjustment of actual to desired employment. Hence, this approach simply modifies the form of the factor demand equations and provides a useful "bridge" between the unrealistic putty-putty model and the complicated full putty-clay models.

V. *TWO RECENT APPROACHES TO AGGREGATE SUPPLY AND FACTOR DEMANDS*

In previous sections we have examined elements of the production function technique which forms the components of models of supply and factor demands. In this section we look at how these techniques are being used in macro-analyses. In particular we examine briefly two important international studies: the first, due to Behrman (1977), seeks to integrate medium-term/capacity aspects of the model with the short-run/utilisation aspects of supply based on an underlying CES production technology; the second, of which Helliwell and McRae (1981) is an example, gives an overview of some of the ways in which international modelling groups are reacting to the changed environment of the 1970s, in particular to the impact of changes in the real prices of material and energy inputs.[29] Both of these, together with the approach of Hickman and Coen drawn on earlier, provide a fairly comprehensive coverage of the contemporary approaches to modelling supply in macroeconometric models using the type of techniques outlined in this chapter.

Reconciliation of the Short-Term and Medium-Term

One of the most interesting aspects of the work of Behrman (1977), on the development of the Chilean economy, lies in the manner in which he has integrated the treatment of short-term and medium-term economic phenomena within a single model framework. Briefly, Behrman attempts to

29. Some of the conceptual issues involved are examined in a recent Bank of Canada paper by Masson *et al.* (1980).

abstract from the short-term, or cyclical, fluctuations of the economy and to concentrate initially on the long-term structure. The rationale for this is the assumption that the pressures for following Neo-classical competitive-like behaviour may be greater in the long term. The linked-peaks method is used to define capacity output for any particular sector of the economy and the secular trend is used for employment. Using the normal definition of the capital stock, a CES production function is estimated indirectly via the marginal condition on labour. The marginal condition for capital yields Jorgenson-like investment equations. Actual output is then related to capacity output via a behavioural equation determining capacity utilisation as a function of short-term factors.

The following points can be isolated for comment:

(i) An empirical definition of long-run or capacity output is introduced in order to estimate the underlying CES value-added technology. Here, the linked-peaks definition is used as a proxy for the essentially unobservable long-run variable.

(ii) Technical change is introduced explicitly into the production function, but is restricted to the neutral disembodied form.

(iii) The criterion of profit maximisation is invoked to derive factor demand equations. However, the factor demand equations are formulated in a hybrid form and not in the reduced form specification used in Appendix 3.1. Hence, Behrman's investment equations are similar in form to the original Jorgenson equations (Jorgenson, 1963), and as such are subject to the various criticisms that have been made of this approach (Brechling, 1975, pp. 20-22).

(iv) Although the long-run output and the factor demand equations are formulated in a fairly tightly specified Neo-classical framework, the determination of actual output (and, by implication, capacity utilisation) is tackled in an *ad hoc* fashion where various short-run market conditions, profitability and weather come into play.

(v) Capacity utilisation feeds back into investment determination as one factor influencing the long-run investment decision.

Supply Modelling in Response to Energy Price Impacts

In order to analyse the problems of the turbulent 1970s, it is fair to say that a major re-evaluation of approaches to model building has been taking place. Some of the issues being re-examined are surveyed in the paper by Masson *et al* (1980).

There seems to be a general view developing that formal econometric techniques may not be the best way to discriminate between alternative theories which are often empirically difficult to distinguish. This has led to a desire to impose more theoretical structure on models, particularly on their medium-term properties, and to use the model results in the light of the particular set of maintained hypotheses chosen.

A recent paper by Helliwell and McRae (1981) stems from this re-evaluation and incorporates many of the newer approaches to model building. It gives a special role to energy as an additional factor input. In its initial form it is very aggregate (about 50 variables in total), an approach adopted in order to permit models of similar structure to be estimated and compared for other countries, without running into too many data difficulties.

The Helliwell and McRae approach contains the following characteristics:

(i) A sequence of nested production functions is used to combine a capital-energy (KE) factor bundle (CES) with labour (CD).
(ii) The capital-energy bundle is modelled using a simple putty-clay vintage approach, i.e., the energy intensity of capital is freely adjustable *ex-ante* but fixed *ex-post.*
(iii) To simplfy estimation, factor demand equations and factor share data are used to obtain values of the production function parameters.
(iv) The actual consumption of energy relative to the amount required to fully utilise the vintage KE bundle is used as a measure of capacity utilisation.
(v) Inventory changes and imports are used to reconcile unanticipated divergences between potential and actual output.
(vi) Factor-based measures of potential output and operating costs are used in conjunction with final sales and desired inventories to derive the short-term production decision.
(vii) The role of imports in aggregate supply is explained; and
(viii) A hierarchical series of interrelated factor demand equations, based on the nested production functions and a derived measure of the expected level cf profitable future production, are calculated.

The resulting overall framework provides a tightly integrated system which can be used to study policy decisions and evaluate alternative policies, and provides a standard or benchmark for evaluating the structure and organisation of other models. The factor input and technology modelling approaches being developed at present impose heavy demands on data and mathematical sophistication, but are made necessary by the complexity of the issues facing economic policy-makers today. As yet there is no consensus as to the most appropriate or fruitful line of development in studying the Irish economy, nor are suitable national accounting data available for such applications. However, the two examples cited in this section seem particularly suggestive for applications to Irish problems in the general area of supply (Helliwell and McRae) and, in particular, agricultural supply (Behrman). In Chapters 4 and 5 we turn to the problem of setting out and attempting to operationalise these techniques.

PART TWO: *SECTORAL MACROECONOMETRIC ANALYSIS*

Chapter 4

DOMESTIC SUPPLY – PART I

I. *INTRODUCTION*

In the preceding chapter some basic technological and behavioural elements for constructing Neo-classical models of production and demand for factor inputs were reviewed and discussed. These elements, as we saw, can be arranged to provide an explicit, consistent and simultaneous framework for the determination of output, capital stock and investment and employment in an added value framework. The basic structure for such a theoretical framework was the assumption of dynamic optimising behaviour by the firm, subject to a production function constraint, in order to maximise profits, or minimise costs, appropriately defined. This meant that:

(i) the optimal level of factor inputs and the time path of adjustment can be determined, and

(ii) the production function constraint makes the determination of these optimal levels and their adjustment paths interrelated.

However, the elements and framework as laid out in Chapter 3 are neutral with respect to the economy and institutions and, furthermore, they do not make allowance for the data available and their appropriate interpretation. Therefore, in order to operationalise this framework, i.e., establish empirical relationships, the theoretical elements must be grounded in the particulars of time and place and take cognisance of data aspects. This task is undertaken in the following two sections of the present chapter and in the first section of Chapter 5. Three sectors are distinguished: agriculture (including forestry and fishing), industry and services. This level of disaggregation was settled on for the following reasons:

(i) it permits the study of the emergence and growth of the industrial sector in Ireland and the transition of the economy from a state of high dependence on the production of agricultural goods to a state of dualism;[30]

30. The most important initial aspects of this dualistic growth took place prior to the data period used to estimate in the present study (e.g., 1960 to 1979). Qualitative descriptions of the process have been given in Whitaker (1973) and (1982) and quantative analysis is available in Kennedy and Dowling (1975).

(ii) while a higher degree of disaggregation would be desirable for the industrial sector, nevertheless, it was felt that for our purposes a sufficient degree of homogeneity was present with an aggregate approach;

(iii) the inclusion of a service sector allowed investigation of the tertiary stage of development. While public administration is separated off for separate consideration in Chapters 6 and 8, further disaggregation is difficult due to lack of data; and

(iv) it was desired to restrict the analytical framework to a "reasonable" size in order to assist with its interpretation and, eventually, with its operational implementation and use.

The procedure for each of the three sectors is, first, to describe in a stylised manner some salient sectoral features and the institutional context. Consideration of the theoretical framework, the technical elements of which are set out and discussed in Chapter 3 above, is carried out against this background. The second stage is to specify and estimate empirical equations for each sector and to attempt to evaluate them not only by the usual statistical criteria but also their correspondence with developments during the historical period being analysed and their behavioural plausibility.

II. *INDUSTRY*

From a purely economic development perspective it would seem appropriate to treat the agricultural sector first, given its historical importance in the early development of the Irish economy. However, the data sample of interest in this analysis is 1960 to 1979 and the priority given to the industrial sector reflects the widely accepted view that it was the growth of this sector that led to the period of rapid economic expansion during 1958 to 1974 (Kennedy and Dowling, 1975, Chapters 4-6) and that this sector is crucial to future growth prospects.[31]

The main task undertaken in this section is to set out some broad features of capitalist business enterprises, which we take as a prototype for firms involved in the industry sector. We do so in order to establish the economic and institutional context for the sectoral analysis so as to be able to specify the overall theoretical framework which incorporates these features. A key relationship is the manner of determining the long-run optimal scale of operation by reference to anticipated demand. In a supply driven sector this scale would be related to measures of fully utilised capital stock and fully

31. "Industrialisation will have to be the main job provider for many years yet before Ireland can consider itself a 'post-industrial' society and rely mostly on service activities for gainful occupation of additions to its workforce". Whitaker (1982).

employed labour force via a production function. However, while such an approach might be appropriate for the agricultural sector, long-run industrial production decisions are taken to be based in a "Keynesian" manner on expected future demand and the profitability of responding to such demand. One component of demand, industrial exports, has been regarded as being of particular significance in the growth of the economy during the period of the model. Writers such as Whitaker (1982), Kennedy and Dowling (1975), Farley (1973) and McAleese (1978), to only name a few, have examined the role of exports in promoting overall growth.

The Kennedy and Dowling (1975) study of economic growth in Ireland concentrated on the investigation of "certain factors which are usually postulated as causes of growth and which seem related, in the Irish case, to the acceleration of economic growth" (1975, p. xvi). Among six major factors thus investigated, the role played by the growth of exports was given most attention.[32] In summarising their treatment of the role of exports in generating growth, they state:

> The 1960s, in contrast to the 1950s, offer us an example of the virtuous circle where growth feeds on growth – at least up to near full employment. Faster growth of exports and expansionary fiscal policy created adequate pressure of demand, rapid growth of output, a rising investment ratio, a faster growth of real income *per capita*, reduced emigration and a rising savings ratio. In turn, the rising savings ratio permitted an increasing investment ratio without unduly large balance of payments problems, thereby increasing capacity and the potential for further growth (Kennedy and Dowling, 1975, p. 248).

The study of the implications of export-led growth has been formalised and treated by modelling techniques by, among others, Beckerman (1962), Dixon and Thirlwall (1975), Cornwall (1977) and Thirlwall (1980a). In Appendix 4.1 we present a brief treatment of the simple analytic approach to these views. From this the following points can be made:

(i) The level of aggregation in analytical studies is, of necessity, very great.
(ii) The behavioural underpinnings are rather simple.
(iii) In particular, any attempt to study export-led growth under the direct

32. The five other factors were the growth of investment, the behaviour of the saving ratio, the effect of structural changes, the effect of policy measures, and the relation between short-term fluctuations and longer-term growth.

imposition of balance of payments equilibrium is fraught with conceptual difficulties. Such analysis would be best performed using more explicit policy criterion functions and optimal control techniques with a fully articulated macromodel of the whole economy.

(iv) The simple analytic model approach relies on a reduced-form production model involving the Verdoorn relationship. This relationship, which is absolutely crucial to the "circularity" of the growth process, has been widely used in studies of the Irish industrial sector (Kennedy, 1971; Katsiaouni, 1979; Kennedy and Foley, 1978).

(v) The autonomous nature of key variables – demand and, especially, the productivity growth rate – means that important aspects of the growth process remain unexplained in the model. This also applies to exports if they are increasing in magnitude and vary as a proportion of total autonomous demand.

Two key elements of the simple export-led growth model can be singled out as being of particular importance. The first is the assumption that the model is demand driven. The second is the manner in which "technology" enters the model via the Verdoorn relationship. In the case of the former it is desirable to generalise the driving force to include other elements of demand, and in the case of the latter, it is desirable to introduce the effects of technology into the model in a more sophisticated way. In Appendix 4.2 we show that the Verdoorn relationship can be interpreted as a special case of the Neo-classical production function approach which excludes important possible channels of influence such as factor and product prices and technical progress. In summary, the export-led growth model as usually presented is essentially a reduced form model of, at most, the industry subset of the economy. While the simple approach yields much insight a number of features autonomous to the export-led growth model emerge endogenously from explicit relationships and channels in a more extensive model of the economy. Using a generalised export-led growth model as a basis, we now turn to elaborating such a theoretical framework for the industry sector.

Theoretical Framework

The starting point for selecting and embedding elements of the technology in a real world industry sector model is a recognition of two obvious characteristics of industrial enterprises; first, uncertainty about outcomes and circumstances is a major feature of the environment and, second, in such an environment business ventures have to be financed in a particular manner. Different types of finance (in terms of contractual obligations as regards renumeration and security) and sources of funds (shareholders, institutional and non-institutional lenders and government) are used by firms. Broadly, there are two methods of financing: dividend earning share instruments (risk finance) and interest bearing debt instrument (loan finance). Although firms are founded in the expectation of being successful ventures, the possibility of losses or total failure determines the financing arrangement. In a market economy characterised by uncertainty, the outcome of a business venture is not assured and cannot be guaranteed. Thus, not all financing can be contractual, i.e., guaranteed a fixed rate of remuneration or even recovery of the principal advanced in the event of liquidation. This in turn means that not all payments to factors can be fixed or paid in advance of production and sales receipts. Some factor must be the equity bearing factor, i.e., receive the residual income of the enterprise, which may be positive or negative, in order to underwrite contractual obligations. This obviously can only be done by capital funds, either money itself or something that can be liquidated to pay creditors. In a capitalist economy, labour services are hired and paid during the production process which may be well in advance of sales receipts; similarly, the payment and trade credit period for other inputs, except owned fixed assets, are relatively short. It is that portion of the capital fund which is assigned to fixed assets – as well as that held as reserves – which is the equity bearing factor in a capitalist firm. Capital stock, i.e., fixed assets, by definition is therefore a quasi-fixed factor and the period over which it is variable may be quite long due to its specificity and to market conditions. Thus there is a particular risk associated with financing fixed asset formation and it is, therefore, usually financed by divident earning share instruments. The provision of risk capital is central to the organisation of industrial business ventures and investors – who retain ultimate control – are interested in the rate of return on these assets.

The typical industrial business firm is an entity involving the purposeful combination of factors of production in order to exploit entrepreneurially perceived opportunities. The basic motive for investing in such a venture is profit, which accrues to the private owners and controllers of the firm. They make their investment and production decisions on the basis of anticipated demand and the profitability of meeting it: judgements have to be made as regards the likely demand for a product, the quantity to be produced, the cost of producing it, and the price at which the product can be sold. For convenience it is assumed that their goal is to maximise profit, i.e., the rate of return on their outlay. To focus on a simple model of a firm, so as to identify the main features relevant to setting up a theoretical framework, it is assumed that all finance is provided as risk finance, i.e., unsecured subscriptions by ordinary shareholders. In order to minimise their risks the shareholders exercise control over the firm's activities. This finance is necessary to start a new venture, as in our example, and to continue in business if already a going concern. It is used to acquire the resources – fixed assets, raw materials and labour services – necessary for the activity selected. The following simple accounting view of the firm is used to isolate the relevant theory of capital and investment.

Suppose the account is for one period which covers the lifespan of the project from start up to termination. Also the price environment is taken to be non-inflationary.[33] To undertake production in order to take advantage of an entrepreneurially perceived opportunity, the necessary resources have to be brought together in some preferred combination. A particular scale of operation may be undertaken, as we saw in Chapter 3, with different combinations of resources. Estimates are made of the costs involved for the various combinations of inputs. These costs are based on estimates of future fixed asset, material and labour prices. On the basis of these calculations the least cost combination of factors is identified. Given the anticipations held for output and price, the difference between anticipated outlays and projected revenues earned is the maximum profit that is expected. The total outlay over the entire period, i.e., the (unsecured) finance committed to acquiring the necessary production resources, is the total investment made by the promoters of the venture. Thus, the total outlay is the capital, in the sense of a required *fund*, that has to be put together to undertake production. Profit plays an important dual role in the process. First, as anticipated profit, in particular as the return on invested capital, it affects the investment decision. Second, as earned profit in a going concern, the actual rate of return is a critical measure of a firm's financial well-being. It may be retained in the firm (but owned by the shareholders) as a means of financing operations.

A number of points can now be highlighted on the basis of this simple account:

(i) Capital is a fund and investment is additions to that fund. At any particular moment this fund, which constitutes the permanent institutional form of the firm, is embodied in some changeable combination of physical capital, wages fund, inventories, etc. Production is thus a process of transforming the capital fund into fixed assets, labour services and materials; then it is turned into inventories, and, finally, into sales revenue, i.e., a capital fund again (Nell, 1980, p. 495).

(ii) At any point the decision can be made whether to continue the

33. These simplifications allow us to abstract from multi-period discounting and inflationary accounting, none of which alters fundamentally the basic theme being developed here.

process on the existing scale, to alter the scale (positively or negatively) or indeed whether to continue at all. Based on the judgements and decisions outlined above, the firm is geared up for a particular rate of output at any given time. If the evaluations made turn out to be correct there will be no reason to change anything, i.e., the firm will be in equilibrium. Should the outcome be other than anticipated, any difference will be revealed in terms of the residual income and indicate the need, at least if negative, for changing some aspect of the operation. In that case the firm will try to adapt as best it can with the particular action taken determined by how the market situation is discerned.

(iii) Although the behaviour sketched in the simple model of the firm was in terms of initiating a new venture, the same logic applies when considering alterations, i.e., investment or disinvestment in an existing project. The distinction made between replacement investment and net investment disappears from a decision-making perspective at the level of the firm.[34] The undertaking of replacement investment is not automatic, as is the case in some models of investment, but is subject in principle to the same type of decision logic as that for new or net investment by a firm and while prior commitments may influence matters, the relevant decision variable is total investment expenditure.

(iv) The investors are concerned with evaluating the expected net returns on the anticipated total project investment in all inputs, i.e., capital, labour and other services, and materials and thereby the rate of return on equity capital. As part of this decision they are concerned with the optimal degree of total factor proportions, i.e., in the two-factor value-added case with the optimal combination of K and L, to minimise costs for the planned scale of operations. Thus, from a decision-making perspective two comparisons are involved:

(a) for the investment decision, the relevant comparison is between the rate of return (percentage earnings per £1 of net capital stock owned) and the cost of (financial) capital (interest on debt and equity which must be paid to raise financial capital); and

(b) for the factor proportions decision the appropriate comparison is between the rental on capital (implicit cost per unit of physical capital) and the equivalent cost for using labour.

34. The malleability of the existing capital stock may, of course, influence the nature of the net investment decision.

(v) Part of the capital fund is spent on acquiring fixed assets such as buildings and machinery,[35] and these expenditures undertaken to put fixed assets in place are, for the total over all firms, the gross "investment" flows of the national accounts. From a decision-making perspective of the firm, as we have seen, this is not the investment decision in the sense of the capital fund that has to be provided and risked to undertake the business venture. So when investment is modelled in terms of the national accounts gross investment data, i.e., expenditures on fixed physical assets, what is being modelled is the decision about the portion of the capital fund that is assigned to fixed assets. Therefore, the Neo-classical model of investment in its economy-neutral and non-institutional sense, is really a *choice of technique* decision about the proportions of fixed assets to labour input, in the two factor case. The interrelationship between the levels of these factors due to the underlying production function and decision model is, as we suggested in Chapter 3, an important contribution of the Neo-classical theoretical framework. *But that framework, in itself, is not a complete theory of business investment* – i.e., a decision theory about whether to advance the capital fund or add to that already advanced for an entrepreneurial project.

(vi) As identified in the discussion of the nature of business enterprise there is a particular risk associated with expenditure on fixed assets which consequently affects the manner in which such ventures are financed and controlled. It is this aspect which allows the expenditure on the fixed assets of the total project outlay, the capital fund, to be regarded as *the* investment decision.

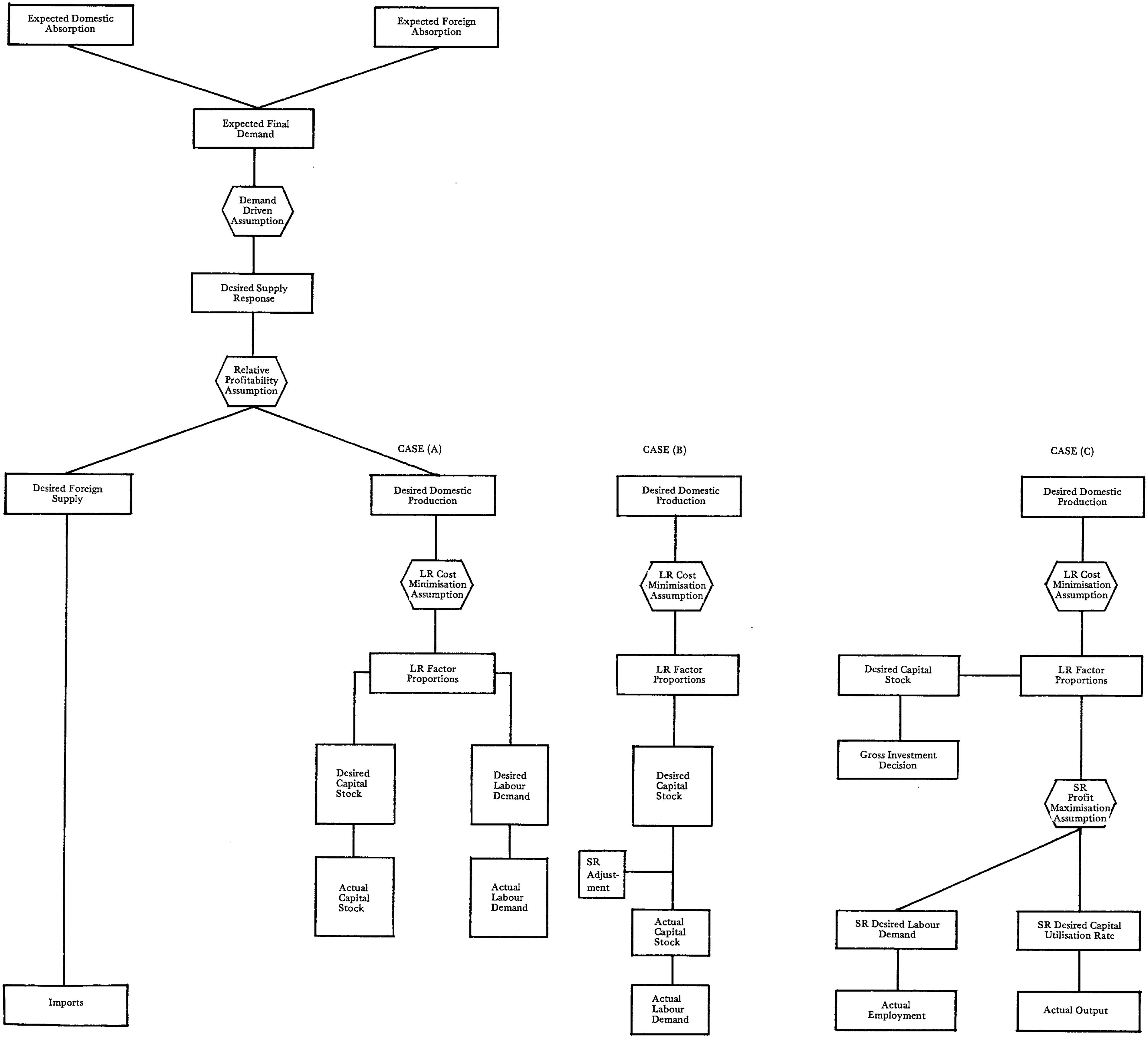
(vii) Once the fixed asset expenditure is treated as the investment decision, the all-embracing simultaneity of the Neo-classical framework, while acceptable as regards choice of technique, is no longer valid as an empirical model of capitalist enterprise. It must be replaced by a sequential optimisation process based consistently on the nature of the firm as outlined above.

For the purpose of our analysis, these considerations suggest a decision hierarchy which can be used to provide the framework for modelling the industry sector. The temporal order is

(i) the long-run scale decision;

35. This is still looking at it in terms of one period – the lifespan of the project. In terms of a multi-period analysis allowance could be made, for instance, for the possibility that these might be rented, i.e., the fund used to purchase services of fixed assets.

Figure 4.1: *Schema of Industry Sector Model*



(ii) the technology decision; and
(iii) the short-run utilisation decisions.

The determination of the scale of production encapsulates a large portion of what we might call the overall "investment" decision. The uncertainty associated with business ventures and the means whereby they are financed in a capitalist economy do indeed identify the fixed asset investment part of total project outlay as being of particular importance. On the basis of the preceding argument there is a separation between the long-run scale decision and the fixed asset investment (or choice of technique) decision. Finally, the nature of the firm is such that with a given commitment to fixed assets, and their financing, to earn as much profit as possible, actual production activity involves deciding the level of variable inputs used and the continual pressure to economise on these factors which are bought into the firm. Thus, a final stage in the decision hierarchy involves determining the short-run rate of capacity utilisation, and thereby output, and employment of labour. In the next three subsections we set out these aspects in our analytical framework.

(i) The Long-Run Scale Decision

Drawing on the viewpoint of the export-led growth model, we assume that the industry sector is demand driven, based on expected demand and profitability. Expected gross final demand for industrial goods (GFD_I*) may be some function of expected overall final demand (GFD*) or income (Y*) such that the changing pattern of demands and resulting changes in the structure of production accompanying economic growth, as well as growth itself, are taken into account, i.e.,

$$GFD_I = f_1\,(E[GFD^*.\,.\,.\,.\,.]) \qquad (4.2.1a)$$

or

$$GFD_I = f_2\,(E[Y^*,\,.\,.\,.\,.\,.])$$

where E [·] denotes the formation of expectations[36] and (. . . .) indicates other explanatory variables. The expected demand for industrial goods gives rise to the opportunity to supply an equivalent amount of goods,

$$GDS_I{}^* = GFD_I{}^*$$

so that, for example,

36. An example of such an expectation formation mechanism, in the context of forward-looking investment behaviour, is given by Helliwell and Glorieux (1970).

$$GDS_I^* = f(E[GFD^*, \ldots]) \tag{4.2.1b}$$

This formulation is simply a more general statement of the equilibrium form of the export-led growth model.

In an open economy, gross final demand for industrial goods is made up of:

(a) gross domestic absorption (GDA_I); and
(b) foreign or export absorption (X_I)

where domestic absorption comprises consumption expenditures by households (CH_I) and government (CG_I) fixed investment (IF_I) and inventory holdings (II_I). The subscripted I denotes the industry content of the respective national accounts aggregates. Gross domestic supply of industrial goods comprises:

(a) domestic production (O_I), and
(b) foreign or imported supply (M_I).

The next issue to be addressed is, therefore, how much of the long-run domestic supply, GDS_I^*, will it be planned to *produce* domestically (O_I^*) and how much it is anticipated will be supplied from abroad (M_I^*), i.e., what determines the split between long-run domestic product and foreign supply, and thus the amount of domestic capacity to be installed? If we assume that purchasers of goods seek to minimise their costs by selecting between foreign and domestic sources of supply, then the relative proportion of domestic to foreign supply would be determined by the relative prices of domestic (P_o) and foreign (P_m) output, and substitution constraints:[37]

$$\left(\frac{O_I^*}{M_I^*}\right) = f_3\left(\frac{P_m^*}{P_o^*}\right) \tag{4.2.2a}$$

Thus, the split between the long-run decision to supply domestically or to import is determined by the competitiveness of production in Ireland as compared to direct importation. The derivation of an appropriate measure of competitiveness is a difficult task and includes, from the purchaser point of view, not only actual quoted price but also waiting time, trade credit terms, and other factors; from the supplier's point of view it includes variables such as grants, incentives, taxes, subsidies, etc., as well as price which relate

37. This approach is set out in Chapter 5.II on imported goods and services. Such a relationship assumes that domestic output and foreign output are, at a minimum, imperfect substitutes.

to domestic or foreign firms. Another difficulty which arises immediately is the availability of data for O_I* and M_I* which are unobservable variables. The measurement of O_I* will be considered in the following section on specification and validation. But at this point we can anticipate that there is little possibility of identifying an appropriate measure of M_I* for a highly open economy. By manipulation of equation (4.2.2a) and using the definition of gross domestic supply (GDS_I*) as the sum of domestic production (O_I*) and imports (M_I*), i.e.,

$$GDS_I^* = O_I^* + M_I^*$$

we obtain

$$O_I^* = f(\frac{P_m^*}{P_o^*}, GFD^*) \qquad (4.2.2b)$$

i.e., planned domestic production as a function of long-run demand and competitiveness variables.

Once an expectation has been formed about the future potential demand and domestic production — the opportunity for investment — the next stage is to translate this into an investment decision and activity. In the light of our discussion of the organisation and characteristics of capitalist firms, a stylised investment function, i.e., a decision to install fixed assets, can now be written as,

$$K_I = f(O_I^*, \pi^*, \pi) \qquad (4.2.3)$$

where π* is the expected rate of profit, and π is the current and past rate of profit or some other variable capturing the ability to finance investment.[38]

(ii) The Technology Decision

If the production function underlying the domestic production process is assumed to be two-factor added value (capital, K_I, and labour L_I), then the Neo-classical theory of the firm is invoked to establish the long-run choice of technique or factor proportions. The problem of maximising profits becomes one of identifying the least cost combination of K_I* and L_I* to produce the long-run (or capacity) level of output O_I*. With cost minimising production of O_I* assumed, and imposing homogeneity, then from Chapter 3, we have shown that

38. The rate of profit can be measured by the actual rate of profit (π/K), or by the share of profits in value added (π/O) if the capital to output ratio (K/O) is constant.

$$\frac{K_I^*}{L_I^*} = f\left(\frac{UCL_I^*}{UCC_I^*}\right) \qquad (4.2.4)$$

where UCC_I^* represents the user cost of capital and UCL_I^* represents the user cost of labour. Hence, using the necessary production function parameters, we may write equations for long-run factor demands as follows:

$$K_I^* = f_1\left(O_I^*, \frac{UCL_I^*}{UCC_I^*}\right) \qquad (4.2.5)$$

$$L_I^* = f_2\left(O_I^*, \frac{UCL_I^*}{UCC_I^*}\right) \qquad (4.2.6)$$

Equations (4.2.5) and (4.2.6) have been derived on the basis of a putty-putty technology assumption (Chapter 3) and represent simultaneous long-run joint factor demand equations. Direct use of these equations is basically the "institutionally neutral" application referred to in the introduction above. There are three approaches one can adopt to interpreting and using these factor demand equations:

(a) Direct application of Equations (4.2.5) and (4.2.6), where the actual technology adopted is a matter for empirical investigation.

(b) The use of a putty-clay technology assumption as regards the capital stock as a means of capturing the hierarchical or sequential nature of factor demand decisions, a point which is developed further below. In this case, using the results from Chapter 3 on malleability of capital, the demand for capital schedule remains

$$K_I^* = f_1\left(O_I^*, \frac{UCL_I^*}{UCC_I^*}\right) \qquad (4.2.7)$$

but the demand for labour equation is now obtained by inverting the (assumed) production function, and is of form

$$L_I^* = f_2(O_I^*, K_I^*, t) \qquad (4.2.8)$$

(c) Finally, the demand for capital and labour can be completely dichotomised into two separate decision processes. The first process involves a demand for capital and is based on long-run factors exclusively, although it may be modified by short-run circumstances. The second process involves the capital stock utilisation decision and decisions on manning requirements, and is an essentially short-run process. This latter case, i.e., the issue of capacity utilisation and manning, we now examine in more detail.

(iii) Short-Run Capacity Utilisation and Manning Decisions

In a world of uncertainty and anticipations, events do not always turn out as expected or desired. Firms, therefore, need flexibility in order to respond to short-run events. Just because a certain long-run output level is desired (based on long-run expectations) and the steps to install a certain output capacity have been commenced does not mean that the firm will actually produce at that level in any particular short-term period. In order to survive it has to be able to adjust its short-term financial structure and cash flows so that actual output (O_I) may differ from long-run expected output (O_I*). The firm's ability to alter its financial position is related to the ownership of factors and the capital (financing) structure of capitalist enterprise. For example, existing capital stock, by definition, is already installed and ownership is on an equity basis, i.e., variable return. Thus, the total running "cost" of fixed assets is variable – the quantity is fixed but the return per unit (as distinct from the opportunity cost) is variable. On the other hand, labour is hired as a service flow at fixed cost, i.e., remuneration per unit. If kept on, employees have to be paid. To maintain flexibility on the labour cost account employees may be laid off and re-hired, or hours of work varied. Thus, the total labour cost is also variable – the rate of return per unit (cost to the firm) is fixed, but the quantity is variable.

This arrangement gives the firm operating flexibility over costs in the short run and thereby the ability to maintain cash flow in order to survive market fluctuations, unanticipated events and erroneous decisions. Hence, even though we use K_I as if it were a simple aggregate, it is in fact composed of divisible units of plant and equipment. Therefore, some units of capital stock can be left idle and all or part can be utilised for certain periods which can be varied. The singling out of fixed asset investment decision based on the financing of factor ownership institutions and the resulting separation between long-run output choice of technique decisions and the short-run utilisation manning decisions, suggest a sequential modelling framework for factor demands. This is in contrast with the interdependent and simultaneous approach of the institution free theoretical framework of Chapter 3.

We consider first the question of capacity utilisation. It is widely accepted that economic growth in developing economies depends primarily on additions to the stock of capital. However, as Winston (1971) has pointed out, it is somewhat of a paradox that in typical developing countries, the utilisation rate of the existing stock of capital often falls short of even current socially acceptable full utilisation. Winston (1974) quotes a study of Korean manufacturing industry where it was found that increased utilisation of the capital stock appeared to have been almost as important as investment in increasing capital services over the period 1962-1971. Indeed, development policies based on cheap capital and expensive labour may result in systematically reducing utilisation, capital productivity and growth. The corollary of low capital productivity is a meagre use of labour with each unit of existing capital and a slow growth of labour use with new investment. Hence, low capital price policies, in discouraging utilisation, may compound sluggish rates of industrial employment growth, a process which is aggravated by high wage policies in the industrial sector.[39] Since the utilisation rate of capital stock is an economic variable, an important implication is that there can be no fixed unique relationship between capital stock and output or employment. The convention of using actual capital stock as an argument in a production function assumes implicitly that optimal utilisation (and hence, capacity) is unaffected by economic variables and that variations in utilisation are unrelated to growth and development policies.

In order to discuss the economic determination of utilisation of capacity, we take some measure, say $CURK_I$, of the utilisation of capital capacity. The questions at issue are what are the determinants of $CURK_I$ and how is the decision to be formulated. Broadly, three types of determinants are relevant:

(a) The short-run profitability of production, as measured say by product/input price ratios;
(b) demand conditions in the short run as indicated by the state of domestic absorption or world trade; and
(c) other factors such as short-term credit availability, and so on.

Essentially the relationship determining $CURK_I$ is a short-run supply function with the appropriate slope (real product price) and shift (demand, credit) variables.

Turning to the second aspect of the short-run utilisation decision — the level of manning or employment of labour — we draw on the separation made between the long-run installation of fixed assets and the short-run hiring of labour.[40]

Whatever about the assumption made as regards the planned installation of capital stock to produce long-run capacity output, the equivalent assumption, however, cannot be made about the employment of labour. This is due to the second special feature of investment in a capitalist economy which we isolated, namely, a recognition of the relationship between the financing

39. The problem is, of course, exacerbated in a small and open economy, where the import content of investment expenditure is often quite high.

40. This system of sequential adjustment to stocks of capital and labour forms the essence of Hick's temporary equilibrium method of analysing investment and growth (Hicks, 1965, pp. 58-75).

aspect and factor ownership institutions: fixed assets are purchased and owned as a stock but labour is purchased only as a service flow. Thus, even if they are both quasi-fixed factors they differ in their degree of fixity. This has implications for the production behaviour of the firm and also the interpretation of observed data on capital per worker. The actual short-run utilisation of capital stock is at the discretion of the factor owner, i.e., the amount of service flow generated per period is varied according to the owner's discretion (Winston, 1974, p. 1304).[41] Labour, since it is not owned as a stock by the firm, can be more easily varied. Fixed assets, which *are* owned as a stock, cannot or are less easily varied.[42]

The determination of employment is, therefore, a decision taken jointly with the decision as regards the short-run utilisation rate of production capacity, $CURK_I$. These decisions are taken with the constraints already implied by the existing production function parameters and capital stock. Thus, the decision involved is short-run (one-period) optimisation of the variables that can be adjusted and subject to some variables being classified as fixed or parametric.

We specify this situation as the maximisation of net returns, R, for a single homogeneous output, O_I, using the two homogeneous factors of production, K_I and L_I, and with parametric prices.[43] We distinguish between the total fixed capital stock in place, K_I, and the utilised capital stock, KU_I.[44] Hence,

$$R = \overline{PO_I}.\ O_I - \overline{W_I}.\ L_I - \overline{UCK_I}.\ \overline{K_I} - \overline{OCK_I}.\ KU_I \qquad (4.2.9)$$

where the bar indicates variables which are parametric to the short-run decision processes, and the notation is as follows:

O_I = Industrial output
PO_I = Price of industrial output
W_I = Wage rate
L_I = Employment
UCK_I = User cost of capital

41. This is a matter that has been analysed by Leibenstein (1976). Employers hire labour time but do not entirely control the labour service flow which is made up of the following components: (A) activities chosen, (P) pace of carrying out activities, (Q) quality of the activities, and (T) the time sequence aspect – Leibenstein's APQT Vector – and are subject to some control at least, by the factor owner, i.e., employees.

42. Labour may be a quasi-fixed factor for a number of reasons, e.g., the firm prefers to hoard labour rather than inventories of goods. These may give rise to adjustment costs but, nevertheless, labour is basically the short-term variable input in the two factor model of a capitalist firm.

43. Price setting behaviour is discussed in Chapter 7 below.

44. Nadiri (1968) uses a similar approach. No attempt is made to measure labour utilisation rates.

K_I = Capital stock
OCK_I = Operating cost of capital
KU_I = Utilised capital stock

Thus, the short-run (one-period) profit maximising problem for price taking firms with fixed total capital stock and technological parameters becomes,

Maximise R
such that $O_I = f(KU_I, L_I)$ (4.2.10)

The first-order conditions for profit maximisation are derived by equating the marginal product of utilised capital and labour to their price, i.e.,

$$\frac{\partial f}{\partial KU_I} = \frac{OCK_I}{PO_I} \qquad (4.2.11)$$

and

$$\frac{\partial f}{\partial L_I} = \frac{W_I}{PO_I} \qquad (4.2.12)$$

Solving for KU_I and L_I yields short-run demand relationships of form

$$KU_I = g(O_I, \frac{OCK_I}{PO_I}) \qquad (4.2.13a)$$

$$L_I = h(O_I, \frac{W_I}{PO_I}) \qquad (4.2.13b)$$

Thus, in the short run, an increase in wage rates results, *ceteris paribus*, in a decrease in the scale of production and some elimination of employment. In the long run, the effect will be substitution of capital for labour (as in Equation 4.2.4). Although the one-period maximisation model is taken as the starting point there may be other factors affecting ability or desire to produce O_I and hire L_I, i.e., O_I and L_I may not be adjusted instantaneously as the model above implies because:

(a) labour may not be instantaneously hireable or fireable. It is a "quasi-fixed" factor, i.e., an adjustable input but not necessarily instantaneously;
(b) credit financing conditions may constrain the ability or willingness to undertake O_I and L_I commitments.
(c) demand conditions — direction of change, inventories, etc. — would modify willingness to go to the optimum position immediately, i.e.,

speed of adjustment is modified in the light of the anticipated state of demand; and

(d) expectations with respect to product and factor prices are uncertain and this also imposes adjustment costs.

Therefore, the adjustment of actual output to short-run desired output, and the corresponding change in employment, can be modelled using adjustment mechanisms where the coefficients of adjustment are parameterised by the relevant modifying variables such as credit and demand. The modelling of output in this manner results in a supply function modified by the state of demand, credit and uncertainty. Hence, the employment decision arises as the result of two quite distinct, but interrelated processes:

(i) The long-run "choice of techniques" relation, L_I^*/K_I^*, where factor utilisation plays no direct role.

(ii) The short-run "manning" decision which is crucially linked to the rate of capital utilisation.

The short-run treatment above allows implicit factor-based modelling of the level of utilisation of the capital stock and, given the value of installed capital stock, the rate of capital stock utilisation.

A more direct method of modelling capacity utilisation, which is independent of factor demand systems, has been suggested by Behrman (1977) and was outlined in Chapter 3. Three sets of factors which go to determine capacity utilisation have been suggested, involving conditions in product and factor markets, financial circumstances and natural conditions. While the latter factor is important in agriculture, its direct effect may be safely neglected in arriving at a model of industrial capacity utilisation. (Indirect effects may, of course, feed through from agriculture in terms of demand.) Using a simple linear formulation leads to a relation of form:

$$CURK_I^* = f(\text{profitability, relative prices, demand, credit}). \qquad (4.2.14)$$

Detailed consideration is reserved to the empirical section below.

We summarise the industrial sector theoretical framework as follows:

(i) The sector is demand driven in the sense that expectations of future expenditure drive long run or capacity output, O_I^*.

(ii) The Neo-classical cost-minimisation model is used to derive long-run optimal factor demands, L_I^* and K_I^*, as a function of expected relative factor prices (UCL_I^*/UCC_I^*) and output O_I^*.

(iii) The capital demand equation derived from (ii) forms the fixed investment decision which is assumed to have long-run characteristics due to the long lags involved in investment planning.
(iv) The long-run factor demands can be related to *actual* observed factor demands by means of empirical adjustment mechanisms.
(v) The short-run rate of capacity utilisation can also be modelled as a supply function which is parametric in demand conditions.
(vi) The Neo-classical model used to derive the optimal labour-capital ratio, when modified for rigidities and for capital services inputs, can also be used to determine the evolution of the short-run labour demand or manning decision.

In Figure 4.1 we bring all these elements together in a schematic diagram of the structure of the industrial sector. In this diagram, the main branch runs from the components of expected demand (domestic and foreign) through to the split between the domestic production and import decisions. Three possibilities regarding consequential factor demands are shown. Case (A) is a system of simultaneous and interrelated employment and investment decisions. Case (B) illustrates the modifications necessary to incorporate a putty-clay type of capital stock, i.e., the factor demands become sequential. Case (C) describes the institutionally more realistic process whereby the investment decision is held to have long-run characteristics, but where a short-run process of profit maximisation determines capital utilisation rates and manning levels. Underlying these elements are, of course, the technology of production (i.e., the specific form of the production function to be used) and the measurement of variables appropriate to the theory. It is to this task of operationalising the theoretical framework that we now turn.

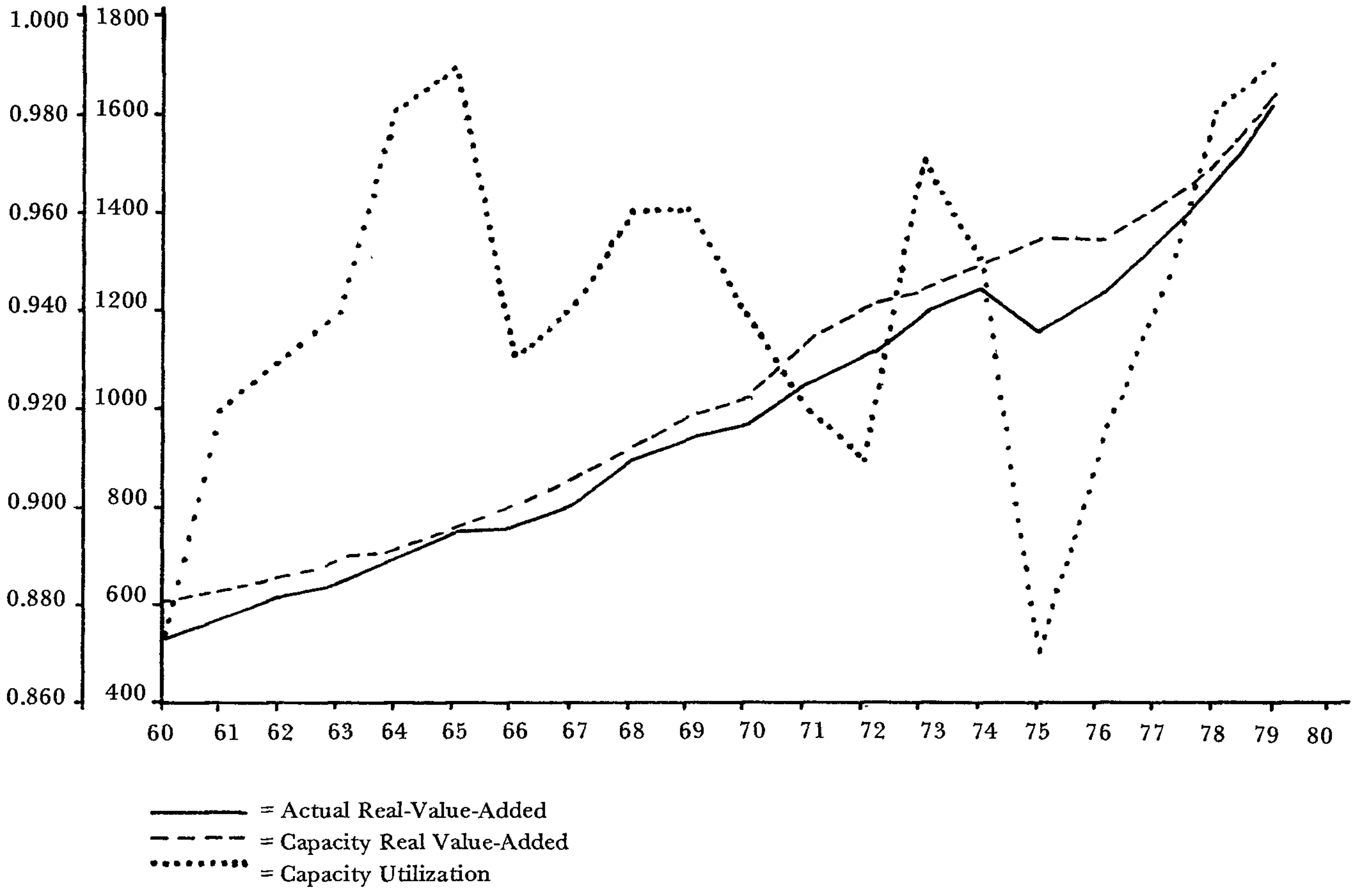
Specification and Validation

In attempting to operationalise the scheme of the industrial sector, outlined in Figure 4.1 above, our specification breaks down into essentially three parts: the determination of long-run desired output, O_I^*; the determination of the long-run capacity capital stock and the determination of the technology facing the industrial sector; and the determination of the short-run manning and capital utilisation levels. We now turn to the empirical examination of each of these three areas in turn.

Long-Run Desired Output: O_I^*

In Chapter 3 we considered two approaches to measuring long-run capacity output: one based on a theoretical system of interrelated factor demand equations and the other more empirical "linked-peaks" method. In order to

Figure 4.2: *Industrial output, capacity output and capacity utilisation*



make a start at modelling long-run capacity output, $O_I{}^*$, we make the assumption for the within-sample period, that the linked-peaks measure of industrial sector capacity output,[45] $OCAP_I$, is a measure of $O_I{}^*$. While such an assumption is somewhat arbitrary, there is, nevertheless, a plausible connection between the empirical capacity measure and the unobservable $O_I{}^*$. It may be reasonable to expect $O_I{}^*$ to be bounded below by $OCAP_I$. However, at periods of peak capacity it is questionable whether $O_I{}^*$ coincides with $OCAP_I$. Our identification of the two variables essentially imposes such an equality, and at such peaks, actual output (O_I), capacity output ($OCAP_I$) and long-run capacity output ($O_I{}^*$) all coincide. To summarise, we construct an empirical measure of capacity utilisation (CUR_I) and define industrial sector capacity output as

$$OCAP_I = O_I/CUR_I$$

where O_I is actual industrial output. We then take $OCAP_I$ as a proxy for $O_I{}^*$. In Figure 4.2 we graph O_I and $OCAP_I$ over time.

In Table 4.2.1 we present a variety of estimations of a relationship determining $OCAP_I$ as a function of three sets of explanatory variables:

(i) Gross domestic absorption, weighted by industrial output content, i.e., private and public consumption, total fixed investment and total inventory investment ($GDAO_I$).
(ii) An index of the volume of world exports of manufactured goods, XWM.
(iii) A relative price measure of domestic industrial gross output prices (PQ_I) relative to the price of imported manufactured goods (PMG).

As expected, it proved impossible with this aggregate approach to obtain relative price (or relative profitability) effects. Such effects are obviously present in the short term, and at the micro level, particularly if the concept of "price" is generalised to include aspects of quality, delivery, reliability, etc.[46] Further investigation, using international profitability measures, is obviously merited in this area.

Since we expect $OCAP_I$ to be relatively impervious to short-run fluctuations in domestic absorption and world trade, we estimate, in Equation 2,

45. The actual empirical measure of capacity utilisation used is constructed by annualising the quarterly data of O'Reilly and Nolan (1977) suitably updated for the manufacturing industry subset of the entire industrial sector.

46. Gregory (1971) elaborates on this idea in the context of imports determination, one aspect of Figure 4.1.

Table 4.2.1: *Industrial capacity output, OLS regressions, 1962-1979*

1.	OICAP	$= \underset{(2.8)}{221.63} + \underset{(2.2)}{0.503}\ \text{GDAOI} + \underset{(5.5)}{6.516}\ \text{XWM}$
	$\bar{R}^2$	= 0.988 SER = 31.4 D.W. = 2.19
2.	OICAP	$= \underset{(0.8)}{63.54} + \underset{(4.6)}{1.017}\ (0.5\ \text{GDAOI} + 0.3\ \text{GDAOI}_{-1} + 0.2\ \text{GDAOI}_{-2})$
		$+ \underset{(3.7)}{4.201}\ (0.5\ \text{XWM} + 0.3\ \text{XWM}_{-1} + 0.2\ \text{XWM}_{-2})$
	$\bar{R}^2$	= 0.994 SER = 21.9 D.W. = 1.90
3.	OICAP	$= \underset{(1.3)}{138.54} + \underset{(2.8)}{0.853}\ (0.7\ \text{GDAOI}_{-1} + 0.3\ \text{GDAOI}_{-2})$
		$+ \underset{(3.2)}{5.258}\ (0.7\ \text{XWM}_{-1} + 0.3\ \text{XWM}_{-2})$
	$\bar{R}^2$	= 0.988 SER = 31.7 D.W. = 1.11

Notation:[a]

OICAP	=	Industrial sector capacity output (£m,75)
GDAOI	=	Gross domestic absorption weighted of industrial output content (£m,75)
XWM	=	Index of volume of world exports of manufactured goods (base 1975 = 100.0)

Note: a Notation used in all tables reporting empirical results is that used in computer data bank.

within a superimposed lag structure, assigning weights of 1/2, 3/10 and 1/5 to the current, lagged and double lagged explanatory variables. In Equation 3 we removed entirely the contemporaneous influence and imposed weights of 0.7 and 0.3 on the lag structure. From Equation 3, the elasticities (for 1975) are as follows:

$$\text{elasticity of OICAP with respect to } \text{GDAO}_{\text{I}}' = 0.55$$

$$\text{elasticity of OICAP with respect to XWM}' = 0.40$$

where the "prime" indicates the composite lagged explanatory variable. However the equation suffers from autocorrelation and multicollinearity so these estimates may not be very reliable. To summarise, capacity output can be explained in terms of a distributed lag on weighted domestic absorption and world trade variables, with approximately equal elasticities. No relative price or relative profitability effects could be detected at this aggregate level. The serious econometric problems with using an interpolated variable as the dependent variable must be emphasised. More sophisticated lag structures could also be investigated.

Industrial Sector Technology and Long-Run Factor Demands

Since the data available obliged us to use only two factor inputs (capital and labour) and a value-added measure of output, an obvious initial choice of production function is the CES. This has the advantage over the Cobb-Douglas function of not imposing a unitary elasticity of substitution and permits a slightly more flexible approach to handling technical progress. Nevertheless, it is still quite restrictive in that it imposes a *constant* elasticity of substitution.

The CES function can be written as follows (dropping the "I" subscript for convenience):

$$O^* = A[\delta(\exp(\lambda_L t)\, L^*)^{-\rho} + (1-\delta)\,(\exp(\lambda_K t)K^{*-\rho}]^{-\mu/\rho} \qquad (4.2.15)$$

where A is a scale parameter, δ is the labour intensity parameter (defined on $0 < \delta < 1$), μ is the degree of homogeneity of the production function (or returns to scale parameter) and ρ is related to the (constant) elasticity of substitution (σ) by

$$\sigma = \frac{1}{1+\rho}$$

If it is now assumed that the long-run capacity inputs of labour (L^*) and capital (K^*) are chosen so as to minimise the cost of producing expected capacity output (O^*) in long-run equilibrium, then by the results in Appendix 3.1:[47]

$$\log\left(\frac{K^*}{L^*}\right) = \log\left(\frac{1-\delta}{\delta}\right)^{\sigma} + \sigma\log\left(\frac{w^*}{c^*}\right) + (1-\sigma)(\lambda_L - \lambda_K)t \qquad (4.2.16)$$

Hence, the optimal factor proportions in long-run equilibrium will be determined by two variables:

(i) the expected long-run relative factor price, w^*/c^*, denoted hence-

47. Boyle and Sloane (1982) use the more general translog production function with three factor inputs — capital, wage earners and salary earners — and data disaggregated by 40 CIP manufacturing industries. However, for the aggregate labour input, they obtain results for the elasticity of substitution which are virtually identical to the CES case shown in Equation (4.2.16). However, Higgins (1981) using a KLEM translog function for three sectors of the Irish food industry, found that the hypothesis of CES technology is rejected.

forth as RFP*,

(ii) the bias in technological progress, $\lambda_L - \lambda_K$.

Solving (4.2.15) and (4.2.16) for K* yields the long-run demand for capital, and is of form:

$$\log K^* = -\frac{1}{\mu}\log A + \frac{\sigma}{1-\sigma}\log(1-\delta) + \frac{1}{\mu}\log O^* \tag{4.2.17}$$

$$+\frac{\sigma}{1-\sigma}\log\left\{\left(\frac{\delta}{1-\delta}\right)^{\sigma} RFP^{*(1-\sigma)}\exp[(\sigma-1)(\lambda_L-\lambda_K)t] + 1\right\} - \lambda_K t$$

with a corresponding long-run demand for labour equation of form:

$$\log L^* = -\frac{1}{\mu}\log A + \frac{\sigma}{1-\sigma}\log\delta + \frac{1}{\mu}\log O^* \tag{4.2.18}$$

$$+\frac{\sigma}{1-\sigma}\log\left\{\left(\frac{\delta}{1-\delta}\right)^{-\sigma} RFP^{*-(1-\sigma)}\exp[-(\sigma-1)(\lambda_L-\lambda_K)t] + 1\right\} - \lambda_L t$$

Clearly, Equations (4.2.17) and (4.2.18) are highly non-linear both in the variables

O*, RFP* and t

and the production function parameters

δ, σ, λ_L, λ_K, A and μ.

Furthermore, the same production function parameters occur in both equations, thus implying cross-equation constraints.

Any empirical analysis requires, of course, measures of the long-run variables O*, L*, K* and RFP*. In the estimation we have used the following empirical proxies for these unobservable variables:

O* = Linked peaks capacity output

K* = Four year moving average of actual capital stock (generated assuming a fixed depreciation rate of 5 per cent (refer data appendix)).

L* = Four year moving average of actual employment (refer data appendix).

$RFP^* =$ W^*/UCC^* where, following Ruane (1982) and Flynn and Honohan (1982), we have defined the user cost of capital, UCC, as follows:

$$UCC = PIF^* \, (0.02(1-\tau\theta-\Psi) + 0.05)/(1-\tau)$$

where PIF = Fixed industrial investment deflator (base 1975 = 1.0)
τ = Rate of corporate income tax
θ = Initial depreciation allowance
Ψ = Capital grant rate

and a constant real rate of interest of 2 per cent and a fixed depreciation rate of 5 per cent are assumed. Defining the cost of labour relative to capital as RFP (relative factor price), we have used a three year weighted average[48] to proxy RFP*, i.e.,

$$RFP^* = \frac{(0.75 \, RFP + 0.75^2 \, RFP_{-1} + 0.75^3 \, RFP_{-2})}{(0.75 + 0.75^2 + 0.75^3)}$$

Free estimation of the underlying production function parameters by means of Equations (4.2.17) and (4.2.18) is theoretically possible using a technique such as non-linear Full Information Maximum Likelihood (FIML). In practice such an approach failed to converge to reasonable values. An alternative less computationally onerous approach was used, as follows:

(i) the long-run factor-proportions (or expansion path) relation (4.2.16) was estimated (using OLS), to obtain values of the parameters σ, δ and $(\lambda_L - \lambda_K)$, i.e., the elasticity of substitution, the labour intensity parameter and the *bias* of technical progress, and

(ii) these values of δ, σ and $(\lambda_L - \lambda_K)$ were imposed on the long-run factor demand relations and the remaining parameters estimated using FIML.

48. A similar approach is used by Ando *et al.* (1974) who suggest the weight 0.75. Obviously different weights could be selected. The estimates are fairly robust with respect to these weights.

The estimation results were as follows:

Table 4.2.2: *Long-run factor proportions, OLS regressions, selected periods 1963-1979*

$$\log \left(\frac{K}{L}\right)^* = a_0 + a_1 \log RFP^* + a_2 t$$

Period	a_0	a_1	a_2	$\bar{R}^2$	*D.W.*	δ	σ	$\lambda_L - \lambda_K$
1963-79	0.602	0.283	0.060	.999	1.36	0.1065	0.283	0.0833
	(11.0)	(4.2)	(25.4)					
1965-79	0.610	0.290	0.050	.999	0.82	0.1089	0.290	0.0837
	(13.4)	(4.8)	(29.8)					
1969-79	0.616	0.301	0.059	.999	0.73	0.1148	0.301	0.0846
	(8.9)	(2.5)	(19.5)					
1971-79	0.662	0.416	0.057	.997	0.63	0.1695	0.416	0.0978
	(5.6)	(1.6)	(10.9)					
1973-79	0.857	1.057	0.048	.999	2.07	–	1.057	–
	(8.1)	(3.9)	(10.2)					

Clearly, the above statistical estimates should be treated with caution and the t-ratios and Durbin-Watson statistics have only a very limited applicability given the derived nature of the data used. Rather than regarding it as a hypothesis-testing method, it should be looked on as merely a way of finding "reasonable" values for the CES parameters under the maintained hypothesis of a CES technology. The underlying parameter values of δ, σ and the technology bias ($\lambda_L - \lambda_K$) are fairly robust when the 1960s and 1970s are included. If the 1960s data are deleted, the value of σ rises slightly. With these caveats, and further experimentation, the data indicate[49] that

(i) the elasticity of substitution between capital and labour is low, and probably in the range

$$0.3 \leqslant \sigma \leqslant 0.4$$

(ii) technical progress over the period 1962-1979 has been non-neutral and biased in a labour saving direction.

49. A recent study by Kalt (1978) for the aggregate US private economy found a value of σ of 0.76, and $\lambda_L - \lambda_K = 0.02$. Hence, while the US economy was not characterised by a Cobb-Douglas ($\sigma = 1$) technology nor a Leontief fixed coefficients technology ($\sigma = 0$), nevertheless a value of $\sigma = 0.76$ implied substantial response of factor proportions to relative factor prices. Glass (1971/72) in his study of GB and Northern Ireland engineering industry found σ_{UK} in the range 0.3 to 0.7 and σ_{NI} in the range 0.3 to 0.4. Katz (1969) in his study of Argentinian industrial growth found values of σ in the range 0.16 to 0.48.

Taking the results for 1965, we find that

$$\sigma = 0.29 \text{ and } \lambda_L - \lambda_K = 0.08.$$

The above empirical findings are similar to those of Katz (1969) in his study of Argentinian industrialisation. For example, they are consistent with a view of Ireland as a small open economy importing the technology necessary for industrial development. The technology thus imported is largely designed in industrial countries in response to *their* need for factor substitution. In imitating and importing foreign production techniques, the resulting factor proportions may not necessarily be reconciled with Irish domestic factor price relations. The fact that labour intensive industries do not characterise the Irish industrial sector could be the result of the non-availability of such technology in internationally mobile investment or simply a conscious decision on the part of foreign industrialists to avoid possible future problems with labour intensive plants. Further disaggregated empirical and theoretical research is needed to explore these complex issues.

We turn now to the determination of the remaining CES production function parameters: A, μ and λ_L. These must be estimated in such a way as to impose a unique technology on the two factor demand equations (4.2.17) and (4.2.18). Given values of δ, σ and $(\lambda_L - \lambda_K)$ (obtained from the factor proportions relationship), these equations can be transformed into the following form:

$$\begin{aligned} X &= -\frac{1}{\mu}\log A + \frac{1}{\mu}\log O^* - \lambda_L t \\ Y &= -\frac{1}{\mu}\log A + \frac{1}{\mu}\log O^* - \lambda_L t \end{aligned} \qquad (4.2.19)$$

where X and Y are complicated (but known) variables, being functions of σ, δ, $(\lambda_L - \lambda_K)$ and RFP* and t. FIML was used to estimate the system (4.2.19) for two cases: CRS ($\mu = 1$) and non-CRS (μ freely estimated). The results were as follows:

Table 4.2.3: *Factor demand systems, FIML regressions, 1965-1979*

	A	μ	λ_L	λ_K	$\bar{R}^2$	*SER*	*DW*
CRS	1.1689	1.0000	0.049	−0.034	0.98	0.025	0.8
	(5.5)	—	(32.9)	—	0.98	0.028	0.8
NCRS	$2.87 \; 10^{-4}$	2.42	0.019	−0.065	0.81	0.0088	1.2
	(9.9)	(6.9)	(3.2)	—	0.55	0.0144	0.8

Once again, the statistics are of dubious significance since the data are of a derived nature and the CRS and NCRS results ($\bar{R}^2$) cannot be directly compared.

In the CRS case, technical progress is labour saving (at 5 per cent p.a.) and capital using (at 3 per cent p.a.). In the NCRS case, the returns to scale were 2.4, and technical progress was labour saving (at 2 per cent p.a.) and capital using (at 6 per cent p.a.).

The above results can be interpreted in the light of the more disaggregated results of Boyle and Sloane (1982), who examined these issues using a dual approach with a translog production function. They also found that technical progress was labour saving and that relaxing the assumption of Hicks neutrality reduced the estimates of the elasticity of substitution. Higgins (1981), in a study of three food industries (bacon, meat processing and dairy processing) found technical change to be labour using, neutral and labour saving, respectively. Boyle (1981), in an aggregate study of the agriculture sector, also found technical change to be labour saving and capital (and materials) using. Boyle also cautions on the possible interactions between returns to scale (μ) and technical change (λ_L, λ_K), an example of which is illustrated in Table 4.2.3 above. A full investigation of these issues would require both time-series and cross-section data and is not attempted here.

The above approach was based on a putty-putty technology and involved the simultaneous estimation of the system of long-run factor demands. In the theory section above we described a heuristic putty-clay model where Equation (4.2.17) was used to determine the long-run demand for capital but the actual demand for labour is derived by simply inverting the CES production function. An empirical implementation of the heuristic putty-clay approach essentially involves recovering *all* the CES production function parameters from the single long-run capital demand Equation (4.2.17). As an example, if we assume neutral technical change ($\lambda_L - \lambda_K = 0$) and CRS ($\mu = 1$), Equation (4.2.17) becomes

$$\log\left(\frac{K^*}{O^*}\right) = -\log A + \left(\frac{\sigma}{1-\sigma}\right)\log(1-\delta) + \left(\frac{\sigma}{1=\sigma}\right)\log \left\{\left(\frac{\delta}{1-\delta}\right)^{\sigma} RFP^{*(1-\sigma)} + 1\right\} - \lambda_K t \qquad (4.2.20)$$

i.e., the four parameters A, σ, δ and λ_K have to be recovered. Attempts to use non-linear maximum likelihood estimation procedures failed to converge to sensible values. Besides the obviously difficult computation problems, Equation (4.2.20) may be under-identified, a matter which is difficult to check analytically due to the parameter non-linearities involved.

For the simpler Cobb-Douglas technology, the capital demand equation may be written as

$$\log K^* = \text{constant} + \left(\frac{\beta}{\alpha+\beta}\right) \log RFP^* + \frac{1}{(\alpha+\beta)} \log O^* - \frac{\gamma}{(1+\gamma)}\, t$$

and yielded the following estimation results:

Table 4.2.4: *Cobb-Douglas capital demand, OLS regressions, 1962-1979*

$$\log K^* = \underset{(4.8)}{4.24} + \underset{(1.7)}{0.156} \log RFP^* + \underset{(2.3)}{0.302} \log O^* + \underset{(12.8)}{0.062}\, t$$

$\bar{R}^2 = 0.999$ SER $= 0.0124$ D.W. $= 1.39$

However, the implied CD parameters are implausible (i.e., $\alpha = 2.80$, $\beta = 0.52$, $\gamma = -0.205$).

Hence, although conceptually attractive, it would appear to be difficult to implement the heuristic putty-clay approach at our level of aggregation.

A deeper investigation of the issues raised above is obviously necessary, but is difficult to carry out within the very aggregate macro-framework we are using. However, the main features of such work must include the following:

(a) use of both time-series and cross-section data;
(b) greater disaggregation along the lines of the Census of Industrial Production (CIP), previously used by Boyle and Sloane (1982);
(c) generalisation to a wider range of production functions;
(d) generalisation to more than a two-factor technology;
(e) a more specific implementation of the putty-clay approach, along the lines advocated by d'Alcantara and Italianer (1982) and implemented for Irish data by Bradley and Wynne (1983).

Short-Run Manning and Capital Utilisation Levels

Above we presented estimates of long-run capacity or equilibrium factor demands in terms of empirical proxies for the unobservable variables K* and L*. We now turn to the process of converting these long-run relations into relations which determine short-run actual (or observed) employment and capital usage measures.

We first consider a situation where a fairly simple adjustment mechanism is used to relate long-run and observed values. We then attempt a simple empirical implementation of the model developed in the theory section where the long-run demand for capital, K*, is separated from the short-run capacity utilisation and manning decisions.

The following three concepts are needed in what follows, where we use the variable Z to represent both K and L.

Z_t^D = the desired level of variable Z in period t.

Z_t^* = long-run full capacity level of Z.

Z_t = the actual (or observed) level of variable Z in period t.

The passage from the desired level to the actual level depends on the extent to which economic agents can (and will) adjust their actual behaviour towards desired levels.

A very general adjustment mechanism is the error-correction (ECM) which is of form:

$$\Delta Z_t = k_1 \, \Delta Z_t^D + k_2 \, (Z_{t-1}^D - Z_{t-1}) + \mu_t$$

Here, the first term on the right hand side represents the short-term or immediate response to changes in the desired level, the second term represents an adjustment in a disequilibrium situation, and the last term is a stochastic error term. If we further assume that the passage from Z^D (the desired level) to the long-run full capacity level (Z^*) is sensitive to the existing rate of capacity utilisation (i.e., low utilisation slows movement to equilibrium, we can write

$$Z_t^D = \Psi \log CUR + Z_t^* \tag{4.2.21}$$

Combining equations (4.2.20) and (4.2.21) together yields

$$\begin{aligned} \Delta Z_t = {} & k_1 [Z_t^* - Z_{t-1}^*] + k_2 [Z_{t-1}^* - Z_{t-1}] \\ & + k_1 \, \Psi \log CUR_t + (k_2 - k_1) \, \Psi \log CUR_{t-1} + \mu_t \end{aligned} \tag{4.2.22}$$

Using the values of Z_t^* predicted on the basis of one of the long-run factor demand models above allows direct estimation of Equation (4.2.22). Alternatively, of course, the long- and short-run processes could be combined in one equation and the unobservable, Z*, eliminated, a procedure which is adopted in the work of Hickman and Coen (1976). Since we wish to examine the long-run technology explicitly, we adopt the former route, and present below statistical estimates for the Equation (4.2.22) for the two cases:

$$Z = \log L_I \text{ and } Z = \log K_I$$

Table 4.2.5: *Short-run factor adjustments, OLS regressions, selected periods, 1963-1979*

Dept. variable	*Period*	k_1	k_2	Ψ	$\bar{R}^2$	*D.W.*	*RHO*
Δlog LI	1963-59	0.75754 (4.5)	0.87075 (3.5)	0.59964 (6.9)	0.602	1.54	–
Δlog KI	1963-79	0.82403 (14.1)	0.66707 (4.8)	0.30103 (3.0)	0.286	0.86	–
Δlog KI	1963-79	0.77601 (10.4)	0.63436 (5.1)	0.21477 (2.4)	0.222	1.83	0.6685

The estimation results are broadly in line with expectations. For example, the elasticity, Ψ, of desired labour input (L_I^D) with respect to capacity utilisation (CUR_I) is larger than the corresponding elasticity of desired capital input (0.6 and 0.2, respectively, for the period 1963-1979). Hence, it would appear that long-run capacity investment plans are modified in the light of short-run conditions by less than the changes made to the parallel long-run employment plans.

In order to interpret the parameters k_1 and k_2, it is useful to give the ECM adjustment process an optimal control interpretation. Equation (4.2.22) states that present factor inputs equal to previous periods inputs adjusted for

(i) changes in desired inputs (the "differential control mechanism") modelled by the term

$$k_1 \Delta Z_t^D$$

and

(ii) corrections to errors made in the preceding period (the "proportional control mechanism") modelled by the term

$$k_2 (Z_{t-1}^D - Z_{t-1})$$

From Table 4.2.5 it is clear that the differential control mechanism (k_1) operates in a similar way for labour and capital inputs, but that the proportional control mechanism (k_2) has a more important role for labour. For example, for the 1963-79 period the values are

	k_1	k_2
Labour	0.76	0.87
Capital	0.78	0.63

What these equations provide is an explicit link between the actual observed factor inputs and the long-run optimal factor inputs. These adjustment processes are independent and have been estimated directly using the observed data and the explicit proxies for L* and K*. If the long-run factor demand system and the short-run adjustment equations are to be used simultaneously, then either of the following courses could be followed:

(i) a single short-run disequilibrium factor demand system could be estimated

or

(ii) the values generated by the long-run factor demand system (L* and K*), estimated separately, could be used to estimate separate short-run ECM adjustment mechanisms.

An Alternative Approach to Short-Run Decisions

Turning now to an alternative approach to short-run decisions, as discussed in the theory section, the demand for capital and labour can be considered as two separate decision processes, the second of which involves capital stock utilisation and manning based on short-run profit maximisation. In Table 4.2.6 we present a range of estimates of the labour demand function while in Table 4.2.7 we present estimations of the utilised capital stock equation. In arriving at a measure of "utilised" capital stock, as distinct from total installed capital stock, K, we have assumed that the rate of capacity utilisation on an output basis (i.e., linked peaks method) is the same as the rate of utilisation on a capital stock basis.[50] Such an assumption is plausible in a situation of excess supply of labour and deficient supply of capital. It is clear

50. O'Reilly and Nolan (1979) attempt the direct measurement of utilisation of the capital stock of manufacturing industry by assuming that the capital stock is totally electrically based, or at least that the variation in utilisation of total capital stock is the same as that of the electrically-based capital stock.

from these results that the price terms do not play any role in the short-run determination of L and KU. The preferred equation in each case is Equation 3 (corrected for autocorrelation in Equation 5). In addition, a simple partial adjustment version (Equation 4) also provides a good fit. From Equation 5 one has the following:

Elasticity of L with respect to O = 0.319
Elasticity of KU and (CUR) with respect to O = 1.517

Hence, in the short run, changes in output have a small effect on employ-

Table 4.2.6: *Industrial employment, OLS regressions, 1962-1979*

1. $$\log LI = \underset{(3.5)}{3.133} + \underset{(2.6)}{0.389} \log OI + \underset{(0.3)}{0.054} \log \left(\frac{WI}{POI}\right) - \underset{(0.9)}{0.0062}\, t$$
$\bar{R}^2 = 0.953$ SER = 0.020 D.W. = 1.48

2. $$\log LI = \underset{(0.5)}{0.616} + \underset{(3.5)}{0.449} \log OI - \underset{(0.3)}{0.049} \left(\frac{WI}{POI}\right) - \underset{(1.9)}{0.012}\, t + \underset{(2.7)}{0.401} \log LI_{-1}$$
$\bar{R}^2 = 0.967$ SER = 0.017 D.W. = 1.92

3. $$\log LI = \underset{(31.6)}{3.574} + \underset{(19.2)}{0.315} \log OI$$
$\bar{R}^2 = 0.956$ SER = 0.019 D.W. = 1.44

4. $$\log LI = \underset{(5.3)}{2.710} + \underset{(5.0)}{0.237} \log OI + \underset{(1.7)}{0.245} \log LI_{-1}$$
$\bar{R}^2 = 0.961$ SER = 0.018 D.W. = 1.83

5. $$\log LI = \underset{(25.3)}{3.543} + \underset{(15.7)}{0.319} \log OI$$
$\bar{R}^2 = 0.936$ SER = 0.0186 D.W. = 1.72 RHO = 0.2752

Notation:
- LI = Numbers employed in industry ('000)
- OI = Output of industry (£m,75)
- WI = Average annual earnings in industry (£K p.a.)
- POI = Deflator of OI (base 1975 = 1.0)
- t = time (1953 = 1.0)

Table 4.2.7: *Utilised industrial capital stock, OLS regressions, 1962-1979*

1. $$\log KFIU = \underset{(1.0)}{1.112} + \underset{(3.9)}{0.785} \log OI - \underset{(0.4)}{0.010} \log \left(\frac{PM3}{POI}\right) + \underset{(3.9)}{0.044}\, t$$

$\bar{R}^2 = 0.996$ SER = 0.030 D.W. = 1.01

2. $$\log KFIU = \underset{(0.3)}{0.358} + \underset{(3.5)}{0.699} \log OI - \underset{(-0.0)}{0.0007} \log \left(\frac{PM3}{POI}\right) + \underset{(1.9)}{0.029} t + \underset{(1.5)}{0.225} \log KFIU_{-1}$$

$\bar{R}^2 = 0.996$ SER = 0.029 D.W. = 1.44

3. $$\log KFIU = \underset{(14.2)}{-3.649} + \underset{(43.0)}{1.594} \log OI$$

$\bar{R}^2 = 0.991$ SER = 0.044 D.W. = 0.83

4. $$\log KFIU = \underset{(3.8)}{-1.857} + \underset{(4.5)}{0.852} \log OI + \underset{(3.9)}{0.459} \log KFIU_{-1}$$

$\bar{R}^2 = 0.995$ SER = 0.032 D.W. = 1.38

5. $$\log KFIU = \underset{(8.4)}{-3.520} + \underset{(26.1)}{1.571} \log OI$$

$\bar{R}^2 = 0.976$ SER = 0.036 D.W. = 1.42 RHO = 0.6275

Notation:

KFIU	=	Utilised capital stock (£m, 75)
OI	=	Industrial Output (£m, 75)
PM3	=	Import unit value for fuel (base 1975 = 1.0)
POI	=	Deflator of OI (base 1975 = 1.0)
t	=	time (1953 = 1.0)

ment, but a much larger effect on capacity utilisation. This would be consistent with a situation where labour is either hoarded or underutilised during cyclical "lows", but excess capacity is available to deal with cyclical "highs". However, a deeper examination of the issues involved would require more disaggregated data.[51]

Finally, in Table 4.2.8 we present statistical estimates for the direct empirical approach to modelling capacity utilisation, based on the model of Behrman (1977). Rising unit wage costs cause a fall in utilisation, as do rising

51. Bowers and Deaton (1980) deal with the issue of the measurement of labour hoarding.

inventory levels per unit of output. Demand expansion causes a rise in utilisation. The results in Table 4.2.8 are only intended to be indicative of the empirical approach. Before such an equation could be safely used, the implications of the magnitudes of the coefficients would have to be examined. Also, the linear functional form may not be appropriate since a rise in demand (say) from a low base might have different effects to a rise in demand when the level of activity is already high (i.e., when CUR is near unity).

Conclusion — Industry

We now summarise our empirical examination of the aggregate industrial sector and its relationship to our theoretical discussion. We approached the operationalisation of the scheme of Figure 4.1 by assuming that long-run capacity output, O*, was proxied by an empirical measure of capacity output, OCAP. While the evolution of O* could be explained in terms of

Table 4.2.8: *Industrial sector capacity utilisation, OLS regressions, 1962 to 1979*

1.
$$\text{CURI} = \underset{(8.2)}{1.333} - \underset{(2.4)}{0.843}\,\frac{\text{KII}}{\text{OI}}$$
$\bar{R}^2 = 0.214$ SER = 0.028 D.W. = 1.32

2.
$$\text{CURI} = \underset{(79.2)}{0.915} + \underset{(3.1)}{0.00556}\,\text{DEM}$$
$\bar{R}^2 = 0.339$ SER = 0.025 D.W. = 1.22

3.
$$\text{CURI} = \underset{(6.5)}{1.130} - \underset{(1.2)}{0.454}\,\frac{\text{KII}}{\text{OI}} + \underset{(2.2)}{0.00434}\,\text{DEM}$$
$\bar{R}^2 = 0.360$ SER = 0.025 D.W. = 1.30

4.
$$\text{CURI} = \underset{(6.9)}{1.175} - \underset{(2.9)}{0.886}\,\frac{\text{WCI}}{\text{POI}} + \underset{(2.7)}{0.400}\,\frac{\text{UCCI}}{\text{POI}}$$
$\bar{R}^2 = 0.304$ SER = 0.0261 D.W. = 1.57

Notation:

CURI = Linked-peaks measure of capacity utilisation in industrial sector
WCI = Wage costs in industry
POI = Deflator of value-added in industry
KII = Stock levels in industry (£m, 75)
OI = Value added in industry (£m, 75)
DEM = Percentage change in gross final demand.
UCCI = User cost of capital in industry

distributed lags on domestic absorption and world trade, no relative profitability or price effects could be detected. Hence, the relationship will be insensitive to policy measures which alter relative profitability and prices in the short term (e.g., corporate profits tax changes, exchange rate policy changes, etc.). At such a high level of aggregation it appears difficult to explore the determinants of the parameters of the relationship.

Assuming long-run cost-minimisation in the production of O*, a CES technology was used to explore the long-run factor demand system. For example, using a CES technology, a putty-putty model of capital stock, and non-neutral technical change, the elasticity of substitution between capital and labour was found to be considerably less than unity.

The short-run, or observed, factor demands were approached in two ways. First, an ECM adjustment mechanism was used to capture the adjustment processes involved in mediating between the long and short run. Then a separate short-run determination of employment and capital stock utilisation was explored (against the background of a long-run demand for capital relation). In these short-run relations, no significant factor price terms were found and employment and utilisation could be explained in terms of actual output alone.

Finally, an empirically-based model of capacity utilisation was estimated with some success, but requiring further investigation. Hence, at the level of aggregation being used, a fairly "degenerate" version of the scheme of Figure 4.1 emerges. The long-run scale of industrial production is driven by the expected domestic and foreign demand. The long-run factor proportions involved in the production process are sensitive to the domestic factor price ratio, but the CES technology has a low elasticity of substitution (0.3). The short-run employment and utilisation decisions are also insensitive to the price of labour and the operating cost of capital.

III. *AGRICULTURE*

A recent survey of macro models of the Irish economy (Fanning and Bradley, 1982) examined 19 models and in only two, Walsh (1966) and Fanning (1979), was any attempt made to model the behaviour of the agricultural sector. Many explanations could be advanced for this, but the fact that the Irish experience has been shared in many other countries suggests that the explanations are not unique to Ireland (Roop and Zeitner, 1977, and Kost, 1981). There have been a number of sectoral studies, at various levels of detail and, before specifying a theoretical model of the agricultural sector, it is useful to examine the manner in which these economic/econometric studies of the agricultural sector have been executed. Such an examination serves to locate the purpose, scope and limitations of the agriculture modelling exercise being undertaken for this analysis of the economy.

Such studies may be conveniently grouped into the following five broad categories.

(i) Descriptive studies
(ii) Microeconomic studies of single commodities or groups of commodities
(iii) Macroeconomic studies at a sectoral level
(iv) Macroeconomic studies within the context of an economy-wide macro-model
(v) Planning models.

In Appendix 4.3 we present a brief review of studies of the agricultural sector classified along the above lines. Clearly, for our purposes, studies of type (iii) (macro studies at a sectoral level) and (iv) (macro studies within the context of economy-wide macro-models) are of most relevance. Our survey shows the very limited range of such previous studies in Ireland. The most informative study in our survey relates to an agricultural sector model developed by Heidhues (1976) for the German economy. Heidhue's model consists of a (Cobb-Douglas) production function and four factor inputs – labour, capital, land and material inputs. Given the structure of farm decision-making (even in the German economy!), a recursive system of estimation was used, where labour and capital adjustments are characterised by a high degree of caution, and long time lags with respect to changes in the agricultural environment. However, the joint determination of output and material inputs is characterised by a process of optimising behaviour (albeit an inefficient one) where agents react to price and quantity signals in a rational manner. It is in the spirit of Heidhue's study that we turn to our own analysis of the aggregate agricultural sector.

Theoretical Framework

Our objective is to construct a fairly aggregate model of the agricultural sector in such a way as to:

(i) test explicit economic hypotheses (or provide explanations) about the workings of the agricultural sector itself;
(ii) lay out a schema showing how the agricultural and non-agricultural sectors are interrelated.

In order to provide an initial structure to the problem, we assume that the agricultural sector displays the following three characteristics:

(i) farming enterprises are motivated by long-run profit maximisation or cost-minimisation;
(ii) farming enterprises are assumed to operate in a price-taking quantity adjusting output and input market structure;
(iii) there is some degree of factor substitutability in the agricultural production function (Boyle, 1981).

Hence, our assumptions are such as to ensure that motivation, market conditions and technical possibilities let individual farm enterprises react to price signals in a well-defined manner. For expository purposes, suppose there are only two factor inputs capital (K_A) and labour (L_A), and the production function is written as

$$O_A = f(K_A, L_A). \tag{4.3.1}$$

In Chapter 3 we showed that the assumption of profit maximisation leads to long-run factor demand and output equations of form

$$K_A = f(\tfrac{w}{p}, \tfrac{c}{p}) \tag{4.3.2a}$$

$$L_A = g(\tfrac{w}{p}, \tfrac{c}{p}) \tag{4.3.2b}$$

and

$$O_A = h(\tfrac{w}{p}, \tfrac{c}{p}) \tag{4.3.2c}$$

while cost minimisation (given an externally determined output level, O_A, leads to factor demand equations of form

$$K_A = f(O_A, \tfrac{w}{c}) \tag{4.3.3a}$$

$$L_A = g(O_A, \tfrac{w}{c}) \tag{4.3.3b}$$

For the agricultural sector, the annual census of agricultural production provides quite detailed data on gross output and factor inputs (feed, seed, fertiliser, labour, other materials, investment). On the one hand, this permits a gross approach to modelling (rather than the more restrictive value-added approach). However, the biological determinism involved in the agricultural sector raises complex issues which do not occur in the industrial sector, and which are best tackled at a highly disaggregated level. The purpose in setting up and estimating Neo-classical-type models of optimising behaviour for the agricultural sector is not so much to suggest a realistic theory of agricultural sector behaviour so much as to set up an illustrative framework. For example, one would be extremely sceptical of the likelihood of explaining demand for labour in Irish agriculture by equations such as those given above. Nevertheless, there may exist a subset of equations where behaviour is of an optimising kind which may be embedded in an overall framework. While it may be possible to seek such a structure in a formal way,[52] we make a very rough approximation along the following lines, guided by existing studies of agriculture in Ireland.

Demand for Labour

Given the structure of Irish farming it is probably unreasonable to attempt to explain agricultural employment as a derived factor demand in a simultaneous optimising framework. The development of the agricultural sector employment pattern should probably be looked at in terms of a developing dualistic economy.

The self-employment aspect, based on land ownership, of employment in agriculture means that a different approach from that pursued in the industry sector must be followed. Indeed, it is the reverse in that the starting point is the priority of employment in the decision process. Farmers do not fire and re-hire themselves. Yet the nature of the economic development process and, specifically, of agriculture within it, is such that the relatively slow growth of demand for agricultural output, combined with the growth of agricultural productivity due to investment and technological improvement, reduces the need for labour inputs. This increase in labour productivity is essential in a price-taking market to the maintenance or improvement in relative standard of living (Kennedy and Dowling, 1975, pp. 16-17). Agricultural employment is, therefore, modelled as a labour-release/migration-out function. Farmers who do not leave the farm are employed. The long-term factor permitting and encouraging the release of labour from agriculture is the growth of labour productivity or capital per worker. Out-migrants from agriculture must be absorbed into non-agricultural sector employment, emigrate abroad, remain unemployed, or leave the labour force entirely. Thus, in the short term relative wages and job availability affect the pace and timing of the decline of agricultural employment.[53] During periods when incomes are increasing (for instance, when relative agricultural prices have been increasing rapidly), there is less pressure to leave the land. When incomes are squeezed (due to price stabilisation or price falls), and with labour pro-

52. Brown and Christensen (1981) provide just such an approach.

53. The relationship between the income and demographic effects has been extensively studied by Walsh (1969) and (1971) who found that for young males, the movement from agriculture is greatest in counties characterised by low agricultural income.

ductivity growing, there is a shakeout of labour. This may be postponed or slowed down by the state of the non-agricultural sectors.[54]

The above considerations lead to an agricultural employment function of the general form

$$L_A = f(\underset{(-)}{\text{productivity}}, \underset{(+)}{\text{relative wages}}, \underset{(+)}{\text{global unemployment}}) \qquad (4.3.4)$$

i.e., employment is some function of productivity, the relative rural/urban wage and the unemployment rate. The signs under each term indicate the expected direction of each effect.

Land

A recent government report has pointed out that the land market in Ireland is "comparatively small, being of most importance to established farmers who wish to expand their holding" (quoted in Attwood, 1978). In addition, the fact that the overwhelming majority of new farmers acquire their land through inheritance may make the question of high land prices less relevant to farm production. Hence, in the production function, with the "volume" of land assumed roughly constant, the land variable is deleted from further consideration. Such an exclusion assumes that the inputs included in the production function (labour, capital, materials) as a group are weakly separable from the one excluded.[55]

Capital Stock, Material Inputs and Output (K_A, M_A, Q_A)

A schematic framework of the remainder of the agricultural sector is illustrated in Figure 4.3. In this framework we invoke the assumption of profit maximisation to determine the factor demands for capital stock ($K_A{}^*$) and material inputs (M_A^*), and the output decision function (Q_A^*). The asterisks are used to indicate "desired" values for these variables. An adjustment process (in which the weather plays an important role) finally produces the observed values K_A, M_A, and Q_A.

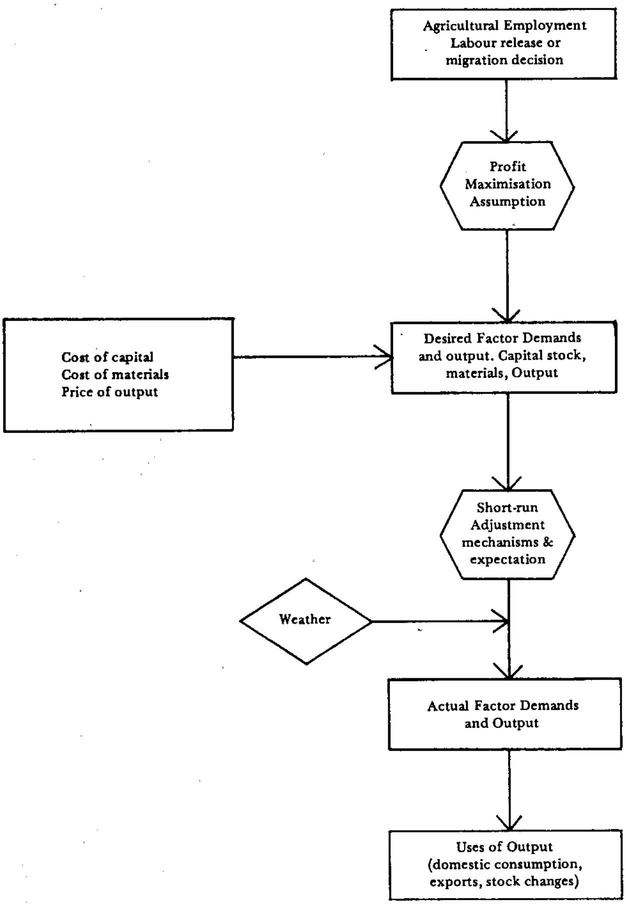
As an illustration of this process, consider a generalised Cobb-Douglas production function of form

$$Q_A^* = A \exp(\gamma t) K_A^{\alpha_1} L_A^{\alpha_2} M_A^{\alpha_3} \qquad (4.3.5)$$

54. A seminal study of the rural-urban migration process is the work of Harris and Todaro (1970). There, migration is made a positive function of the urban-rural expected wage differential (i.e., the difference between the urban wage, adjusted for the probability of finding work, and the agricultural wage).

55. Boyle (1981) makes a similar assumption.

Figure 4.3: *Schema for agricultural sectoral analysis.*



where γ is the rate of disembodied neutral technical progress. If employment, L_A, is determined recursively (in a non-optimising way), then profit maximisation yields the following factor demands and output equations:

$$\log K_A^* = b_0 + \frac{\gamma}{1-\alpha_1-\alpha_3} t - \frac{1-\alpha_3}{1-\alpha_1-\alpha_3} \log \left(\frac{\bar{c}}{p}\right)^* - \frac{\alpha_3}{1-\alpha_1-\alpha_3} \log \left(\frac{\bar{m}}{p}\right)^* \quad (4.3.6a)$$

$$+ \frac{\alpha_2}{1-\alpha_1-\alpha_3} \log \bar{L}_A$$

$$\log M_A^* = b_1 + \frac{\gamma}{1-\alpha_1-\alpha_3} t - \frac{\alpha_1}{1-\alpha_1-\alpha_3} \log (\frac{\bar{c}}{p})^* - \frac{1-\alpha_1}{1-\alpha_1-\alpha_3} \log (\frac{\bar{m}}{p})^* \quad (4.3.6b)$$

$$+ \frac{\alpha_2}{1-\alpha_1-\alpha_3} \log \bar{L}_A$$

$$\log Q_A^* = b_2 + \frac{\gamma}{1-\alpha_1-\alpha_3} t - \frac{\alpha_1}{1-\alpha_1-\alpha_3} \log (\frac{\bar{c}}{p})^* - \frac{\alpha_3}{1-\alpha_1-\alpha_3} \log (\frac{\bar{m}}{p})^* \quad (4.3.6c)$$

$$+ \frac{\alpha_2}{1-\alpha_1-\alpha_3} \log \bar{L}_A$$

where c, m, and p represent the prices of capital, materials and output, respectively. The above is a simple illustration of a framework where one has a multi-factor production technology but where not all the factors are estimated as derived demands in a simultaneous optimising system. In the case of profit maximisation, the demand for some of the factors and output are endogenised where the remaining factors are either exogenous or fixed (in the case of land) or are determined by a pre-recursive process (in the case of labour).

The investment function in agriculture is a particularly difficult one to specify behaviourally. Not only is the investment decision and process in agriculture largely unexamined but there are two particular features that have to be accounted for. First, the major part of any total measure of capital stock in agriculture consists of cattle stocks which may be subject to substantial downward variation over a fairly short period of time. Farmers seem to be prepared to get out of cattle fairly quickly. We ignore this element in our subsequent work. Second, the more limited fixed asset investment (comprising building and machinery and land improvement, including drainage) is almost entirely government funded and influenced.

Our approach to modelling the agricultural sector is based on a supply-driven process, in contrast to the industry sector in which output is demand determined. We characterise a supply-driven sector by a central sequence from given and fully employed (even if not fully utilised in the sense of maximum hours operated) labour, capital and material inputs, to output via the production function and then to uses of output. The basis for this approach is the stylised view of the agriculture sector as essentially comprising family farming and self-employed units.[56] In addition, we study

56. Hired labour constituted 23.1 per cent of total agricultural employment in 1960, falling to 12.4 per cent in 1979.

only total real agricultural output and not its composition. The presumption here is that the determination of agricultural output can be dichotomised into, first, a total output decision and, second, a portfolio decision whereby the specific composition of that output is determined. The latter stage would, of course, be an essential element of any comprehensive model of the agriculture sector. By including a comprehensive, if highly aggregative, agricultural sector in the study, important links which affect the overall state of the economy are endogenised. Agriculture is a major net contributor to the trade balance. Furthermore, an important and truly exogenous, element of uncertainty – weather variation – is included and can substantially affect the outcome of the agriculture sector and thereby the remainder of the economy. Thus, not only the trade balance but also farmers' incomes, and hence domestic demand for consumption and investment goods, is affected. Agricultural prices, while left exogenous, obviously feed into farmers' incomes and they also feed into the cost of living of the non-agricultural sectors.

Specification and Validation

A schema for the agricultural sector[57] has been given in Figure 4.3. In attempting to operationalise this schema, certain data restrictions have to be borne in mind. First, although fairly detailed data on material inputs are available in nominal terms, published deflators are available only for farm material inputs. Second, the investment data for agriculture, forestry and fishing are not published in *National Income and Expenditure*, but have been assembled from UN and OECD publications and have been subject to changes and reclassifications.[58]

Our empirical investigation takes four parts:

(i) Agricultural employment determination
(ii) Agricultural investment in buildings and machinery
(iii) Material input usage
(iv) Agricultural output determination

Agricultural Employment

In Table 4.3.1 we exhibit results for agricultural employment, disaggregated into hired labour (LAH), self-employed (LASE) and for the total (LAFF). The estimates (which suffer from autocorrelation) are consistent with the

57. The term "agriculture" will be used to include forestry and fishing unless specifically stated otherwise.
58. Separate documentation of the agricultural sector data base is available in Reilly (1982).

expectations discussed in the theory section. A variable RAAD is designed to capture the relative advantage of working in the agricultural sector *vis-à-vis* the non-agricultural sector In the spirit of the Harris and Todero models of urban-rural migration, RAAD is the product of agricultural income per capita divided by the non-agricultural wage rate and the inverse of the global employment rate, i.e.,

$$\text{RAAD} = \frac{\text{Income per capita in agriculture}}{\text{Non-agricultural wage rate}} \quad \frac{*1.0}{(1\text{-UR}/100)} \tag{4.3.7}$$

The relative advantage variable, RAAD, is separated into its two component parts: relative earnings (RAW) and unemployment (UR).

From Equations 1 and 3, it is seen that the level of hired labour has been falling at about three times the rate of self-employed (i.e., -6.46 per cent as against -2.17 per cent). Taking the aggregate Equation 6, it is seen that a one per cent rise in trend agricultural productivity is associated with a 0.75 per cent fall in employment, while a one per cent rise in the relative wage variable is associated (*ceteris paribus*) with a 0.4 per cent rise in employment. The effect of high general unemployment is to slow the rate of decline in agricultural employment.

Agricultural Investment in Buildings and Machinery

In the scheme shown in Figure 4.3 the demand for capital and material inputs is the outcome of a process of profit mazimisation and is carried out with the imposition of a unique and consistent technology. However, attempts to carry out empirical estimations using Cobb-Douglas, CES, and bundled Cobb-Douglas and CES technologies did not yield plausible results, particularly in the case of demand for capital. Such a result was not surprising in the light of the findings of Boyle (1981) who, using a very general flexible functional form for the production function with five factor inputs, found no unique well-behaved technology over the same period 1953 to 1977. Consequently, we have formulated the investment equation for machinery, equipment and building, as a simple flexible accelerator model. In such a model, it is assumed that a desired capital stock, K*, exists, and that actual capital stock adjusts to desired stock by a parital adjustment mechanism:

$$K_t - K_{t-1} = (1-\lambda)(K^*_t - K_{t-1}) \tag{4.3.8}$$

Under the standard assumption that gross investment equals net investment

Table 4.3.1: *Agricultural employment, OLS regressions, 1963-1979*

(A) *Hired agricultural labour:*

1.
$$\log LAH = \underset{(135.4)}{4.96} - \underset{(34.5)}{0.0646}\, t$$
$$\bar{R}^2 = 0.987 \qquad SER = 0.0378 \qquad D.W. = 0.50$$

2.
$$\log LAH = \underset{(56.6)}{4.41} - \underset{(15.1)}{1.57} \log \overline{LPRA} + \underset{(2.6)}{0.546} \log \overline{RAW} + \underset{(3.0)}{0.047}\, UR$$
$$\bar{R}^2 = 0.984 \qquad SER = 0.041 \qquad D.W. = 0.72$$

(B) *Self-employed agricultural labour:*

3.
$$\log LASE = \underset{(288.3)}{5.83} - \underset{(21.0)}{0.0217}\, t$$
$$\bar{R}^2 = 0.965 \qquad SER = 0.021 \qquad D.W. = 0.52$$

4.
$$\log LASE = \underset{(261.5)}{5.69} - \underset{(19.5)}{0.563} \log \overline{LPRA} + \underset{(5.5)}{0.316} \log \overline{RAW} + \underset{(3.0)}{0.013}\, UR$$
$$\bar{R}^2 = 0.990 \qquad SER = 0.011 \qquad D.W. = 2.20$$

(C) *Total agricultural labour:*

5.
$$\log LAFF = \underset{(257.7)}{6.13} - \underset{(23.6)}{0.0286}\, t$$
$$\bar{R}^2 = 0.972 \qquad SER = 0.024 \qquad D.W. = 0.24$$

6.
$$\log LAFF = \underset{(224.2)}{5.94} - \underset{(21.2)}{0.746} \log \overline{LPRA} + \underset{(5.7)}{0.400} \log \overline{RAW} + \underset{(3.8)}{0.020}\, UR$$
$$\bar{R}^2 = 0.991 \qquad SER = 0.014 \qquad D.W. = 1.16$$

Notation:

LAH = Hired agricultural labour ('000)
LASE = Self-employed agricultural labour ('000)
LAFF = Total agricultural labour ('000)
LPRA = Labour productivity in agriculture ("bar" denotes 3-year average)
RAW = Agricultural income per head relative to non-agricultural wage rate ("bar" denotes 3-year average)
UR = Unemployment rate
t = time (1953 = 1)

plus replacement, and that replacement investment is proportional to the existing stock, one has

$$I_t = K_t - (1-\delta)K_{t-1} \tag{4.3.9}$$

where δ is the depreciation rate. Substitution yields the following equation for gross investment:

$$I_t = (1-\lambda)K_t^* - (1-\lambda-\delta)K_{t-1} \tag{4.3.10}$$

Further simple transformation yields

$$I_t = (1-\lambda)K_t^* - (1-\lambda)(1-\delta)K_{t-1}^* + \lambda I_{t-1} \tag{4.3.11}$$

A theory of investment essentially considers the determinants of the desired capital stock, K_t^*. While examination of the role of factors influencing K^* can take place within a purely empirical framework, nevertheless, the Neo-classical theory of factor demands can be invoked for guidance.

In Table 4.3.2 we present some OLS regession results for the "restricted" agricultural investment equation. In case (A) of Table 4.3.2, three income/output measures are examined as determinants of K^* in an equation of form (4.3.11) i.e., a two-year average (lagged) of agricultural product, agricultural output, and real income from self-employment, and an additional explanatory variable, the product or output cost of capital is included in a simple linear relation with partial adjustment. In case (B), only the scale term is included in a relation of form (4.3.11).

The dominant fact to emerge from all the estimates is the very sluggish nature of investment, i.e., the large value of the adjustment parameter λ in Equation (4.3.11). An obvious modification to the estimated equations would be the inclusion of a measure capturing the effect of government grants to the agricultural sector for investment purposes. However, in the absence of a suitable theoretical framework, such estimates are at best *ad hoc* in nature and are left for subsequent empirical work.

Material Inputs

Having separated both employment and investment as recursive to the behavioural element of Figure 4.3, it remains to determine the demand for material inputs. Consider the case of a simple three-factor Cobb-Douglas production technology.

$$Q_A = A \exp(\gamma t)\, K_A^{\alpha_1}\, L_A^{\alpha_2}\, M_A^{\alpha_3} \tag{4.3.12}$$

Such a simple technology forces all partial elasticities of substitution to be unity. We also impose constant returns to scale (CRS) i.e.,

$$\alpha_1 + \alpha_2 + \alpha_3 = 1$$

If farmers maximise profits but consider material usage as the only *variable* input in the short run, then they will use material inputs at a level where the additional output obtained from using more material inputs equals its price. Hence, the demand for material inputs with a simple CD technology is

$$M_A = \gamma Q_A \left(\frac{PM_A}{PQ_A}\right)^{-1} \tag{4.3.13}$$

where PM_A is the price of material inputs and PQ_A is the price of agricultural output. In Table 4.3.3 we present OLS estimates based on versions of the above material inputs equation. The first set considers inputs of agricultural materials (i.e., feed, seed and fertiliser); the second set considers other inputs (i.e., non-agricultural materials, energy, etc.); the third set considers aggregate material inputs. Related equations for a range of agricultural material input components have been used by Boylan, Cuddy and Ó Muircheartaigh (1980a) although they did not work within an overall production function framework. Boyle and Sherington (1980), however, criticise this approach on the basis that the exclusion of other relevant variables may seriously bias the estimates and lead to problems with the long-run elasticity estimates.

Turning to Table 4.3.3, in each case the own-price elasticity is negative and the output elasticity is positive. However, while at the 95 per cent level of confidence, the hypothesis of unit price elasticity cannot be rejected (Equations 1 and 4), the hypothesis of a unit output elasticity is rejected (Equations 1, 3 and 4).

The results of Boyle (1981) suggest that a more general technology for agriculture might consist of a bundled capital-materials aggregate combined with labour. If an outer capital-materials (KM) and labour (L_A) relationship is assumed to be Cobb-Douglas with CRS and technical progress is assumed to be embodied in labour, one may write

$$Q_A = A\, KM^{\alpha} (e^{\gamma t} L_A)^{1-\alpha} \tag{4.3.14}$$

where KM represents the capital/materials "bundle". If KM is now assumed

Table 4.3.2: *Agricultural investment in buildings, machinery and equipment, OLS regressions estimates, 1962 to 1979*

(A) $IFAFF = a_0 + a_1 X1 + a_2 X2 + a_3 IFAFF_{-1}$

X1	*X2*	a_0	a_1	a_2	a_3	$\bar{R}^2$	*SER*	*DW*	*RHO*
$\frac{OAFF_{-1} + OAFF_{-2}}{2}$	$\frac{UCCA}{POAFF}$	−20.2	0.334	−104.2	0.663	0.918	7.5	1.87	0.4581
		(0.6)	(4.5)	(3.9)	(4.9)				
$\frac{QAG_{-1} + QAG_{-2}}{2}$	$\frac{UCCA}{PQAG}$	36.9	0.171	−128.4	0.702	0.862	8.8	1.54	0.5551
		(0.6)	(2.3)	(3.7)	(4.2)				
$\frac{\frac{YSEAFF}{PCPER_{-1}} + \frac{YSEAFF}{PCPER_{-2}}}{2}$	$\frac{UCCA}{POAFF}$	74.4	0.144	−123.1	0.803	0.849	10.9	1.70	0.3912
		(2.2)	(1.5)	(3.0)	(3.2)				

(B) $IFAFF = a_0 + a_1 X1 + a_2 IFAFF_{-1}$

X1	a_0	a_1	a_2	$\bar{R}^2$	*SER*	*DW*	*RHO*
$\frac{OAFF_{-1} + OAFF_{-2}}{2}$	−68.0	0.212	0.774	0.922	10.8	1.74	–
	(2.5)	(2.5)	(4.8)				
$\frac{QAG_{-1} + QAG_{-2}}{2}$	−116.6	0.234	0.519	0.720	12.3	1.84	0.5814
	(1.9)	(2.3)	(2.3)				
$\frac{\frac{YSEAFF}{PCPER_{-1}} + \frac{YSEAFF}{PCPER_{-2}}}{2}$	−14.1	0.084	0.981	0.890	12.8	2.02	–
	(0.8)	(0.6)	(4.2)				

Notation:

OAFF = Agricultural product (£m, 75)
QAG = Gross agricultural output (ex. FF) (£m, 75)
YSEAFF = Income for self-employment in agriculture (£m)
PCPER = Deflator of personal consumption expenditure
UCCA = Cost of capital in agriculture (PIAFF (0.02 + 0.05))
POAFF = Deflator of OAFF
PQAG = Deflator of QAG
IFAFF = Investment in building and machinery (£m, 75)
RHO = AR(1) parameter

Table 4.3.3: *Material inputs in agriculture, OLS regressions, 1962-1979*

(A) *Agricultural materials*

1.
$$\log MATA = \underset{(7.1)}{-7.28} - \underset{(5.0)}{0.833}\log\left(\frac{PMATA}{PQAG}\right) + \underset{(12.1)}{1.878}\log QAG$$

$\bar{R}^2 = 0.923$ SER = 0.076 D.W. = 2.25

2.
$$\log MATA = \underset{(2.5)}{-4.422} - \underset{(3.1)}{0.911}\log\left(\frac{PMATA}{PQAG}\right) + \underset{(5.8)}{1.184}\log QAG + \underset{(2.0)}{0.336}\log MATA_{-1}$$

$\bar{R}^2 = 0.935$ SER = 0.070 D.W. = 1.91

(B) *Non-agricultural materials*

3.
$$\log MATNA = \underset{(11.6)}{-9.93} - \underset{(0.9)}{0.217}\log\left(\frac{PMATNA}{PQAG}\right) + \underset{(17.1)}{2.214}\log QAG$$

$\bar{R}^2 = 0.952$ SER = 0.061 D.W. = 1.18

(C) *Total materials*

4.
$$\log MAT = \underset{(8.2)}{-7.582} - \underset{(3.6)}{0.681}\log\left(\frac{PMAT}{PQAG}\right) + \underset{(14.3)}{2.00}\log QAG$$

$\bar{R}^2 = 0.938$ SER = 0.068 D.W. = 2.01

5.
$$\log MAT = \underset{(1.8)}{-3.231} - \underset{(4.7)}{0.749}\log\left(\frac{PMAT}{PQAG}\right) + \underset{(2.1)}{0.893}\log QAG + \underset{(2.8)}{0.526}\log MAT_{-1}$$

$\bar{R}^2 = 0.957$ SER = 0.056 D.W. = 1.65

Notation:

MATA	=	Agricultural material inputs (food, seed, fertiliser) (£m, 75)
MATNA	=	Non-agricultural material inputs (energy, etc.) (£m, 75)
MAT	=	Total material inputs (£m, 75)
PMATA	=	Price of farm material inputs (base 1975 = 1.0)
PMATNA	=	Price of non-farm inputs (base 1975 = 1.0)
PMAT	=	Price of total inputs (base 1975 = 1.0)
QAG	=	Gross agricultural output (£m, 75)

to be CES in capital and materials, one may write

$$KM = \left[\beta K_A^{\frac{\sigma-1}{\sigma}} + \delta M_A^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}} \qquad (4.3.15)$$

where σ is the (constant) elasticity of substitution between capital and materials. A long-run cost-minimisation assumption now gives the optimum materials to capital ratio of

$$\left(\frac{M_A}{K_A}\right)^* = \left(\frac{\delta}{\beta}\right)^{\sigma} \left(\frac{PM_A}{PI_A}\right)^{-\sigma} \qquad (4.3.16)$$

where PI_A is the price of agricultural investment. Estimation yielded the results shown in Table 4.3.4.

Table 4.3.4: *Materials to capital ratio in agriculture, OLS regressions, 1961-1979*

$$\log\left(\frac{M_A}{K_A}\right) = \underset{(1.4)}{-0.150} - \underset{(2.4)}{0.474}\log\left(\frac{PM_A}{PI_A}\right) + \underset{(8.8)}{0.893}\log\left(\frac{M_A}{K_A}\right)_{-1}$$

$\bar{R}^2 = 0.821$ SER = 0.068 D.W. = 2.04 RHO = 0.4472

While the impact elasticity of substitution (0.47) is plausible, the long-run value of 4.4 is both implausibly high and subject to a high margin of error.

Agricultural Output

Under the assumption of a simple CRS Cobb-Douglas technology and profit maximising use of material inputs, the demand for material inputs,

$$M_A = \gamma Q_A \left(\frac{PM_A}{PQ_A}\right)^{-1} \qquad (4.3.17)$$

can be substituted into the production function to yield

$$Q_A = \left(A \exp(\gamma t)\, K_A^{\alpha_1}\, L_A^{\alpha_2} \left(\frac{PM_A}{PQ_A}\right)^{-\alpha_3}\right)^{1/(1-\alpha_3)} \qquad (4.3.18)$$

an equation which could be used to endogenise agricultural output. Direct estimation of the above relation, in both static and dynamic forms, yielded perverse results, as, for example, shown in Table 4.3.5.

Table 4.3.5: *Agricultural output, OLS regressions, 1962-1979*

$$\log\left(\frac{Q_A}{L_A}\right) = \underset{(2.3)}{0.409} + \underset{(1.8)}{0.408}\log\left(\frac{K_A}{L_A}\right) + \underset{(0.7)}{0.050}\log\left(\frac{PM_A}{PQ_A}\right) + \underset{(0.4)}{0.0092}\,t$$

$\bar{R}^2 = 0.954$ SER = 0.0306 D.W. = 1.87 RHO = 0.5731

Rather than explore more sophisticated technological models and production functions, we present a fairly simply agricultural supply function of a form used by Behrman (1977), and by Fanning (1979) in a study of the Irish economy. In this model, agricultural output (Q_A) is hypothesised to be a linear function of capacity output ($QCAP_A$), with a coefficient which is parametric in profitability conditions in agriculture. The ratio of output prices to material input prices (lagged) is taken as a profitability measure, and the level of agricultural inventories to output is used as a cyclical indicator.

$$Q_A = a_0 + \left[a_1 \; \frac{PQ_A}{PM_A}_{-1} + a_2 \; \frac{IIV_A}{QV_A}_{-1} \right] QCAP_A \quad (4.3.19)$$

In addition, a variable is used to capture the possible effects of weather on utilisation. Three measures of weather effects were examined.

(i) A measure of rainfall less evapotranspiration constructed by simply subtracting total evapotranspiration from total rainfall for the seven months of the growing season.

(ii) To allow for a dry season with low rainfall and high evapotranspiration, the mean annual difference between rainfall and evapotranspiration was also used.

(iii) The growing season is usually defined as the period for which the mean air temperature is above a specified threshold, taken arbitrarily as 6° C. Degree days are then an arithmetic accumulation of daily mean temperatures above this threshold, and are the third measure of weather effects.[59]

In Table 4.3.6 we present some estimates of the agricultural output supply Equation (4.2.19). The signs of the coefficients are in line with *a priori* expectations. In Equations 2 and 3, the weather variable, WEATH3, is such as to indicate a better growing season for increases in its value. Also, a rise in the gross agricultural output price relative to total material inputs causes an increase in utilisation.

Conclusion — Agriculture

In summary we can say that our attempt to model the agriculture sector within the fairly light theoretical framework of Figure 4.3 was not as success-

59. Data were kindly supplied by the Meteorological Service.

Table 4.3.6: *Agricultural output and capacity utilisation, OLS regressions, 1962-1979*

1. $$QAG = \underset{(4.2)}{315.1} + \left[\underset{(1.7)}{3.15.10^{-4}}\ WEATH2 + \underset{(5.9)}{0.565}\left(\frac{PQAG}{PMAT_{-1}}\right)\right] QAGCAP$$

$\bar{R}^2 = 0.659$ SER = 54.3 D.W. = 1.94

2. $$QAG = \underset{(3.4)}{191.9} + \left[\underset{(5.4)}{3.37.10^{-4}}\ WEATH3 + \underset{(2.9)}{0.228}\left(\frac{PQAG}{PMAT_{-1}}\right)\right] QAGCAP$$

$\bar{R}^2 = 0.863$ SER = 34.4 D.W. = 1.98

3. $$QAG = \underset{(3.8)}{193.7} + \left[\underset{(4.1)}{2.74.10^{-4}}\ WEATH3 + \underset{(3.7)}{0.331}\left(\frac{PQAG}{PMAT_{-1}}\right) - \underset{(1.9)}{0.580}\left(\frac{IIAV}{QAGV_{-1}}\right)\right] QAGCAP$$

$\bar{R}^2 = 0.883$ SER = 31.8 D.W. = 2.16

Notation:

QAG	=	Agricultural output (excluding forestry and fishing) (£m, 75)
QAGCAP	=	Four year moving average of QAG
WEATH2	=	Mean annual difference between rainfall and evapotranspiration
WEATH3	=	Cumulative degree days about 6°C
PQAG	=	Deflator of QAG (base 1975 = 1.0)
PMAT	=	Deflator of total material inputs (base 1975 = 1.0)
IIAV	=	Inventory investment in cattle (£m)
QAGV	=	Agricultural output (excluding forestry and fishing) (£m)

ful as one would desire for macroeconometric analysis of a major production sector. However, the framework proposed respresents some advance over the existing, rather unco-ordinated, approaches to quantifying agricultural sector behavioural relationships within an economy-wide perspective. It provided useful measures of employment relationships in particular (and the determinants of employment levels), as well as the core process of material inputs and output determination that lies at the heart of agricultural economic analysis. We have concentrated on the key behavioural relationships, i.e., employment, investment, materials usage and output, leaving prices as being fixed externally to the Irish agricultural sector (by the CAP of the EEC). The income and expenditure identities showing the integration of the agricultural sector within the macro-economy are not presented here but are part of the operational macro-model being developed. Such relationships, relating agricultural exports, output and stock changes will be crucial in making an agricultural sector of a model operational.

Chapter 5

DOMESTIC SUPPLY – PART II

I. SERVICES

The services sector is particularly difficult to analyse in terms of a relatively simple but theoretically adequate empirical model. Given the requirement to work at a fairly aggregate level, one is faced with a highly heterogeneous grouping made necessary by the available data. Thus, the service sector includes:

> Distribution, transport and communications;
> Insurance, finance, banking and business services;
> Professional (religion, education, health etc.,) and
> Personal (domestic, catering, social welfare) services;
> Other industries (recreational, cultural, diplomatic).

This heterogeneity makes it difficult to derive a generally accepted theoretical framework. A more satisfactory explanation of scale, technology, and factor demand relations would require more disaggregated data than are presently available. Therefore, accepting the available data and the level of aggregation as a constraint, the services sector includes private and state activities.[60] Some of the state elements are commercially and semi-commercially operated, while others are not. Furthermore, these are mixed between infrastructural and social; some have no direct productive impact; others directly affect productivity and private activity. Investment activity by the state embraces physical capital and human capital. But even here the division is not clear as these activities serve a dual purpose since there is also a consumption element involved in, for example, roads and education. In the private component there is a fairly high degree of self-employment in the areas of professional and personal services and small retailing. At the other extreme, the service sector includes large-scale insurance, banking and financial services. In terms of

60. A breakdown of service sector employment into private and public elements is made by Sexton (1982) who provides the breakdown for Census years. Our services category excludes public administration and defence. It does, however, include rent of dwellings.

possible market structures, the public elements (health, education, social welfare activities) have been removed from the direct market system; certain communication and transport elements operate as "state-sponsored" enterprises; elements of the banking and financial services operate without effective price competition; and the retail, distribution and recreational elements tend to be subject to fully competitive markets.

A common approach to examining the development of the service sector is to place it in the context of a three-stage view of the development of the economy. The services sector is then identified as the tertiary sector which follows the primary (agriculture) and secondary (industry/manufacturing) sectors (Clark, 1960). In the course of economic development there are resource shifts from agriculture to industry and from industry to services. These shifts are related to differences in income elasticity of product demand as income rises, and to sectoral differences in the rates of labour productivity growth. Since the establishment of the state the importance of the services sector has been relatively high by European standards, particularly when consideration is given to respective levels of *per capita* income. Cogan (1978) in his survey of the Irish services sector, comments that the reasons for this apparent anomaly may be historical rather than economic, in that the close historical relationship with the UK may have resulted in an infrastructure of medicine, professional, financial and similar services appropriate to a wealthier economy. Whatever the reasons for the early "maturing" of the Irish services sector, one of the consequences may have been its subsequent lack of vigour and dynamism.

As yet there have been few attempts to analyse formally the behaviour of the services sector.[61] A detailed investigation of productive efficiency in the services sector has been made by Cogan (1978) who makes a plea that this sector be recognised as a separate, independent sector and not merely a "parasitic" growth deriving from agriculture or manufacturing industry. The only formal hypotheses that Cogan tests relate to the idea that there is a steady state or equilibrium in sectoral employment and output patterns, i.e., a condition in which the percentages of the total workforce employed in each of the main sectors remain constant as income per head rises.

Cogan interprets his regression results as lending support to the "equilibrium" hypothesis, but his conclusions have been criticised by O'Riordan (1981) who shows that on both economic and statistical grounds such a relationship is not supported by the data.

Part of the difficulty in approaching the service sector arises from its very

61. The macroeconometric models by Fanning (1979) and the various versions of the Central Bank/Department of Finance models (Bradley, *et al* 1981), included basic employment and output equations for the service sector.

characterisation as the "tertiary" sector and its accompanying association with increasing level of development or standard of living, reflecting higher income elasticity of demand for that sector's output and the release of labour from "primary" and "secondary" activities due to productivity growth, to the service sector to be able to meet such needs. This view has been subject to some critical examination (Thirlwall, 1978, pp. 40-41; Mandel, 1970, pp. 204-206). Thirlwall, for instance, points out that the overall proportion of resources devoted to service activities does not change very much in the course of development but that, when disaggregated into even broad sub-categories of services, the pattern of resource allocation changes differently and in an off-setting manner during the process of development (Thirlwall, 1978, p. 41). Following the arguments of Thirlwall and Mandel we can set out one perspective on service sector expansion by isolating three sub-categories which provides an insight into the difficulties involved. The sub-categories are:

(i) "newer" service activities which are linked with the growth of leisure and mass consumption associated with higher real incomes. Such a grouping includes the cultural, scientific and educational activities and would appear to be the area that most corresponds to theories of service sector expansion of the Clark type, i.e., most closely linked with economic progress and increasing labour productivity.

(ii) "intermediate" service activities which are linked to the growth of the other sectors of the economy, in particular, manufacturing. The process involved here is much more in the nature of an industrialisation process (which is why we refer to this grouping as intermediate). For instance, the large-scale development and specialisation by some countries in certain areas should really be classed as secondary, e.g., shipping in Norway (Mandel, 1970, p. 206). Increased capitalisation, economies of scale and the shift to larger units of organisation and production, and technical progress, are important features of this aspect of service sector development. For instance, as the scale of activity expands the organisation and technology of retailing undergoes dramatic changes, electronic calculating, accounting and other business machines replace labour in banking, financial, and administrative institutions, and a wide range of activities becomes increasingly centralised and capitalised; and

(iii) "traditional" services which are characterised by backwardness as regards mechanisation and organisation of certain areas of distri-

> bution and personal services compared with industrialised production. This results in tertiary sector employment being larger as a result of growth in industrial productivity. But this is a temporary feature resulting from the survival of small-scale retailing and "middleman" operations which are not yet absorbed into the developed industrial sector. The shift of activity from the traditional service sector to industrially produced goods, particularly affects areas such as catering, domestic service, and entertainment. These changes, however, also result in a development and expansion of other areas of small-scale services, such as repairing and maintenance.

Therefore, as Thirlwall says, "tertiary production is an aggregation of many dissimilar service activities, some of which are retlated to low *per capita* incomes and some to high *per capita* incomes. Today, there is very little disparity between the proportion of total resources devoted to services in the developed and developing countries" (1978 p. 41). To these diverse features of service sector activity must be added the second perspective, mentioned above, of the difference between the market and non-market types of behaviour involved in the different agents in this sector. Such diversity makes it difficult to justify any simple and unified theoretical framework, even if the public element could be separated out. In addition, it also makes it difficult to apply the autonomous-induced breakdown to explain the growth and evolution of the services sector paralleling the regional studies of Baker (1966) and Baker and Ross (1975).

Theoretical Framework

For the reasons just discussed we do not attempt to implement a comprehensive decision-based factor demand system. For instance, the inclusion of large non-commercial and self-employment components, as well as the major contrast in the type of decision-making units, are likely to affect the sensitivity of employment and investment to the wage rate/capital cost ratio. A simple factor requirement or productivity approach, based on the inputs needed to produce a particular level of output, is utilised. Desired output (O_S*) is assumed to adjust to actual output (O_S) within one period, a year. The main justification for such an assumption is the shorter production processes involved, the more simplified technology and the less structured labour force.

The output decision is related to demand or activity variables, an appropriate scale variable being final demand weighted by the output content of services (GFD_S). Hence,

$$O_S = f(GFD_S) \tag{5.1.1}$$

Other variables, such as real *per capita* disposable income, could be used as indicators of the stage of development.

Given its heterogeneous nature, a simple form of the flexible accelerator model is used to study service sector investment decisions (IF_S) i.e.,

$$IF_S = f(O_S, \pi) \tag{5.1.2}$$

where π is a measure of the profitability of investment. A simple labour requirements approach to labour demand can be used to derive the demand for service sector employment. Assuming a production function of the form

$$O_S = f(K_S, L_S) \tag{5.1.3}$$

inversion of the production function yields

$$L_S = g\,(O_S, K_S) \tag{5.1.4}$$

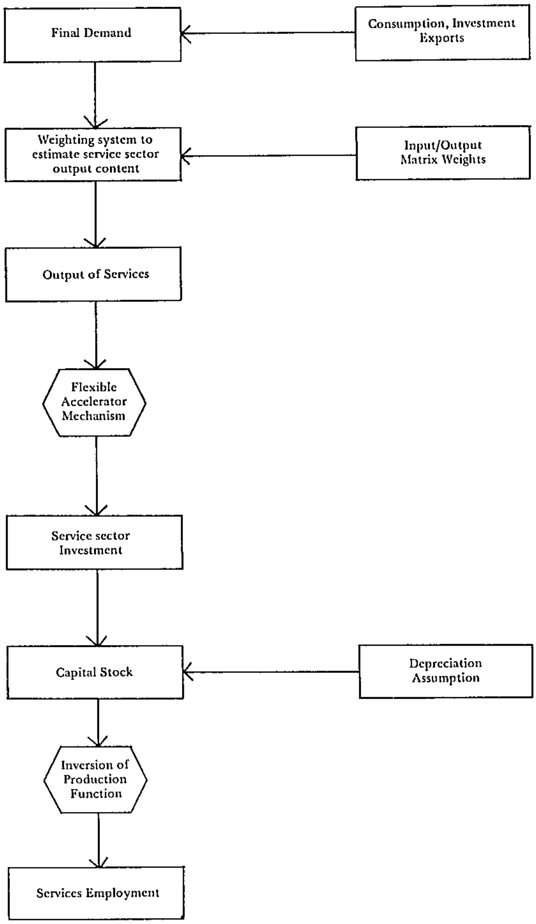
In actual estimation, various expectational and adjustment lags are used. The overall framework is illustrated in Figure 5.1. The causal sequence runs downwards from the top of the diagram: weighted demand, or income, determines output; a flexible accelerator (or similar relationship) determines investment; output and investment (via a measure of capital stock) determines employment. In the next section we investigate this schema empirically and attempt to quantify the relationships involved.

Specification and Validation

Given the very heterogeneous nature of the service sector discussed already, a fairly pragmatic approach was adopted in model specification. The main driving force of service sector output is taken to be a weighted sum of the components of final demand, GFD_S, where the weights are derived from the 1969 input-output table and represent the average amount of each component of final demand which is derived, either directly or indirectly, from net service sector output. A second approach, using real *per capita* personal disposable income was also used.

In Table 5.1.1 we present some statistical estimates of the service sector output relation using weighted final demand. If I/O weights were available for each year of the sample period, then the relation between output and weighted expenditure would be an identity. The unknown (but probably changing) pattern of weights is proxied by making the coefficient of weighted final demand (GFD_S) parametric in real *per capita* disposable income (Equations 2 and 2a), or by simply including a separate time trend (Equations 1

Figure 5.1: *Schema for the services sector analysis*



and 1a). All equations in Table 5.1.1 suffered from first-order autocorrelation (Equations 1b, 2b).

In Table 5.1.2 we show estimates using real personal disposable income as the main explanatory variable.[62] The preferred statistical result (Equation 4 of Table 5.1.2) shows a real income elasticity of 0.219 and a secular growth rate of service output of 3.23 per cent per annum, results which are quite similar to those given in Table 5.1.1, where weighted expenditure is the explanatory variable. The income elasticity is on the low side, since one

62. The choice between these approaches depends, among other factors, on whether the equation is embedded in an economy-wide model, i.e., how the overall system of aggregate supply and demand is operationalised.

Table 5.1.1: *Output of service sector (weighted final demand approach), OLS regressions, 1962-1979*

1.

$$\underset{}{OS} = \underset{(2.3)}{132.0} + \underset{(3.8)}{0.825}\ GFDOS + \underset{(3.6)}{24.85}\ t$$

$\bar{R}^2 = 0.986$ SER = 31.9 D.W. = 0.41

1a.

$$\log OS = \underset{(5.9)}{4.802} + \underset{(1.9)}{0.264} \log GFDOS + \underset{(5.6)}{0.030}\ t$$

$\bar{R}^2 = 0.992$ SER = 0.019 D.W. = 0.57

2.

$$OS = \underset{(1.1)}{216.36} + (\underset{(1.9)}{0.963} + \underset{(1.2)}{0.340} \frac{YPERD}{PCPER*NT})\ GFDOS$$

$\bar{R}^2 = 0.977$ SER = 41.56 D.W. = 0.66

2a.

$$\log OS = \underset{(2.6)}{2.928} + (\underset{(2.8)}{0.564} + \underset{(2.3)}{0.0686} \frac{YPERD}{PCPER*NT}) \log GFDOS$$

$\bar{R}^2 = 0.982$ SER = 0.029 D.W. = 0.81

1b.

$$OS = \underset{(2.9)}{217.4} + \underset{(4.5)}{0.665}\ GFDOS + \underset{(4.7)}{28.45}\ t$$

$\bar{R}^2 = 0.939$ SER = 19.00 D.W. = 1.45 RHO = 0.9000

2b.

$$\log OS = \underset{(2.5)}{3.338} + (\underset{(4.6)}{0.537} + \underset{(2.0)}{0.032} \frac{YPERD}{PCPER*NT}) \log GFDOS$$

$\bar{R}^2 = 0.792$ SER = 0.020 D.W. = 1.34 RHO = 0.999

Notation.

OS	=	Output of service sector (£m, 75)
GFDOS	=	Final demand weighted of service output content (£m, 75)
t	=	time (1953 = 1.0)
YPERD	=	Personal disposable income (£m)
PCPER	=	Deflator of personal consumption (base 1975 = 1.0)
NT	=	Total population ('000)

would have expected an elasticity greater than unity. However, part of the explanation may lie in the fact that, due to multicollinearity the time trend is picking up the trend element in real income and expenditure. When the time trend is excluded (Equation 2 of Table 5.1.2), the real income elasticity rises to 1.086, more in line with prior expectations. An interpretation of Equation 4 is that the time trend represents the trend real income effect, and is quite high (3.23 per cent per annum), while the real income term is capturing the cyclical variations about the trend, indicating that such variations are quite inelastic.

In Table 5.1.3 we show estimates of service sector investment equations. These include an accelerator model (Equation 1) and two examples of demand for capital models based on profit maximising behaviour. The flexible accelerator model has already been presented in the agricultural sector analysis. If I_S is investment by the service sector and $K_S{}^*$ is desired capital stock, then from Equation 4.3.11,

$$I_{St} = (1 - \lambda) K^*_{St} - (1 - \lambda)(1 - \delta) K^*_{St-1} + \lambda I_{St-1} \qquad (5.1.5)$$

where δ is the depreciation rate (exogeneous and assumed constant at 5 per cent) and $(1 - \lambda)$ is the rate of adjustment (of actual stock to desired).

Table 5.1.2: *Output of service sector (income approach), OLS regressions, 1962-1979*

1.	$OS = \underset{(2.0)}{-114.37} + \underset{(24.1)}{1501.6}\left(\frac{YPERD}{PCPER.NT}\right)$
	$\bar{R}^2 = 0.972$ SER = 46.3 D.W. = 1.71
2.	$\log OS = \underset{(819.3)}{7.233} + \underset{(26.8)}{1.086} \log\left(\frac{YPERD}{PCPER.NT}\right)$
	$\bar{R}^2 = 0.977$ SER = 0.0329 D.W. = 1.59
3.	$OS = \underset{(2.4)}{247.84} + \underset{(2.0)}{304.5}\left(\frac{YPERD}{PCPER.NT}\right) + \underset{(6.2)}{41.46}\,t$
	$\bar{R}^2 = 0.892$ SER = 25.93 D.W. = 1.39 RHO = 0.8910
4.	$\log OS = \underset{(74.0)}{6.547} + \underset{(2.0)}{0.219} \log\left(\frac{YPERD}{PCPER.NT}\right) + \underset{(7.7)}{0.0323}\,t$
	$\bar{R}^2 = 0.981$ SER = 0.0156 D.W. = 1.60 RHO = 0.5909

Notation:

OS	=	Output of service sector (£m, 75)
YPERD	=	Personal disposable income (£m)
PCPER	=	Deflator of personal consumption (base 1953 = 1.0)
NT	=	Total population ('000)
t	=	time (1953 = 1.0)

In generating K_S, a depreciation rate was assumed. Hence, if we further assume that output, O_S, is the sole determing influence on K_S^*, we can write

$$I_{St} = \alpha (1 - \lambda) [O_{St} - 0.95\, O_{St-1}] + \lambda I_{St-1} \qquad (5.1.6)$$

where α is a proportionality factor.

From Table 5.1.3 (Equation 1) we obtain estimated values of

$$\lambda = 0.716 \quad (1 - \lambda = 0.284)$$
$$\alpha = 2.261$$

Hence, adjustment of actual to desired capital stock is a relatively slow process, only just over one-quarter of the disequilibrium being removed within the first year.

Equations 2 and 3 can be interpreted in the light of a model of profit maximisation. Both equations have the expected negative real cost of capital term, but have statistically insignificant output elasticities.

Table 5.1.3: *Investment expenditure in the service sector, OLS regressions, 1962-1979*

1.	$IFS = \underset{(4.0)}{0.642} (OS - 0.95\, OS_{-1}) + \underset{(8.3)}{0.716}\, IFS_{-1}$
	$\bar{R}^2 = 0.906$ SER = 19.08 D.W. = 2.38
2.	$\log KFS = \underset{(2.4)}{8.178} - \underset{(1.6)}{0.848} \log OS - \underset{(4.4)}{1.273} \log \frac{UCCS}{POS} + \underset{(5.0)}{0.105}\, t$
	$\bar{R}^2 = 0.991$ SER = 0.043 D.W. = 0.88
3.	$\log KFS = \underset{(1.1)}{-0.339} + \underset{(1.3)}{0.0796} \log OS - \underset{(3.6)}{0.285} \log \frac{UCCS}{POS} + \underset{(26.7)}{0.879} \log KFS_{-1}$
	$\bar{R}^2 = 0.999$ SER = 0.010 D.W. = 2.20

Notation:

IFS = Gross fixed capital formation in service sector (£m, 75)
OS = Output of service sector (£m, 75)
KFS = Gross fixed capital stock in service sector (£m, 75)
UCCS = User cost of capital in service sector
POS = Deflator of service sector output (base 1975 = 1.0)
t = time (1953 = 1.0)

In Table 5.1.4 we present statistical results bearing on the underlying technology of the service sector. Both in the case where the capital stock, KFS, is "corrected" for utilisation rates (proxied in the absence of any alternative, by the rate of capacity utilisation in industry, CUR_I), and in the "uncorrected" case, the cost minimising capital-labour ratio is negatively related to the capital-labour price ratio (with an elasticity of approximately unity), and positively related to time, i.e., the capital-labour ratio is rising over time. Equations 2 and 4 give results where the elasticity of substitution is constrained to be unity. In the case of CES technology one expects the time trend (technical progress) to be zero if $\sigma = 1$, i.e., if the technology reduces to Cobb-Douglas. Conclusions one can draw are that either the measure of capital stock, K_S, is inadequate (and was, after all, generated artifically in the complete absence of official data), or that the cost of

Table 5.1.4: *Production technology in the service sector, OLS regressions, 1962-1979*

1. $$\log\left(\frac{CURI*KFS}{LS}\right) = \underset{(4.4)}{-2.488} - \underset{(4.6)}{1.027}\log\left(\frac{UCCS}{WS}\right) + \underset{(2.9)}{0.0268}\,t$$

$\bar{R}^2 = 0.982$ SER = 0.050 D.W. = 1.51

2. $$\log\left(\frac{CURI*KFS}{LS}\right) = \underset{(57.9)}{-2.421} - 1.000\log\left(\frac{UCCS}{WS}\right) + \underset{(12.8)}{0.0279}\,t$$

$\bar{R}^2 = 0.983$ SER = 0.048 D.W. = 1.49

3. $$\log\left(\frac{KFS}{LS}\right) = \underset{(6.9)}{-2.942} - \underset{(7.2)}{1.226}\log\left(\frac{UCCS}{WS}\right) + \underset{(2.7)}{0.0193}\,t$$

$\bar{R}^2 = 0.990$ SER = 0.038 D.W. = 1.29

4. $$\log\left(\frac{KFS}{LS}\right) = \underset{(70.7)}{-2.374} - 1.000\log\left(\frac{UCCS}{WS}\right) + \underset{(16.2)}{0.0283}\,t$$

$\bar{R}^2 = 0.989$ SER = 0.038 D.W. = 0.90

Notation:

KFS = Gross fixed capital stock in service sector (£m, 75)
LS = Employment in service sector ('000)
CURI = Capacity utilisation rate in industry
UCCS = User cost of capital in service sector
WS = Average annual earnings in service sector (£,000 p.a.)
t = time (1953 = 1.0)

capital variable, UCC_S, is not capturing the true cost of capital facing service sector firms.[63]

Given the poor quality of data, it would be difficult to explore more general flexible functional form production functions. Even if such an exploration were possible, it is unlikely that the service sector can be characterised in terms of a unique well-behaved technology.[64]

Finally, in Table 5.1.5 we show results for service sector employment, L_S. The first four equations are justified by various forms of an inverted Cobb-Douglas production function. From Equation 2 the parameters of the underlying C-D production function are as follows:

Table 5.1.5: *Employment in the service sector, OLS regressions, 1962-1979*

1. $$\log LS = \underset{(24.7)}{3.285} + \underset{(20.5)}{0.384} \log OS$$

$\bar{R}^2 = 0.961$ SER = 0.017 D.W. = 0.80

2. $$\log \left(\frac{OS}{LS}\right) = \underset{(26.3)}{0.631} + \underset{(1.1)}{0.083} \log \left(\frac{KFS}{LS}\right) + \underset{(3.5)}{0.0101}\, t$$

$\bar{R}^2 = 0.967$ SER = 0.0242 D.W. = 0.84

3. $$\log LS = \underset{(5.0)}{2.165} + \underset{(8.3)}{0.563} \log OS - \underset{(2.7)}{0.244} \log \frac{WS}{POS}$$

$\bar{R}^2 = 0.972$ SER = 0.014 D.W. = 1.23

4. $$\log LS = \underset{(0.3)}{0.193} + \underset{(2.0)}{0.244} \log OS - \underset{(1.8)}{0.145} \log \frac{WS}{POS} + \underset{(2.9)}{0.697} \log LS_{-1}$$

$\bar{R}^2 = 0.981$ SER = 0.012 D.W. = 1.69

Notation:

LS = Employment in service sector ('000)
OS = Output of service sector (£m, 75)
KFS = Gross fixed capital stock in service sector (£m, 75)
WS = Average annual earnings in service sector (£,000 p.a.)
POS = Deflator of service sector output (base 1975 = 1.0)

63. The cost of capital variables, UCC_S, was generated as

$$UCC_S = PI^*_S\,(0.02 + 0.05)$$

i.e., assuming a fixed depreciation rate of $\delta = 0.05$ and a fixed real interest rate of 2 per cent.

64. Boyle (1981) arrives at such a conclusion for the agriculture sector.

$$O_S = A \exp(\gamma t) K_S^{\alpha} L_S^{(1-\alpha)} \text{ where}$$
$$A = 1.879, \gamma = 0.0191 \text{ and } \alpha = 0.083.$$

The value of α, besides being statistically insignificant, is implausibly low, representing a capital share of less than 10 per cent. In fact, over the period 1961 to 1979, factor shares were as follows:

	1961	1965	1970	1975	1979
			per cent		
Service sector wage share	58.6	60.4	63.2	68.5	62.1
Service sector capital share	41.4	39.6	36.8	31.5	37.9

Equations 3 and 4 consider employment as a function of output (O_S) and the wage rate (W_S) denominated in output prices (PO_S). Such equations can be justified in terms of a profit maximisation behaviour. However, as comparison with Equations 2 and 3 in Table 5.1.3 show, it would be difficult to reconcile demand for capital and labour as deriving from a simple unique underlying technology. The summary results are as follows:

	SR output elasticity	LR output elasticity	SR price elasticity	LR price elasticity
Capital	0.0796	0.66	-0.285	-2.36
Labour	0.244	0.81	-0.145	-0.48

Hence, there seems no simple way of econometrically modelling the service sector in a consistent technological fashion. Any set of equations will be internally inconsistent at this level of aggregation. Output could be determined by an equation such as 3 of Table 5.1.2. Investment could be determined by a fairly simple accelerator model such as Equation 1 of Table 5.1.3, or by means of Equation 3, justified by a form of profit maximisation behaviour. Finally, employment could be determined either by inverting a factor proportions relationship such as Equation 3 of Table 5.1.4 or by a derived labour demand equation such as 3 or 4 of Table 5.1.5. Any projections using such analysis of the service sector factor demands must be used with caution given the theoretical inconsistencies underlying the approach. Advances in quantitative analysis of the service sector output, investment and employment relations will be made only when better data become available and more suitable volume and thereby productivity, measures are developed. The consequences of poor data in this area are serious since service sector employment constitutes the single largest element of total employment in the economy, and will be subject to fairly dramatic changes due to advances in micro-electronic and other labour-saving developments in the near future.

II. IMPORTED GOODS AND SERVICES

We now consider the question of the determination of import demand. This was a matter which was briefly alluded to in the industry sector, where we illustrated in Figure 4.1 the split between the two sources, domestic and foreign, of gross domestic supply in an open economy. A decision to use a foreign source of supply manifests itself in a demand for imported goods and services, a fact which emphasises that an "import" is not a particular type of commodity but rather is a term which identifies the location of the supplier as being foreign. We will use this framework to consider briefly the three main approaches that have been followed in analysing import demand. These are a demand-theoretic approach, associated with Gregory (1971), a production-based approach proposed by Burgess (1974a), and the more frequent empirical-approach which has been widely applied in Irish studies by, for example, McAleese (1970), and elsewhere (Warner and Kreinin, 1980).

Theoretical Framework

The location of imports in the supply block of the model might be considered somewhat unusual. However, in recent economy-wide macromodelling an important role is usually assigned to imports in mediating unforeseen divergences between potential output and domestic final demands (Helliwell and McRae, 1981) as well as, of course, making available goods that are not or cannot be produced domestically. Thus, imports are treated as a component of supply to meet final expenditure demands. In order to set out explicitly the place of imports in gross domestic supply (GDS) we shall consider the case of the industrial component of GDS and the corresponding supply of industrial goods via importing.

The first, long-run, decision in the industrial framework, Figure 4.1, is the choice as to whether production capacity would be installed in Ireland or whether future demand would be met by importing from abroad. The decision was seen as being taken on the basis of relative profitability, and led to a long-run decision path of the form shown in Figure 4.1. This decision had real consequences in that it resulted in the installation, via fixed investment expenditures, of productive capacity. As with any other good in an open economy, there are two sources of supply, domestic and foreign, for producers' capital goods. Once the long-run decision is made and capacity is in place, there still remains the question of the short-run utilisation of that capacity to meet actual demand. The counterpart of that decision is how much of domestic demand, in the short-run case for intermediate (materials) inputs and final goods themselves, will be met by foreign supply. If we assume for the moment a KLM production technology (where K is capital, L is labour and M is materials inputs) our stylised production framework results in demands for the three inputs and the split into that part of each which is met by foreign supply. Obviously, the labour supply sector will not operate in a similar manner and discussion of that element of input supply is postponed until the last section of this chapter. As well as intermediate demand for inputs K and M there is also direct domestic demand for final goods, i.e., a decision by purchasers as to how much of their demand they will assign to foreign instead of domestically produced final goods. In a macroeconometric study of the Irish economy there is no need for an explicit connection between the long-run and short-run decision levels on the foreign side of capacity and utilisation. Hence, the translation of the long-run split in desired supply into the short-run context involves deciding the split between domestic and foreign sources of supply for intermediate materials, capital goods and final goods. These demands for foreign goods become actual imports. In this discussion we have followed the sequence of development through the industry sector to get to foreign demand and supply. To this must also be added the demand for, and supply of, foreign services, as well as of foreign goods and services relevant to the other domestic sectors of the economy.

The manner in which the split between domestic and foreign sources of supply is made, still remains to be determined. Our basic assumption is that purchasers seek to minimise the cost of meeting their demands by selecting between foreign and domestic sources of supply. Thus, the theoretical decision framework is that of selecting foreign goods (Z_f) and domestic goods (Z_d) so as to solve the cost-minimising problem,

$$\text{Minimise } P_d.Z_d + P_f.Z_f$$

$$\text{such that } Z_0 = z(Z_d, Z_f) \qquad (5.2.1)$$

where Z_0 is the required volume of goods and P_d and P_f are domestic and foreign prices. The constraint reflects the technological and/or preference possibilities of substituting domestic for foreign produced goods and vice versa. Aggregate and disaggregate studies of trade show that changes in foreign relative to domestic prices do not cause, even in the long run, large movements towards either complete import domination or complete domestic domination (Magee, 1975, p. 178). Imperfect substitutability in response to relative prices generates finite price elasticities.[65] If the transformation relationship were of the Cobb-Douglas type, with the elasticity of substitution of foreign for domestic goods equal to unity ($Z_0 = Z_d^\theta . Z_f^\theta$), then the first order minimising conditions with respect to Z_d, and Z_f, would yield a desired proportion of demand assigned to foreign and to domestic sources as

$$\left(\frac{Z_f}{Z_d}\right)^* = f\left(\frac{P_d}{P_f}\right) = \frac{\theta}{\phi}\left(\frac{P_d}{P_f}\right) \tag{5.2.2}$$

In order to complete the theoretical framework at the aggregate level it is useful to distinguish between imported materials for further production (MFP) and other imported goods and services (MGSO). Taking MGSO first, and since it corresponds more to the domestic production of final goods and services, we can state the two sources of supply as domestic production (GDP) and imports (MGSO). Also, we generalise the transformation relation to allow for a constant substitution elasticity different from unity by means of a CES function, i.e.,

$$Z_0 = (\theta GDP^{(\epsilon-1)/\epsilon} + \phi MGSO^{(\epsilon-1)/\epsilon})^{(\epsilon-1)/\epsilon} \tag{5.2.3}$$

where ϵ is the substitution elasticity. Cost minimising behaviour gives rise to the desired ratio of imports to domestic output as

$$\left(\frac{MGSO}{GDP}\right)^* = \left(\frac{\theta}{\phi}\right)^\epsilon \left(\frac{P_d}{P_m}\right)^\epsilon \tag{5.2.4}$$

where P_d and P_m are the appropriate domestic and foreign output supply prices, respectively. In practice, various processes modify the above desired relationship:

(i) there may be lags in the adjustment of imports to their desired level determined by relative prices;

(ii) for small open economies, imports provide a source of goods and services to cover any unforeseen and temporary changes in final sales which are not matched by corresponding increases in capacity.

65. Also with homogeneity of degree zero in nominal prices gross substitutability is required when there are only two goods (Magee, 1975, p. 179).

Hence, capacity utilisation, CUR, will be an explanatory variable in the short-run imports relationship;

(iii) possible shifts in the utility function over time could be allowed for by the addition of a time trend; and

(iv) the existence of rigidities in the domestic factor supply system means that at a high level of aggregation it may be more appropriate to use domestic costs (C_d) rather than domestic output prices (P_d) when the two diverge, where C_d is a weighted average of capital and labour costs.

These considerations lead to an imports equation of the form

$$\left(\frac{MGSO}{GDP}\right) = a_0 \left[\frac{P_d}{P_m}\right]^{-\epsilon} \left[\frac{P_d}{C_d}\right]^{\epsilon_1} [CUR]^{\epsilon_2} \tag{5.2.5}$$

Thus, the level of imports can be determined if GDP is known. The choice of the CES transformation function has strong implications for price and income elasticities (Geary and McDonnell, 1977). For example, given prices, the optimal (MGSO/GDP) ratio is invariant with respect to changes in total expenditure on goods. Hence, the income elasticities for domestic and foreign goods are equal to each other and to the income elasticity for goods as a group.

Turning to imports of materials for further production, MFP, the approach followed is basically similar to that for other goods and services. The choice by purchasers of domestic or foreign supplies is then seen to be made in the same manner as before, i.e., in general terms

$$\left(\frac{MFP}{RM_d}\right) = f\left(\frac{P_d}{P_m}\right) \tag{5.2.6}$$

where P_d and P_m are the relevant domestic and foreign prices, and therefore

$$MFP = f\left(\frac{P_d}{P_m}\right) RM_d \tag{5.2.7}$$

The complication in this case is that there are no data for RM_d and so if a linear technology assumption is invoked to provide an operational theoretical framework, then

$$RM_d + MFP = RM = \gamma GDP$$

so that

$$RM_d = \gamma GDP - MFP$$

This then yields

$$MFP = f(\frac{P_d}{P_m})(\gamma GDP - MFP)$$

and, by rearrangement,

$$MFP = [1 + f(\frac{P_d}{P_m})]^{-1} . f(\frac{P_d}{P_m}) \gamma GDP \qquad (5.2.8)$$

The approach outlined here, particularly the manner in which the volume of imports is derived from the proportion of foreign to domestic goods and services, amounts to relating the volume of imports (M) to some appropriate measure of the level of economic activity (A),

$$M = mA$$

The coefficient of this relationship, m, is then parameterised by variables such as those listed in Equation (5.2.5). Implicit in this, and the manner in which the domestic production sectors are specified, is the view that domestic producers make decisions — based on their own anticipations about market demand, profitability, etc. — independent of foreign competitors and are only influenced by explicit channels such as relative prices. Although they are small in terms of the total potential supply, they are not facing a situation of perfectly competitive markets and hence the transformation relation we use between foreign and domestic goods and services allows for imperfect substitutability.

The more usual empirical approach to examining import demand employs single commodity demand functions, usually involving restrictive assumptions and a limited theoretical specification.[66] For example, one can regard the import demand function as an *excess demand* function which reconciles domestic demand and domestic supply. Domestic demand is usually

66. The general criticisms made of single-equation import demand functions is similar to that made in studies of consumer demand (Geary, 1973).

written as a function of income (Y), domestic price (P_d) and foreign price (P_m), i.e.,

$$D_d = f_1 (Y, P_d, P_m) \tag{5.2.9}$$

Domestic supply is a function of income (or output) and domestic price, i.e.,

$$S_d = f_2 (Y, P_d) \tag{5.2.10}$$

Hence, excess demand (or desired imports) is then

$$M^* = D_d - S_d = f (Y, P_d, P_m) \tag{5.2.11}$$

In a number of applications of this approach the functional relation, f, is usually assumed to be homogeneous of degree zero in prices and income, leading to an import equation of form

$$M^* = f(^Y/P_d, {}^{P_m}/P_d) \tag{5.2.12}$$

i.e., real desired imports are a function of real income and relative prices. A further term is often included: the capacity of the country to produce the goods itself. While some imports are not competitive with domestic goods because the country does not have the physical capacity to produce them, other imports will be competitive, and the demand for them will depend on the countries' ability to supply the substitutes.

Other than as an indication of the type of variables that may be relevant, international trade theory gives little guidance on the appropriate functional form to specify and estimate. Two particular functional forms are commonly used: the linear form and the log-linear form, although generalised functional forms are sometimes tested. Studies of the most appropriate form by Khan and Ross (1977) and Boylan, Cuddy and Ó Muircheartaigh (1979, 1980b) have concluded that the log-linear form was preferred, according to best-fit and Box-Cox search techniques, on the basis of empirical application to data for a selection of countries. In the linear case, the impact coefficients are constrained to be constant; in the log-linear case the elasticities are constrained to be constant. The log-linear form may be written as

$$\log M = a_0 + a_1 \log Y + a_2 \log \left(\frac{P_m}{P_d}\right) \tag{5.2.13}$$

Estimates using models along these lines have been presented by McAleese (1970), Sloane (1974) and Kelleher and Sloane (1976), using fairly aggregate data. FitzGerald (1979) studied the effects of shifts in the composition of final demand on imports by weighting each category of expenditure by the direct and indirect import content of that category, as derived from the 1969 input-output table.

An approach to investigating the role of capacity effects in the import equation makes use of a distinction between trend and cyclical income. The presumption is that as trend income grows, imports rise according to slowly changing consumption or production patterns. The trend income/import relation thus reflects both the effects of growing capacity and the Engel curve effect of growing income on consumption. Over the business cycle, however, the pressure of demand may cause supply bottlenecks which necessitate additional importing. Geary and McDonnell (1977) implement this concept in a very simple way. Trend income is derived by an exponential time trend. The cyclical variable is then derived as the ratio of income to trend income, i.e.,

$$Z_t = Y_t/\text{trend}\ (Y_t)$$

The variable Z_t will reflect the cyclical influence of income, and both Z_t and trend (Y_t) are entered into the import equation separately. One expects the coefficients on Z_t to be larger than the coefficient on trend (Y_t), thus quantifying the pro-cyclical nature of import demand.

The derivations outlined draw on some of the more recent international studies in this area. Gregory (1971) obtains import share equations from demand functions derived under the assumptions of utility maximisation. This approach has been applied to the Irish economy by Geary and McDonnell (1977). The economy is assumed to allocate expenditures as if it possessed a utility function weakly separable with respect to goods and services, and goods are assumed to be of two types: domestic and foreign.

This assumption implies that a two-stage budgetary procedure is optimal, i.e., total income is first allocated between goods and services and then a particular bundle of goods is chosen without reference to services. Gregory comments that his approach is more appropriate to the study of imports of consumer goods than to the study of total imports in the situation where a significant proportion of imports consists of intermediate goods. If all imports are intermediate goods, the utility tree may be re-interpreted as a production function, weakly separable with respect to the partition of inputs into intermediate goods and other inputs. Burgess (1974a, 1974b) derives import demand on the basis of such a production approach in which output (domestic gross value-added plus imported durables and non-durables) is produced by a three-factor production function where the three primary inputs are capital, labour and imported raw materials. Using this framework, he examines the consequences of the assumption that all imports are purchased by firms attempting to minimise costs of production. His empirical findings are that the assumed production technology is well behaved, (using a translog form), but that the conditions for separability between imported materials and primary factors are rejected.

Specification and Validation

The first decision to be made in estimating the import functions set out above concerns the degree of disaggregation by the type of goods to be used. In setting out the theory we distinguished two categories, imports for further production (materials) and imports of other goods and services. An obvious extension of this would be to separate out services as a separate category. Given our imposed limits on the degree of disaggregation we can pursue in this sectoral study we take this three-way split as the limit for empirical investigation. There are a number of data difficulties that have to be addressed prior to estimating empirical relationships and these are considered in Appendix 5.1.

In Table 5.2.1 we present OLS estimates for an aggregate equation explaining imports of goods (MG), based on Equations (5.2.4), (5.2.5) and (5.2.8). In Table 5.2.2 we present similar estimates for imports of goods and services (MGS) and in Table 5.2.3 and Table 5.2.4 we present a separate treatment of imports of services (MS). Finally in Table 5.2.5 estimates for goods for further production and other imports are given.

Turning first to Table 5.2.1 (imports of goods) for Equation 3 the summary results are as follows:

Elasticity with respect to:	Numerical value
Gross domestic product	1.681
Capacity utilisation in industry	1.289
Relative price	–0.368

The GDP elasticity is about at the lower point of the range of three elasticities estimated by McAleese (1970, p. 32). In FitzGerald (1979) an elasticity of imports of SITC categories 5-9 with respect to import weighted final demand was found to be approximately 1.5.

A variation of Equation 4 of Table 5.2.1 is one where gross domestic product (GDPFC) is purged of its cyclical component (proxied by CURI) and a trend or "capacity" GDP is defined as:

Table 5.2.1: *Imports of goods, OLS regressions, 1962-1979*

1.
$$\log MG = \underset{(11.5)}{-5.998} + \underset{(25.3)}{1.671} \log GDPFC - \underset{(2.6)}{0.387} \log \left(\frac{PMG}{PGDPF}\right)$$

$\bar{R}^2 = 0.978$ SER $= 0.0568$ D.W. $= 1.58$

2.
$$MG = \underset{(2.0)}{-954.6} + \underset{(12.3)}{0.963}\, GDPFC \quad \underset{(0.6)}{248.1} \left(\frac{PMG}{PGDPF}\right)$$

$\bar{R}^2 = 0.906$ SER $= 114.3$ D.W. $= 1.66$ RHO $= 0.4889$

3.
$$\log MG = \underset{(18.7)}{-6.006} + \underset{(41.5)}{1.681} \log GDPFC + \underset{(5.1)}{1.289} \log CURI - \underset{(4.1)}{0.368} \log \left(\frac{PMG}{PGDPF}\right)$$

$\bar{R}^2 = 0.992$ SER $= 0.0348$ D.W. $= 1.69$

4.
$$\log MG = \underset{(13.3)}{-5.759} + \underset{(30.1)}{1.650} \log GDPFC + \underset{(4.8)}{1.174} \log CURI$$
$$\underset{(3.6)}{-0.369} \log \left(\frac{PMG}{PGDPF} + \frac{PMG_{-1}}{PGDPF_{-1}}\right)/2$$

$\bar{R}^2 = 0.986$ SER $= 0.0313$ D.W. $= 1.77$ RHO $= 0.3387$

Notation:

MG	=	Imports of goods (£m, 75)
GDPFC	=	Gross domestic product at factor cost (£m, 75)
CURI	=	Rate of capacity utilisation in industry
PMG	=	Deflator of MG (base 1975 = 1.0)
PGDPF	=	Deflator of GDPFC (base 1975 = 1.0)

$$GDPCAP = GDPFC/CURI$$

In regressing imports on GDPCAP, CURI and relative prices we expect *a priori* that the trend (GDPCAP) elasticities would be smaller than the cyclical (CURI) elasticities. Estimation yielded the following results:

$$\log MG = \underset{(15.7)}{-6.082} + \underset{(34.5)}{1.691} \log GDPCAP + \underset{(11.4)}{3.024} \log CURI$$
$$\underset{(3.2)}{-0.320} \log \left(\frac{PMG}{PGDPF}\right)$$

$\bar{R}^2 = 0.988$ SER $= 0.0344$ D.W. $= 1.89$ RHO $= 0.2228$

This behaviour is consistent with the explanation advanced in the theoretical framework section, i.e., trend income influences imports through slowly changing production or consumption patterns but over the business cycle demand pressure may cause supply bottlenecks which necessitate additional importing. In the above equation, a one per cent rise in "trend" GDP causes a 1.7 per cent rise in imports, while a one per cent rise in the rate of industrial capacity utilisation causes a 3 per cent rise in imports.

Given the large size of the output elasticity, care should be exercised in using the double-log equations of Table 5.2.1 to project import behaviour out-of-sample. Nevertheless, even though the linear Equation 2 has more desirable *a priori* elasticity properties, the double log form dominates them, thus confirming the results of Boylan, Cuddy and Ó Muircheartaigh (1979). Finally, the results for imports of goods and services (MGS) are very similar to the Table 5.2.1 results for imports of goods, a fact which is not surprising given the relatively small size of services imports (Table 5.2.2).

Imports of services (MS) have been separated from total imports and can be treated in a different way to imports of goods (MG). In Table 5.2.3 we regarded MS as a function of weighted final demand. Equations 1 and 2 use double-log and linear formulations, while Equations 3 and 4 explore

Table 5.2.2: *Imports of goods and services, OLS regressions, 1962-1979*

1. $$\log MGS = \underset{(7.9)}{-6.10} + \underset{(17.4)}{1.694} \log GDPFC - \underset{(1.5)}{0.278} \log \left(\frac{PMGS}{PGDPF}\right)$$

$\bar{R}^2 = 0.954$ SER = 0.0564 D.W. = 1.79 RHO = 0.3906

2. $$MGS = \underset{(2.0)}{-1106.2} + \underset{(11.2)}{1.0578}\, GDPFC - \underset{(0.6)}{232.1} \frac{PMGS}{PGDPF}$$

$\bar{R}^2 = 0.886$ SER = 116.8 D.W. = 1.65 RHO = 0.6271

3. $$\log MGS = \underset{(11.5)}{-5.856} + \underset{(26.1)}{1.673} \log GDPFC + \underset{(5.0)}{1.331} \log CURI - \underset{(2.2)}{0.251} \log \left(\frac{PMGS}{PGDPF}\right)$$

$\bar{R}^2 = 0.980$ SER = 0.0351 D.W. = 1.90 RHO = 0.4357

Notation:

MGS = Imports of goods and services (£m, 75)
GDPFC = Gross domestic product as factor cost (£m, 75)
CURI = Rate of capacity utilisation in industry
PMGS = Deflator of MGS (base 1975 = 1.0)
PGDPF = Deflator of GDPFC (base 1975 = 1.0)

Table 5.2.3: *Imports of services (weighted final demand approach), OLS regressions, 1962-1979*

1. $\log MS = \underset{(7.3)}{-4.055} + \underset{(16.1)}{1.882} \log GFDMS$

$\bar{R}^2 = 0.942$ SER = 0.0474 D.W. = 1.90 RHO = 0.4562

2. $MS = \underset{(5.7)}{-132.3} + \underset{(11.6)}{2.334}\, GFDMS$

$\bar{R}^2 = 0.893$ SER = 7.663 D.W. = 1.77 RHO = 0.6581

3. $\log \left(\frac{MS}{GFDMS}\right) = \underset{(3.4)}{-0.437} + \underset{(4.4)}{0.0288}\, t$

$\bar{R}^2 = 0.536$ SER = 0.0583 D.W. = 1.90 RHO = 0.6828

4. $\log \left(\frac{MS}{GFDMS}\right) = \underset{(4.1)}{-0.636} + \underset{(5.0)}{0.796} \left(\frac{YPERD}{PCPER.NT}\right)$

$\bar{R}^2 = 0.598$ SER = 0.0536 D.W. = 1.69 RHO = 0.6987

Notation:

MS = Imports of services (£m, 75)
GFDMS = Gross final demand, weighted by (1969) services import content (£m, 75)
YPERD = Personal disposable income (£m)
PCPER = Deflator on personal consumption expenditure (base 1975 = 1.0)
NT = Total population ('000)
t = time (1953 = 1.0)

models of the average propensity to import services. In Table 5.2.4 we explore similar relationships, using real *per capita* personal disposable income as the main explanatory variable. There is nothing much to choose statistically between the results in Table 5.2.3 and 5.2.4.[67]

In Table 5.2.5 we present estimates for a two-way split of imports into goods for further production (MMFP) and other imports (including services) (MGSO). As discussed in Appendix 5.1 there are many problems with disaggregating import data into economic categories, particularly with the absence of appropriate price deflators. The equations of Table 5.2.5 are approximate in nature. The key fact to emerge is the insensitivity of imports

67. However, as pointed out in connection with the service sector (footnote 62), in an economy-wide model framework the choice of what particular equation to use has to be made by taking cognisance of how the "independent" variables in these equations would be actually endogenised.

Table 5.2.4: *Imports of services (income approach), OLS regressions, 1962-1979*

1. $$\log MS = \underset{(65.9)}{4.951} + \underset{(6.2)}{1.573} \log \left(\frac{YPERD}{PCPER.NT}\right)$$

$\bar{R}^2 = 0.685$ SER = 0.0866 D.W. = 1.67 RHO = 0.7491

2. $$MS = (\underset{(0.6)}{29.01} + \underset{(2.9)}{5.587}\, t) \left(\frac{YPERD}{PCPER.NT}\right)$$

$\bar{R}^2 = 0.672$ SER = 10.70 D.W. = 1.28 RHO = 0.8715

Notation:

MS = Imports of services (£m, 75)
YPERD = Personal disposable income (£m)
PCPER = Deflator of private consumption (base 1975 = 40)
NT = Total population ('000)
t = time (1953 = 1.0)

of goods for further production to any relative price effect, but their sensitivity to capacity utilisation, with an elasticity of 1.3. Other imports are quite sensitive to relative price effects (elasticity of -0.6) but are less sensitive to capacity utilisation (elasticity 0.7). Both categories of imports have the same elasticity with respect to GDP of approximately 1.7. These findings are broadly in line with *a priori* expectations.

To summarise this section, we have examined a number of the theoretical issues that influence the formulation of the import equation. There is an essential ambiguity about imports. On the one hand, they are a factor of production, and the largest part of imports concerns intermediate goods where large scale relacement by domestically produced goods is unrealistic. On the other hand, they are a component of final demand. Some of the main difficulties with using Irish trade data were discussed and results for aggregate import equations were presented. In these results, an essential distinction is made between trend effects and cyclical effects although a more detailed study of this important area is merited.

III. LABOUR SUPPLY

The framework for analysing production activity in the industry and services sectors is at a highly aggregate level with just two physical factors of production; capital and labour. The demand for capital, and, implicitly, the accommodating supply of capital, were analysed in Chapter 4 and

Table 5.2.5: *Imports of goods for further production and other imports, OLS regressions, 1962-1979*

1. $$\log(\text{MMFP}) = -6.714 + 1.704 \log(\text{GDPFC}) - 0.089 \log\left(\frac{\text{PMG}}{\text{PGDPF}}\right)$$
(11.9) (23.9) (0.6)

$\bar{R}^2 = 0.974$ SER = 0.061 D.W. = 2.15

2. $$\log(\text{MMFP}) = -6.722 + 1.714 \log(\text{GDPFC}) - 0.071 \log\left(\frac{\text{PMG}}{\text{PGDPF}}\right) + 1.256 \log(\text{CURI})$$
(16.8) (33.9) (0.6) (4.0)

$\bar{R}^2 = 0.987$ SER = 0.043 D.W. = 1.82

3. $$\log(\text{MGSO}) = -6.970 + 1.696 \log(\text{GDPFC}) - 0.578 \log\left(\frac{\text{PMGS}}{\text{PGDPF}}\right)$$
(4.2) (8.1) (2.7)

$\bar{R}^2 = 0.834$ SER = 0.064 D.W. = 1.31 RHO = 0.7832

4. $$\log(\text{MGSO}) = -6.303 + 1.616 \log(\text{GDPFC}) - 0.583 \log\left(\frac{\text{PMGS}}{\text{PGDPF}}\right) + 0.666 \log(\text{CURI})$$
(4.4) (9.0) (2.8) (1.5)

$\bar{R}^2 = 0.873$ SER = 0.061 D.W. = 1.42 RHO = 0.707

Notation:

MMFP = Imports of goods for further production (£m, 75)
MGSO = Other imports (£m, 75)
GDPFC = GDP at factor cost (£m, 75)
PMG = Deflator of imports of goods (base 1975 = 1)
PMGS = Deflator of total imports (base 1975 = 1)
PGDPF = Deflator of GDP at factor cost (base 1975 = 1)
CURI = Rate of industrial capacity utilisation

Section I of this chapter. The demand for labour by the three domestic production sectors, industry, agriculture and services,[68] was also examined theoretically and empirically. The supply of labour, however, has not yet been addressed. Just as in the case of investment expenditure, which is both a component of aggregate demand and has a capacity effect, there is a dual aspect to labour. Sufficient availability of labour is a key element in

68. Employment in public administration is discussed in Chapter 6.

the process of economic development. But the rate at which labour is absorbed into employment, the second aspect of labour, has also important consequences for the growth of the economy. In the absence of emigration outlets, a relatively high rate of population growth combined with the rapid release of labour from agriculture, as was the case in Ireland up to the 1950s, results in an increasing rate of unemployment if the rate of absorption by the industry and service sectors is inadequate.[69] This rising dependency rate among the working age population – to which is added the dependency of the non-working population – places a severe burden on the tax-financed redistribution mechanism. Such taxation has serious consequences for employment, investment and growth. Emigration is thus like a safety valve and has been of major importance in the past, serving to lower the rate of unemployment from what it otherwise might have been. It has also, probably, facilitated social "stability", albeit at the cost of the stagnation that accompanies a declining population due to enforced exodus. But the costs of emigration and unemployment extend to effects on capacity and output which result in loss of labour itself, as well as the skills and investment that went into education and training and lead to a depressed entrepreneurial environment and declining markets.[70] The mass emigration experience is one that has been of particular significance in the development of the Irish economy. But the demographic experience since the 1960s has been a sharp contrast to that of the preceding decades. Although emigration continued to exceed immigration, on a diminishing scale, up to 1971, overall population was expanding from a decade earlier, 1961. Also the return migrants were generally more skilled than those leaving and were often accompanied by a young family. Indeed, the age of the eldest child was an important influence on the migration decision because of schooling. Furthermore, the impact of civil disturbances in Northern Ireland also appears to have had a significant effect. However, in the early 1980s the position would appear to be one of a precarious balance: population continues to expand, and currently 48 per cent of the population is under 25 years of age; employment prospects are declining; the traditional emigration outlets are closed down as a consequence of world recession and demographic and labour force developments internal to these countries. Therefore, as this brief account suggests, the interrelationship between employment and labour supply is a crucial one in analysing Irish economic development.

69. In the period covered by our analysis, 1960-1979, the decline in agricultural employment is due primarily to retirement from work rather than migration of working age persons to alternative employment. This does not affect the point being made here.

70. The economic implications of falling population due to large-scale emigration are discussed by O'Mahony (1964a, pp. 11-16).

We now turn to consider a framework that permits examination of, at least, some of these features at an aggregate level.

Theoretical Framework

The supply of labour is defined as the amount of labour available for employment in a particular period of time and, theoretically, the appropriate measure of labour supply is person-hours. For a given population of working age this is the result of two decisions; the first is to participate in the labour force, i.e., to seek gainful employment, and the second, given that participation, is to supply a particular number of hours. The supply of labour is, therefore, the combined result of these decisions and the overall labour supply function is of the form:

$$LSH = LFPR\,(Z_1) \times LFH\,(Z_2) \qquad (5.3.1)$$

where LSH is the total person-hours available, LFPR is the labour force participation rate (the proportion of working age population engaged in or seeking paid employment), LFH is the labour force supply of hours, and Z_1 and Z_2 are sets of factors, which may have elements in common, determining the respective decisions about LFPR and LFH. The decision to participate also involves, perhaps in an interrelated way, a decision about *where* to participate. In an aggregate labour market that is closed to migration across national boundaries, the net effect of the internal gross migration flows cancel out. However, in an open labour market the decision to participate in the labour force may involve moving across national boundaries. Therefore, the possibility of emigration and immigration must be allowed, and the impact of these flows on population and its structure must be included in an analysis of a labour market such as that in Ireland. In the following three subsections we consider the theoretical aspects of labour supply and migration, and then combine the relevant features of both in an overall framework for econometric modelling.

Labour Force Participation

The supply of labour function stated above had two elements to it: the labour force participation decision and the supply of hours decision. Although these decisions are not necessarily independent as mentioned, empirical studies of overall labour supply have generally concentrated on either the population activity rate or the hours decision. In Appendix 5.2 we provide a brief review of the elements of both approaches with a view to isolating the main features of each and identifying the data requirements for empirical work. In empirical work, the decision of persons to participate in the labour force is generally studied as a labour-force participation rate equation. This participation rate, generally expressed as the fraction of the economically active population (NA) available for work (LF), i.e., LF/NA, is interpreted as the probability that a person with certain demographic characteristics will be active in the labour force, i.e., seeking employment, or in employment. The demographic characteristics separately identified include such items as age, sex, location, primary/secondary labour force characteristics, occupation, etc. Data considerations obviously limit our ability to quantify such matters and furthermore, available data effectively limit us to an examination of the effect and determinants of net changes in labour force participation where the gross flows, which may be considerable, are not observable. Our treatment of labour supply is, therefore, concerned only with the net number of persons recorded as active in the labour force and the approach we follow is that associated with the empirical studies of the labour-force participation rate. From Appendix 5.2, one such equation is of form:

$$\frac{LF}{NA} = (UR, RW, t) \tag{5.3.2}$$

i.e., the labour-force participation rate is determined by the unemployment rate (UR) the real wage (RW) and a time trend to capture slowly changing demographic characteristics. *A priori* we expect the unemployment rate to exercise a negative effect (the discouraged worker effect), the real wage to exercise a positive effect (upward sloping labour supply curve), and the trend to capture the net effect of such factors as falling age of retirement and rising proportion of married women working.

The above basic format can be generalised to include such effects as money-illusion, i.e., changes in labour force participation in response to nominal rather than to real wages, and cyclical effects, which drive a wedge between numbers at work and hours worked.

Net Migration Abroad

The preceding discussion of aggregate labour supply took no account of the possibility that the decision to participate in the labour force may involve the decision to emigrate from, or immigrate into, the domestic labour market. The usual theoretical framework for analysing emigration and immigration is based on the view that such movements can be regarded as a subset of the overall migration flows. The basic theoretical formulation is derived from a human capital approach in which migration is regarded as an investment decision. Migration is regarded as due primarily to the relative differential in expected returns from migration with allowance made for the variability of return.[71] The expected lifetime net advantage from migration is taken to be due to income differentials and job opportunity differentials as a measure of the variability of returns. In this context, if inter regional income differentials are constant, job opportunity differentials are of primary importance in the timing of migration decisions and the direction of migration is determined by net expected returns to migration. Thus, wage differentials are a necessary but not a sufficient condition for migration (Langley, 1974, p. 260). A distance variable to take some element of the costs of migration into account, and a migrant stock variable to include information, income assistance, and other influences from relatives and friends are also included (Langley, 1974, pp. 263-267). The four behavioural elements of a migration model are, therefore, expected return, job opportunity as a measure of earnings variability, distance, and a relatives/friends factor. It is also necessary to control for scale effect, the relative sizes of the population pools exposed to migration, by including an appropriate population variable. The relevant population base is identified by matching with the migration groups whose behaviour should be homogeneous with respect to the determining variables (Langley, 1974, p. 261).

In Appendix 5.3 we consider an analytical formulation of the migration function along the lines set out above. This allows us to identify some problems with existing empirical studies of Irish net migration. These concern the treatment of the respective populations from which outmigration may occur, the manner of operationalising the relation of the foreign and domestic explanatory variables, the specific explanatory variables to be chosen, and the treatment of expectations. This examination of the specification and estimation of net migration functions together with the unsatisfactory experience in estimating such relations[72] suggest the need to reconsider such a task in the light of the needs of empirical analysis. In particular, if the choice is between omitting necessary population variables, or using poor proxies, it may be better to make an alternative, direct simple approach.

Therefore, because of the difficulties involved in specifying and operationalising a net migration function and the binding data constraint, we propose an alternative approach based on the domestic demographic origin of emigrants or destination of immigrants. It is assumed that the flow of emigrants ($M_{DF,\,t}$) during a particular period originates from the potential emigrant population of the preceding period, say domestic working age

71. The specification of this type of migration model is set out, for instance, in Langley (1974) and Walsh (1974).

72. Keenan (1981) found great instability and poor out-of-sample predictive power when he replicated some previous models using alternative series of net migration estimates.

population (N1564), and that there is a certain propensity (η_1) to emigrate from that stock, i.e.,

$$M_{DF,t} = \eta_1 \ N1564_{t-1} \tag{5.3.3a}$$

Correspondingly, it is assumed that the flow of immigrants ($M_{FD,t}$) enters the appropiate population stock, for the moment taken to be the same working age population, and measured for the same period as the flow, and that there is a certain propensity (n_2) to enter that stock, i.e.,

$$M_{FD,t} = \eta_2 \ N1564_t \tag{5.3.3b}$$

Net migration abroad is, therefore,

$$NMA_t = M_{DF,t} - M_{FD,t} \tag{5.3.4a}$$

Since the formulation set out in (5.3.4a) implies that emigration and immigration takes place irrespective of domestic economic and labour market conditions, we allow for such influences on the timing of flows by parameterising the estimated propensities with appropriate factors (Z), i.e.,

$$\eta_1 = \delta_0' + \delta_1' Z \tag{5.3.4b}$$

and

$$\eta_2 = \delta_0'' + \delta_1'' Z$$

This technique, however, decreases the degree of freedom in a small sample and to reduce this problem we could define a single population stock available as a two-year moving average of those in (5.3.4a), i.e.,

$$NM1564_t = 0.5 \ (N1564_{t-1} + N1564_t)$$

and, therefore,

$$NMA_t = (\delta_0 + \delta_1 Z) \ NM1564_t \tag{5.3.5}$$

Only domestic population variables are included and with the avoidance of foreign population variables, which are not available, the foreign origins and destinations are not limited to one, such as the UK. The effect of alternative origins and destinations can be more easily included in the parameterising variables, thus avoiding the omission of population variables. Specifying the estimating equation as in (5.3.5) has the further advantage that the population variable can be disaggregated into components to allow for differing propensities to migrate from each part and to allow for differing impacts from the parameterising variables. There is, therefore, no need to confine the population variable to working age population. The net migration data available include all age groups and, as the evidence cited already shows, the relative magnitude differ substantially between age groups and for net emigration and net immigration.

Before concluding this section, it is worth considering the relation between this formulation and the equation as usually estimated. From Appendix 5.3, we can write a net migration function of the form commonly used, as

$$NMA_t = [a_0 + a_1 (Z_{D,t} - Z_{F,t})] \, NM_{D,t-1} \tag{5.3.6}$$

where

NM_D = Potential domestic population exposed to out-migration
Z_D = Domestic (non-population) explanatory variables
Z_F = Foreign (non-population) explanatory variables

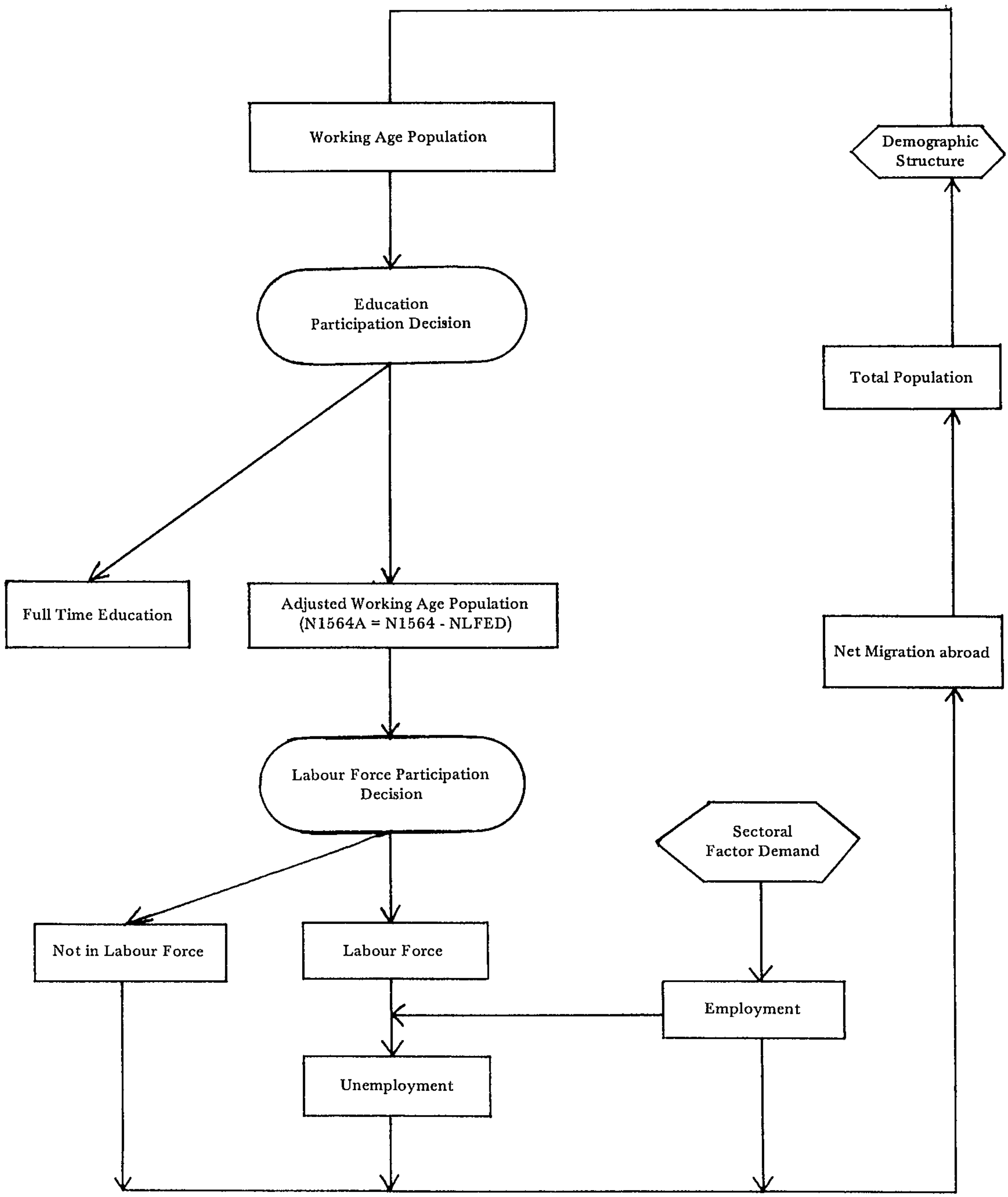
which gives an estimate of the propensity to migrate from $NM_{D,\ t-1}$ parameterised by the net difference between domestic and foreign expected advantages. However, this specification, as pointed out, omits a theoretically important, but unavailable population variable ($NM_{F,\ t-1}$) and is not derivable from the correctly specified structural equations. Alternatively, if interpreted on the basis of the pragmatic approach in (5.3.4a) above, it omits a different population variable, $NM_{D,t}$. Given these difficulties of operationalising and interpreting single equation net migration functions, the simple approach suggested above may be more suitable for structural analysis and permit greater empirical flexibility.

Overview of Labour Supply

The formulations outlined for labour force participation and net migration abroad provide the framework for empirical analysis of aggregate labour supply. Figure 5.2 provides and overview of the structure of the decision framework followed. The starting point is the division of the total population into three age groups: less than or equal to 14 years (NLE14), working age population (N1564), and equal to or greater than 65 years (NGE65). These are derived by the population identity.

Change in Population = Natural Increase — Net Migration Abroad

Figure 5.2: *Labour Supply Decision Framework*



where natural increase (NNI) is the growth that would occur in the population of each specific age group in the absence of net migration. Having derived population of working age we isolate those who are removed as potential labour force participants by virtue of taking up full-time education. The remainder is then further separated into those who are actively participating in the labour force (LF) and those others remaining outside the labour force (NLFO). Of those in the labour force, the numbers employed are determined by the factor demand for labour in the three domestic production sectors of the supply block and employment in public administration. Unemployment then emerges as a residual. The population stock out of which working age emigrants exit or immigrants enter is made up of L, U and NLFO (perhaps NLFED). However, the available data on net migration abroad are not disaggregated into working age population and this has to be taken into account. It can be done by using a broader measure of population than working age or by using the estimated coefficients on NMA from the demographic equations to subdivide the net migration flow. Finally, the net migration flows feed back into the demographic growth section and, together with the estimated (exogeneous) natural growth in population by age group, alters working age population.

Specification and Validation

In this section empirical relationships based on the schematic diagram, Figure 5.2 above, are specified and estimated. Four behavioural elements can be isolated:

(i) population growth equations for the population disaggregation level chosen in specifying the model;
(ii) education participation decision equations for working age population;
(iii) labour-force participation decision equation for the adjusted working age population; and
(iv) net migration functions.

In the case of working age education participation, the relevant age group is probably 15 to 24 since the probability of participating in education after 24 is likely to be extremely low. In the case of labour force participation, it is probably desirable to split the labour force into male and female (indeed, into male, single female and married female) since major changes in behaviour have been occurring in the participation levels of married females. For this first specification we decided to use a more aggregate approach than is strictly required by data limitations. The schema we have outlined in Figure 5.2, if it proves useful in analysis of past behaviour of labour supply phenomena, can be easily disaggregated, along the lines suggested above, at the expense of enlarging the size of the sector.

In Table 5.3.1 we show estimates of the three age-specific population growth rates. In each case the change in population is related to a "natural" increase (assuming a constant growth rate) and migration correction. This excludes the effect of changes in the population of preceding cohorts. Also, in the case of Equation 1, this results in the omission of an important effect, due to a key age group outside the population less than or equal to 14 years, namely, the number of women of child bearing age and their fertility rate. Furthermore, since we do not have age-specific net migration data, we essentially estimate the fraction of the net migrant flow which falls in each age group. Equations 1, 2 and 3 of Table 5.3.1 show independent estimates for the three-way population age breakdown. Since the summation of the

Table 5.3.1: *Population growth, OLS regressions, 1962-1979*

1. $$\Delta NLE14 = \underset{(15.9)}{0.00933}\ NLE14_{-1} - \underset{(5.2)}{0.205}\ NMA$$

$\bar{R}^2 = 0.664$ SER $= 2.33$ D.W. $= 2.08$

2. $$\Delta N1564 = \underset{(14.1)}{0.01162}\ N1564_{-1} - \underset{(6.6)}{0.678}\ NMA$$

$\bar{R}^2 = 0.757$ SER $= 6.08$ D.W. $= 1.64$

3. $$\Delta NGE65 = \underset{(12.0)}{0.00810}\ NGE65_{-1} - \underset{(4.5)}{0.072}\ NMA$$

$\bar{R}^2 = 0.577$ SER $= 0.950$ D.W. $= 1.79$

4. $$\Delta NT = \underset{(15.5)}{0.01052}NT_{-1} + NMA$$

$\bar{R}^2 = 0.757$ SER $= 8.664$ D.W. $= 1.80$

Notation:

NLE14 = Population aged between 0 and 14 ('000)
N1564 = Population aged between 15 and 64 ('000)
NGE65 = Population aged over 64 ('000)
NT = Total population ('000)
NMA = Net migration abroad ('000)
Δ = First difference operator

three age-specific groups equals the total population, NT, we also estimate the total population change equation where we constrain the coefficient on net migration to be minus one. In fact the first three coefficients sum to almost unity (actually, 0.955). If the equations are used together, one of them must be estimated with an imposed value for the migration coefficient to ensure the adding up constraint.

Turning to the results of the first three equations, we summarise the conclusions in Table 5.3.2. below.

Table 5.3.2: *Summary results for population growth*

	Natural growth rate (% p.a.)	*Migration (fraction)*
Population aged between 0 and 14	0.933	0.205
Population aged between 15 and 64	1.162	0.678
Population aged over 64	0.810	0.072
Total population	1.052	1.0

One of the problems with an approach of this kind is that the migration fraction in each age group depends crucially on the direction of net migrant flows. If, as occurred in the 1960s, the net flow is abroad, i.e., NMA positive, then the fraction of migrants in the 15-30 age group is thought to have been very large as young single people left. However, in the early 1970s, the direction of net flow reversed, i.e., NMA negative, and it is thought that the inward migrant flows included a large component of people in the 30-40 age bracket, accompanied by young families. Consequently, these equations, which were estimated over the entire 1960 to 1980 period, should be interpreted with caution.

As mentioned above, the estimation we have carried out does not make full use of available population data classified by age groups. In order to keep the sectoral detail to a manageable size, we estimate working age education participation in terms of the percentage of *total* working age population in full-time education. In Table 5.3.3 we present some statistical estimates. In these models, the "explanatory" variables are of three types[73]:

73. Sexton and Walsh (1982) give a full treatment of data sources. It must be noted that the methods used to derive the data in many cases preclude formal hypothesis testing because the data are constructed on the basis of maintained economic hypotheses (Sexton, 1981).

Table 5.3.3: *Working age education participation, OLS regressions, 1962-1979*

	Dependent Variable: log (EDPR)								
Eq.	*Intercept*	*log UR*	*log LR*	*DUMED*	*t*	*log* $EDPR_{-1}$	$\bar{R}^2$	*SER*	*D.W.*
1.	0.666 (3.2)	0.773 (6.0)	—	—	—	—	0.671	0.134	0.50
2.	-1.173 (3.5)	—	-6.006 (9.1)	—	—	—	0.828	0.097	0.38
3.	0.592 (1.0)	—	-2.193 (1.8)	0.322 (3.5)	—	—	0.899	0.074	0.31
4.	1.719 (4.4)	—	1.230 (1.3)	0.147 (2.3)	0.039 (5.5)	—	0.966	0.432	0.55

Notation:

EDPR = Percentage of population of working age in full-time education
UR = Unemployment rate
LR = Employment rate
DUMED = Dummy variable for free secondary school education
t = time (1953 = 1.0)

Note: The equations are heavily autocorrelated due to the trend nature of the data, which are not really suitable for hypothesis testing.

(i) job availability measures (i.e., the unemployment rate or the employment rate);
(ii) A dummy variable designed to capture the effect of the introduction of free secondary school education in 1968 (i.e., of value zero up to 1967, and rising to unity over five years by steps of 0.2 per year); and
(iii) A time-trend, to capture slowly changing demographic factors.

In isolation, the job availability effects have the expected signs, i.e., if the unemployment rate rises, the participation rate also rises (Equation 1), while the employment rate has the opposite effect (Equation 2). Inclusion of the free education dummy variable causes a fall in the magnitude and significance of the jobs availability variable, and the dummy variable causes a fall in the magnitude and significance of the jobs availability variable, and the dummy variable has the expected positive sign. Inclusion of all three explanatory measures causes the jobs availability term to become insignificant (and reverse sign), the dummy variable effect falls in magnitude and significance, while the time trend effect is strongly significant and positive.[74]

At the level of aggregation used in Table 5.3.3 it is difficult to pinpoint these three effects more precisely. For example, in addition to the excessively broad target population measure used (N1564 instead of N1524), the aggregate unemployment rate, UR, may not be a good measure of the probability of a person of age between 15 and 24 finding a job.

In Table 5.3.4 we present estimates of labour force participation, once again using a single aggregate measure. Four explanatory variable types are used:

(i) Job availability measure (as in the education participation model).
(ii) An index of real non-agricultural wages.
(iii) A time trend to capture slowly changing demographic effects.
(iv) The average rate of unemployment transfers.

Equations 3 and 4 appear satisfactory showing, in the case of 3, an encouraged worker effect and a positive real wage effect, and, in the case of 4, a positive trend in participation over time. Inclusion of both the real wage term and the time trend resulted in both being insignificant, probably due to multicollinearity.

Inclusion of a lagged dependent variable resulted in total loss of significance of all the other explanatory variables. In Equation 5, the unemployment compensation measure has a positive effect on participation, although this variable, which trends positively over time, could be merely picking up the real wage or demographic effects. Because of the degree of aggregation it is not possible to isolate influences which affect different age or sex groups, except to the extent that net effects may be captured by the time trend. Specifically, the rapid decline in fertility throughout the 1960s and especially 1970s has important consequences for labour force participation by women — whether the causal influences run from having fewer children and therefore being available for, and seeking, market employment, vice versa, or interdependent, is a subject that requires consideration at a more detailed level of analysis than can be undertaken here. However, there is also a major data difficulty here that imposes a severe constraint on the explanatory power of any theoretical framework. First, the annual population estimates for non-census and labour force survey years are all estimated by linear interpolation, between point estimates for census or labour force survey

74. Also, there was a significant increase in the numbers of education over 1975-1976 (Sexton and Walsh, 1982, p. 60) coinciding with a recession in the economy.

Table 5.3.4: *Labour force participation, OLS regressions, 1962-1979*

Dependent variable: log (PART)

Eq.	*Intercept*	*log UR*	*log LR*	*log WIRIR*	*t*	*log RUCP*	$\bar{R}^2$	*D.W.*
1.	4.259 (840.)	-0.026 (8.2)	–	–	–	–	0.851	0.90
2.	4.312 (399.)	–	0.186 (6.5)	–	–	–	0.866	0.45
3.	4.381 (143.)	–	0.313 (5.5)	0.021 (2.4)	–	–	0.896	0.62
4.	4.260 (676.)	-0.028 (4.2)	–	–	$1.19.10^{-4}$ (2.4)	–	0.843	0.97
5.	4.269 (252.)	-0.028 (5.8)	–	–	–	$5.22.10^{-3}$ (1.6)	0.846	1.07

Notation:

PART = Labour force participation rate (percentage)
UR = Unemployment rate
LR = Employment rate
WIRIR = Index of real non-agricultural wages (1975 = 1.0)
RUCP = Unemployment compensation measure (i.e., average unemployment transfer per unemployed person).
t = time (1953 = 1.0)

Note: The equations are heavily autocorrelated due to the trend nature of the participation rate data. Correction procedures did not remove the autocorrelation. The equation is best thought of as an attempt at *parametrisation* rather than *estimation*.

years, within age groups by sex. Then, second, participation rates are interpolated from point estimates in census and labour force survey years. There is, therefore, a regularity imposed on these data which probably did not exist in reality. In other words, the data were *constructed* independent of the economic forces influencing the actual outcomes. This seriously hinders the task of identifying true coefficients.

In Table 5.3.5 we present estimates of the relationship explaining net migration abroad. The first set of models includes only a single population cell and the net migration coefficients are parametric in the relative Irish-UK employment rate (as a proxy for relative job availability), the relative Irish-UK real wage (as a proxy for relative returns to working), and the product of both measures (as a proxy for the relative net advantage of the

Table 5.3.5: *Net migration abroad, OLS regressions, 1962-1979*

(A) *Single population cell models:* 1962-1979

1. $$\text{NMA} = \underset{(0.1)}{(-0.046} + \underset{(0.1)}{0.047}\ \text{RE})\ \text{NM1564}$$

$\bar{R}^2 = 0.00$ SER = 14.8 D.W. = 0.30

2. $$\text{NMA} = \underset{(4.6)}{(0.057} - \underset{(4.6)}{0.060}\ \text{RW})\ \text{NM1564}$$

$\bar{R}^2 = 0.54$ SER = 9.72 D.W. = 0.74

3. $$\text{NMA} = \underset{(1.6)}{(-0.405} + \underset{(1.8)}{0.478}\ \text{RE} - \underset{(5.2)}{0.068}\ \text{RW})\ \text{NM1564}$$

$\bar{R}^2 = 0.60$ SER = 9.08 D.W. = 1.01

4. $$\text{NMA} = \underset{(4.4)}{(0.055} - \underset{(4.4)}{0.059}\ \text{RE. RW})\ \text{NM1564}$$

$\bar{R}^2 = 0.51$ SER = 9.98 D.W. = 0.71

(B) *Two cell models: labour force and not in labour force:* 1962-1979

5. $$\text{NMA} = \underset{(1.8)}{(13.67} - \underset{(1.7)}{13.75}\ \text{RE})\ \text{LFM} + \underset{(1.8)}{(-23.29} + \underset{(1.8)}{23.43}\ \text{RE})\ \text{NLFM}$$

$\bar{R}^2 = 0.68$ SER = 8.15 D.W. = 1.09

6. $$\text{NMA} = \underset{(3.1)}{(1.118} - \underset{(2.5)}{0.923}\ \text{RW})\ \text{LFM} + \underset{(3.1)}{(-2.020} + \underset{(2.6)}{1.682}\ \text{RW})\ \text{NLFM}$$

$\bar{R}^2 = 0.71$ SER = 7.65 D.W. = 1.46

7. $$\text{NMA} = \underset{(3.2)}{(1.063} - \underset{(2.5)}{0.902}\ \text{RE. RW})\ \text{LFM} + \underset{(3.2)}{(-1.903} + \underset{(2.6)}{1.625}\ \text{RE. RW})\ \text{NLFM}$$

$\bar{R}^2 = 0.72$ SER = 7.61 D.W. = 1.43

Notation:

NMA	=	Net migration abroad ('000)
RE	=	Measure of relative Irish-UK employment rates
RW	=	Measure of relative Irish-UK real wage rates
NM1564	=	Adjusted population of working age (refer text) ('000)
LFM	=	Adjusted labour force ('000)
NLFM	=	Adjusted numbers not in labour force ('000)

Irish versus the UK labour markets). This latter measure is in the spirit of the Harris-Todaro models of rural-urban migration (Harris and Todaro, 1970). For the single-cell model, we also include a linear combination of both effects. The empirical results indicate, in the case of Equations 2 and 4, that improvement in relative wages or relative advantage (for Ireland over the UK) reduces the otherwise positive migration abroad tendency. The results of Equation 4 can be interpreted as follows. If the relative advantage of working in Ireland *vis-a-vis* the UK falls below 0.93 then the net flow of migrants related to the population cell is outward. If relative conditions rise above 0.93, the net flow is inward.

Turning to the two-cell models, Equation 7 gives the best overall statistical fit when the two cells consist of those in the labour force (LFM) and those not in the labour force (NLFM).

To summarise the analysis conducted in this section, we set out, in Figure 5.2, a schema of the analytical framework followed in approaching the aggregate labour supply, the internal relationships within that sector, and the external linkages to other sectors of the economy. Population growth determines the working age population pool, the size of which is sensitive to decisions to participate in full-time education. Next, labour force participation was found to be sensitive to employment opportunities (encouraged worker affects), real wages, and trending demographic and social changes. Finally, a simple migration mechanism is posited, where the propensity to migrate out of population cells (classified by labour force status) is parametric in the relative attractiveness of employment conditions in Ireland. Overall, the results are adequate for analysis at this level of aggregation. Analysis offering a higher degree of explanatory power would have to be conducted at a higher level of disaggregation of dependent and independent variables. However, the available data of the type used would hardly be suitable for the task and the econometric use we have made of them has, indeed, probably pushed it too far.

Chapter 6

ABSORPTION

I. *INTRODUCTION*

In Chapters 4 and 5 we have examined aggregate supply within a structural framework. This involves estimating output and factor demand relationships for the industry, services, and agriculture sectors. The output of the fourth production sector of the economy, the public administration branch of the state sector, is of a different nature than the other sectors because it is measured purely in terms of labour input, i.e., it is assumed that capital makes no contribution to output. This sector is considered later in the context of the government absorption subsector. The summation of the four sectoral outputs at current prices gives gross domestic product at factor cost (GDPFCV) i.e.,

$$GDPFCV = OIV + OAFFV + OSV + OPAV$$

which is then adjusted to market prices, by adding net indirect taxes, to give gross domestic product at market prices (GDPMV). Imported goods and services (MGSV) are also part of the overall supply of goods available domestically, so that total supply, or gross domestic supply at market prices (GDSV), is given by

$$GDSV = GDPMV + MGSV$$

This is balanced by total demand, according to the national accounts identity which is being used as the organising framework for our analysis and in a manner similar to total supply, is composed of domestic and foreign components. The domestic spending on goods and services is made up of four broad categories: personal consumption expenditure (CPERV), government current expenditures (CGV), gross domestic fixed capital formation (IFV), and changes in inventory holdings (IIV). When these are valued at current market prices, their summation gives the value of gross domestic absorption at current market prices (GDAV), i.e.,

$$GDAV = CPERV + CGV + IFV + IIV$$

The fifth, and final, component of total demand is gross foreign absorption, or in the usual terminology, exports of goods and services (XGSV), which, when added (at current market prices) to gross domestic absorption gives gross final demand at current market prices (GFDV)

$$\text{GFDV} = \text{GDAV} + \text{XGSV}.$$

The demand for, and expenditure on, the private non-residential part of fixed investment has already been analysed in the supply sectors and results from derived factor demands for fixed assets. The remaining components of gross final demand are examined in this chapter. The chapter is organised into five parts. The purpose of the first four subsections is to study the elements of domestic absorption which we have not already analysed in other sectors, namely, private consumption (CPERV), public consumption (CGV), housing investment (in terms of its private, IHPV, and public, IHGV, elements), other public investment, and inventory investment (in its industrial, IIIV, services, IISV, and agricultural, IIAV, components). The bulk of fixed investment (i.e., the non-residential building part) has already been determined in the supply sectors. In the fifth subsection we consider the final, foreign component of total demand, exports of goods and services (XGSV). The total demand side, in contrast to the total supply side, of the overall accounting balance has been the subject of quite extensive empirical analysis. In particular, personal consumption expenditures, exports and, to a somewhat lesser extent, inventory holdings have been widely studied. Some attention has been paid to residential investment and to components of government current expenditure.

Our purpose in this section is to make as much use of the previous analyses of elements of total demand, by re-estimating previously estimated relationships with a common data set, and most important, approaching the empirical analysis so as to maintain consistency with the overall framework which guides this study.

II. *PERSONAL CONSUMPTION EXPENDITURE*

Theoretical Framework

The consumption function has been one of the more widely researched areas of Irish applied economics (e.g., Kennedy and Dowling, 1970; Kelleher, 1977; and Honohan, 1979), but has proved to be very unstable in specification over the years when re-estimated with additional national accounts data.

Kennedy and Dowling (1970) considered the problem in its savings ratio form and initiated the most recent Irish research. They were interested not merely in getting a good short-run explanatory equation but also in testing variables which are commonly thought to influence personal saving in the longer run.[75] To this end they carried out extensive statistical testing and used 40 explanatory variables in estimating some 400 equations. The explanatory variables were classed under five headings: income, taxation, demographic, monetary and a miscellaneous class. Their final choice of best equation related the savings ratio linearly to eight explanatory variables: real income; the share of farm in total income; the ratio of direct taxes to non-agricultural income; the ratio of indirect taxes (less subsidies) to consumption; the employment dependency ratio; the rate of change of the population; the rate of change of credit and a real rate of interest.

On re-estimation with the most recent data set, the results show a large fall in significance and even opposite signs on some of the coefficients. This is an example of parameter instability and although this set of variables may well influence the savings ratio, it causes out-of-sample tracking problems and illustrates the limitations of modelling from small samples. An equation of this nature can appear to be very significant but really is only applicable to a very specific data set. When re-estimated using other data sets the fit may be very poor.

The aggregate consumption function was specified to incorporate a real liquid assets effect on consumer behaviour by Kelleher (1977), which was based on work for the UK by Townend (1976). Kelleher's work suggested that since the recession of 1974-1976 standard consumption functions were unable to track the observed high level of savings ratios simply because they failed to take account of the role of liquid assets. In addition, Kelleher investigated the possibility of different MPCs out of agricultural and non-agricultural income, examined the time pattern in the response of consumer expenditure to changes in income (i.e., the existence of lags) and tested for the existence of money illusion. His initial specification was

$$C_t = a_0 + a_1\ YA^r_t + a_2\ YNA^r_t + a_3\ LIQ^r_t + a_4\ CPER_{t-1} \qquad (6.1.1)$$

where

C_t is real personal consumers' expenditure
YA^r is real (i.e., deflated) agricultural disposable income
YNA^r is real non-agricultural disposable income
LIQ^r is real value of liquid assets held by the personal sector.[76]

75. A similar study of the determinants of the savings ratio in the context of economic growth had been carried out by Modigliani (1970).

76. Kelleher (1977) gives exact data definitions. The liquid assets variable is a stock variable and should more properly have entered the equation as a lagged value.

Kelleher expected *a priori* that $a_1 < a_2$.[77] After empirical investigations, he dropped the lagged adjustment mechanism and accepted the hypothesis of no money illusion. Thus the consumption function which best described Irish behaviour from 1954-1976 included real income and real liquid assets and allowed for the different MPCs out of agricultural and non-agricultural income. Subsequent re-estimation showed up instability in both the agriculture non-agricultural MPC split and in the significance of the real liquid assets term.

The next major revision of the aggregate consumption function was due to Honohan (1979) and was based on work by Deaton (1977). Very simply, this theory proposed that consumers, in inflationary times, tend to mistakenly regard the higher prices for certain goods that they observe as higher relative prices for these goods. If inflation continues to accelerate and if expectations lag behind reality, the savings ratio will remain abnormally high. A conventional consumption function relating saving and consumption to real income, and estimated over a period when inflation was more or less correctly anticipated, will underestimate the savings ratio in a period of unanticipated inflation. Honohan used the following equation:

$$\Delta(S/Y) = a_0 + a_1 g + a_2 p + a_3 (S/Y)_{t-1} \qquad (6.1.2)$$

where

S/Y – is the savings ratio

g – rate of growth of real disposable income

p – rate of inflation.

This equation is able to track the unusual movements in the savings ratio in the six years, 1973-1978. Honohan found that the inclusion of explanatory variables like the ratio of agricultural to total disposable income, the growth rate of agricultural income, lagged real liquid assets, and a linear time trend, did not improve the fit of the equation.

Bradley (1979b) examined the estimation of disaggregated consumption functions. It is plausible that the breakdown of total consumption into, say, durables, non-durables and services will allow a more detailed investigation of the determinants of these three categories. They are broad enough to avoid any substantial price effects and furthermore such classification occurs in many international econometric models so that it is useful for comparative purposes (Waelbroeck, 1975, p. 436). Also, the effects of fiscal and monetary

77. The variability of income in agriculture is the main reason for such an expectation.

policy can be more easily monitored with a disaggregated approach.[78] Bradley (1979b) treated the consumption of durables as personal investment decisions, where the desired stock of consumer durables (KD*) is determined by real income, relative prices and unemployment, which yields the equation

$$\log(KD) = a_0 + a_1 \log YD^r + a_2 \log\left(\frac{PCD(RPL + \delta)}{PCPER}\right) + a_3 \log UR + a_4 \log(KD)_{-1} \qquad (6.1.3)$$

$$\text{and } CD = KD - (1 - \delta)\, KD_{-1}$$

where

YD^r is real disposable income
KD is stock of durables
PCD/PCPER is ratio of deflator of durables to deflator of total consumption
RPL is the Irish prime lending rate
δ is the rate of depreciation (assumed in generating KD)
UR is the unemployment rate.

The estimation results were promising, but failed to track well during the 1974-76 recession. A related approach to disaggregation was used by Fanning (1979) which was based on the work of Bodkin (1974). This combines some of the advantages of both the internal consistency of the expenditure system method and the simplicity of the macro consumption function method to model the household allocation of disposable income between different uses, one of which was personal savings. Other work has been carried out in the area of consumption behaviour in the last few years. Kilduff and Thom (1979) researched the demand for durable household goods. Their results suggest that expenditure on household durables can be explained as a function of real disposable income and relative prices. However, their model, like the model (6.1.3) above, failed to predict adequately consumer expenditure over 1974-1975. Conniffe and Killen (1977) modelled consumers' expectations with an adaptive expectations model from information provided by the EEC Harmonised Consumer Survey from 1974 to 1976. More recently Honohan (1982b) used a Baysian approach and O'Reilly (1981) has developed quarterly data by interpolation of the annual data.

78. This approach should be distinguished from the division of consumption proposed by O'Riordan (1974/75) and McCarthy (1977), where consumers' expenditure was divided into components — food, drink, tobacco, etc. The division is accomplished through the estimation of linear expenditure or Rotterdam systems for the expenditure categories. One of the motivations for this exercise, in the case of McCarthy (1977), was to permit a corresponding breakdown of indirect tax-yield in the endogenisation of government revenue in the Central Bank macro-model (Bradley, *et al.*, 1978).

Recent international work on consumption has greatly influenced applied work in Ireland.[79] In Appendix 6.1 we examine briefly some of the recent formulations including the concept of "negative income" and the use of the error-correction mechanism to dynamise the equations.

Specification and Validation

It must be borne in mind, when using national accounting data on consumption in Ireland, that the category "personal consumers' expenditure on goods and services" is derived as a residual expenditure category in *National Income and Expenditure* (Ireland, 1979, Appendix 3). This fact may go some way towards explaining the very chequered history of consumption functions in Ireland, although Ireland is by no means unique in this respect (Davidson *et al.*, 1978).

In this study we restrict ourselves to the re-estimation of the range of consumption functions discussed above and, after analysis of the results, we isolate the more useful equations. This approach has the virtue of allowing a comparison of the range of alternatives using a common data sample. We confine ourselves to aggregate consumption functions. In a short-run model whose objective is to track and forecast the minutiae of, say, tax revenue, a greater level of consumption disaggregation could be useful (say, into durables, non-durables, and services). For our purposes an aggregate approach is sufficient.

Results for the Kennedy/Dowling equation are shown in Table 6.2.1. Although the variables used do not correspond exactly to those used in the original study, we have constructed close approximations within the constraints of our data bank. Equation 1 is a replication of the equation used in Kennedy and Dowling (1975, p. 162). The dominant explanatory variable is income *per capita* (V1) and none of the other variables reaches an acceptable level of significance. However, some of the other explanatory variables are used below in a different functional form.

In Table 6.2.2 we show results for the Kelleher model. Clearly, the agricultural/non-agricultural breakdown is not as satisfactory as in the original Kelleher (1977) study. In Equation 2 the MPC out of agricultural income is over twice the value out of non-agricultural income. On purely statistical grounds, Equation 3 is best, closely followed by Equation 4. However, in both cases the impact MPC out of aggregate income is implausibly low (0.381 and 0.299, respectively). In the absence of quarterly data, when the lag structure could be quantified more precisely, it is necessary to fall back

79. Davidson *et al.*, (1978); Hendry and Von Ungern-Sternberg (1979); and Von Ungern-Sternberg (1981).

Table 6.2.1: *Personal consumption expenditures, OLS regressions for preferred Kennedy/Dowling Model, 1962-1979*

Equation:

1.
$$\text{SAVRAT} = \underset{(0.6)}{-28.7} + \underset{(3.0)}{30.4}\,\text{V1} + \underset{(1.2)}{0.471}\,\text{V2} + \underset{(0.3)}{0.181}\,\text{V3} - 0.353\,\text{V4}$$
$$+ \underset{(0.5)}{13.4}\,\text{V5} - \underset{(1.4)}{3.0}\,\text{V6} - \underset{(1.2)}{0.11}\,\text{V7} - \underset{(0.3)}{0.08}\,\text{V8}$$

$\bar{R}^2 = 0.877$ SER = 1.736 D.W. = 2.60

2.
$$\text{SAVRAT} = \underset{(0.4)}{-0.873} + \underset{(9.6)}{25.26}\,\text{V1}$$

$\bar{R}^2 = 0.842$ SER = 1.968 D.W. = 1.58

Notation:

SAVRAT	=	Personal savings ratio (%)
V1	=	Real personal disposable income per capita (£m, 75)
V2	=	Agricultural income as fraction of total disposable income
V3	=	Direct tax revenue as fraction of taxable income
V4	=	Net indirect tax rate (average)
V5	=	Number of dependants per worker
V6	=	Rate of growth of total population
V7	=	Rate of change of nominal domestic credit
V8	=	Real rate of interest

on the very simplistic Equation 5 where the impact (and long run) MPC is 0.568, still low but not implausibly so. Estimated in *per capita* form, the results show no statistical improvement.

In Table 6.2.3 we present a re-estimation of the Deaton/Honohan model. Statistically this is an excellent equation and relates to the Kennedy/Dowling model by basically expressing the savings ratio as a function of the rate of change of real income and prices, with a partial-adjustment mechanism. However, the implied MPC is parametric in changes in real income and inflation and varies with changes in these. In long-run equilibrium, i.e., when

$$\Delta\text{SAVRAT} = \text{YRDOT} = \text{PCDOT} = 0$$

the implied savings ratio is

$$\text{SAVRAT}_{\infty} = \frac{2.297}{0.325} = 7.068$$

Table 6.2.2: *Personal consumption expenditures, OLS regressions for Kelleher Model, 1962-1979*

Dependent variable: CPER

Equation	*Independent variables*								
	Intercept	*YAR*	*YNAR*	*YR*	*LIQ(-1)*	*CPER(-1)*	$\bar{R}^2$	*SER*	*D.W.*
1.	243.89 (1.7)	0.594 (1.6)	0.294 (2.5)	–	0.300 (1.3)	0.082 (0.2)	0.980	57.6	2.10
2.	250.87 (1.9)	0.636 (2.1)	0.305 (2.9)	–	0.347 (3.3)	–	0.982	55.6	2.12
3.	341.35 (4.2)	–	–	0.381 (6.8)	0.293 (3.5)	–	0.982	55.0	1.99
4.	276.93 (2.7)	–	–	0.299 (3.5)	–	0.499 (3.3)	0.981	56.9	1.84
5.	555.97 (7.8)	–	–	0.568 (23.2)	–	–	0.969	72.1	1.39

Notation:

CPER = Personal consumers expenditure on goods and services (£m, 75)
YAR = Real disposable agricultural income (£m, 75)
YNAR = Real disposable non-agricultural income (£m, 75)
YR = Real disposable personal income (= YAR + YNAR)
LIQ = Real liquid assets of private sector (£m, 75)

Table 6.2.3: *Personal consumption expenditures, OLS regressions for Deaton/Honohan model, 1962-1979*

$$\Delta SAVRAT = \underset{(1.1)}{2.297} + \underset{(5.7)}{0.539}\ YRDOT + \underset{(3.5)}{0.309}\ PCDOT - \underset{(3.1)}{0.325}\ SAVRAT(-1)$$

$\bar{R}^2 = 0.696$ SER = 1.672 D.W. = 1.89

Notation:

SAVRAT = Savings ratio (%)
YRDOT = Rate of change of real disposable income (%)
PCDOT = Rate of change of consumption prices (%)
Δ = First difference operator

However, since the intercept in the estimated equation is not statistically significant at any reasonable level, this figure is not reliable.

In Table 6.2.4 we present estimates for the error-correction mechanism

Table 6.2.4: *Personal consumption expenditures, OLS regressions for error correction mechanism model, 1963-1979*

General Form

$$\log RCPER = c_0 + c_1 \log RYR + c_2 \log RYRCR(-1) + c_3 \log RP + c_4 \Delta UR + c_5 \log RN + c_6 \log FSSS$$

Equation	*Regression coefficients*									
	c_0	c_1	c_2	c_3	c_4	c_5	c_6	$\bar{R}^2$	*SER*	*D.W.*
1.	-0.006 (0.2)	0.300 (1.7)	0.115 (0.9)	–	–	–	–	0.084	0.0301	1.95
2.	-0.010 (0.4)	0.234 (1.7)	0.305 (2.7)	-0.446 (3.3)	–	–	–	0.458	0.0231	1.83
3.	0.009 (0.3)	0.270 (1.6)	0.068 (0.6)	–	-0.019 (1.8)	–	–	0.216	0.0278	2.28
4.	4.650 (3.6)	0.521 (3.6)	0.869 (3.8)	–	–	5.606 (3.6)	–	0.504	0.0221	1.75
5.	-0.377 (2.6)	0.404 (2.6)	0.532 (2.8)	–	–	–	-0.076 (2.6)	0.357	0.0252	1.86
6.	3.185 (2.3)	0.411 (2.9)	0.748 (3.4)	-0.273 (1.9)	–	3.845 (2.3)	–	0.591	0.0201	1.86

Notation:

CPER	=	Real personal expenditure on consumption (£m, 75)
YR	=	Real personal disposable income (£m, 75)
PCPER	=	Consumption deflator (base 1975 = 1.0)
ΔUR	=	Change in unemployment rate
NT	=	Total population ('000)
FSSS	=	Social insurance contributions as a fraction of disposable income
RCPER	=	CPER/CPER (-1)
RYR	=	YR/YR(-1)
RYRCR	=	YR/CPER
RP	=	PCPER/PCPER(-1)
RN	=	Dependency ratio

equation (ECM) derived in Appendix 6.1. The basic ECM model (Equation 1) is rejected by the data. The overall best statistical fit is given by Equation 6, which includes a negative inflation effect on the rate of growth of consumption (i.e., the mirror image of the positive effect on savings in Table 6.2.4), and a positive dependency rate effect. In long-run equilibrium, the implied average propensity to consume is

$$APC_{LR} = 0.817.$$

The impact MPC (on a *ceteris-paribus* basis) is

$$MPC_{impact} = 0.411 \left(\frac{CPER}{YR}\right)$$

which takes the value 0.323 in 1970. As with the earlier dynamic models, this impact effect is on the implausible low side. However, the long-run properties are plausible. It is interesting that the estimated "forced savings" effect (captured by the FSSS variable in Equation 5) is negative, where we expect its sign is positive (i.e., consumers regard social security contributions as forced savings (at least partially) and accordingly decrease their own rate of savings).

Finally, in Table 6.2.5 we test the von Ungern-Sternberg "negative income" hypothesis using a simple permanent income model (Equations 1 and 2) and a simple ECM model (Equation 3) as derived in Appendix 6.1. In the case of Equation 1, the value of δ (i.e., the fraction of negative income to be subtracted from real disposable income with an expected value of 1.0) is 1.039, but the t-ratio is very low. For the static version (Equation 2), the value of δ is not statistically different from zero. For the ECM model, it is interesting to compare Equation 3 with Equation 1 of Table 6.2.4 (the standard ECM model). The implied equilibrium APC is 0.970, but this is of doubtful significance given the low t-ratio on the equation intercept. Also, for Equation 3 one cannot reject the hypothesis of $\delta = 1$.

In summary, although the dynamic equations provide good statistical fits to the data, the impact MPCs are uniformly on the low side (e.g., Equation 4 of Table 6.2.2; and Equation 6 of Table 6.2.4). Even the long-run MPC in Equation 4 (Table 6.2.2) is only 0.6 while for Equation 6 (Table 6.2.4) the long-run value is the more acceptable 0.8, the impact value being 0.3. The final choice lies between these dynamic equations and a simple static equation like Equation 5 of Table 6.2.2. Hence, in selecting an aggregate consumption function for use in empirical analysis the following criteria would be used:

(i) statistical fit which, however, is not a very discriminating criterion;

Table 6.2.5: *Personal consumption expenditures, OLS regressions for Von Ungern-Sternberg model, 1963-1979*

Permanent income models

1. $$\underset{}{CPER} = \underset{(0.6)}{105.896} + \underset{(2.5)}{0.239}\,(YR - \underset{(1.1)}{1.039}\,EPDOT.LIQ(-1)) + \underset{(3.3)}{0.693}\,CPER(-1)$$

$\bar{R}^2 = 0.980$ SER $= 55.5$ D.W. $= 2.13$

2. $$CPER = \underset{(7.0)}{621.967} + \underset{(13.6)}{0.535}\,(YR + \underset{(0.8)}{0.235}\,EPDOT.LIQ(-1))$$

$\bar{R}^2 = 0.967$ SER $= 72.5$ D.W. $= 1.50$

Error-correction mechanism model

3. $$\log\left(\frac{CPER}{CPER(-1)}\right) = \underset{(0.3)}{-0.008} + \underset{(2.8)}{0.257}\log\left(\frac{YR - \underset{(2.8)}{1.388}\,EPDOT.LIQ(-1)}{YR(-1) - \underset{(2.8)}{1.388}\,EPDOT(-1).LIQ(-2)}\right) + \underset{(2.0)}{0.262}\log\left(\frac{YR(-1) - \underset{(2.8)}{1.388}\,EPDOT(-1).LIQ(-2)}{CPER(-1)}\right)$$

$\bar{R}^2 = 0.403$ SER $= 0.0243$ D.W. $= 2.15$

Notation:

CPER = Real personal consumers expenditure (£m, 75)
YR = Real personal disposable income (£m, 75)
EPDOT = Two year average of consumption deflator
LIQ = Real liquid assets (£m, 75)

(ii) correspondence of estimated with *a priori* reasonable values for impact and long-run marginal propensities to consume, which tends to reject any of the dynamic formulations using annual data; and

(iii) implications of an equation for any particular use, such as government policy-making, that is being made of it.

III. *GOVERNMENT CONSUMPTION*

In a medium-term model of the economy the role of the state sector, in terms of its revenue and expenditure levels and pattern, can hardly be taken to be autonomous and independent of the development of the rest of the economy. However, there are two aspects, one theoretical and the other practical, which make the endogenisation of state sector behaviour difficult. First, the state sector is a particularly complex combination of commercial and administrative units and market and non-market decision-making behaviour in a wide range of fiscal, monetary and industrial activities. It has a highly complicated interaction with the private sector which it both promotes and depends on in a manner that has significant distributional consequences and which occurs within the overall context of an electoral democratic system. All this makes the stylisation of a state sector exceedingly difficult and, furthermore, it is an area that has not been the subject of any systematic quantitative research as yet in Ireland. The second aspect relates to data availability which, as mentioned in Chapter 5.1, is complicated by the fact that the data for large parts of state activity are included in the service sector and are not easily available on a separate consistent basis. For these reasons the endogenisation of the state sector is only on a partial basis which neither ensures consistency nor is based on a coherent behavioural and decision-making framework.[80]

Theoretical Framework

On the assumption that governments are concerned that some particular level of employment and growth are achieved, the fiscal and monetary variables under their control are adjusted to ensure that investment and foreign resources are made available. Government policy can then be interpreted as seeking to maintain some appropriate balance between public and personal components of the overall consumption expenditures in the economy. A utility function, U(G), can be used to represent this preference trade-off between public and personal consumption (Barten *et al.*, 1976, pp. 71-72). This gives a formalisation of the government's behaviour as maximising U(G) subject to a resource constraint, i.e.,

$$\text{MAX } U(G) = A(\theta_1 \text{ CPERV*}^{\phi_1} + \theta_2 \text{CGV*}^{\phi_2})^{\gamma}$$

$$\text{such that CTV*} = \text{CPERV*} + \text{CGV*} \qquad (6.3.1)$$

where CTV* is the policy-makers' estimate of available total consumption which is then to be divided between the personal CPERV* and public CGV* categories and where a CES utility function is chosen for simplicity. Maximising (6.3.1) and solving for CGV then gives desired public consumption.

$$\text{CGV*} = \alpha_0 \text{ CPERV*}^{(\phi_1 - 1)/(\phi_2 - 1)} \qquad (6.3.2)$$

80. The public authorities' sector is discussed further in Chapter 8.

where α_0 is a constant. The adjustment of actual to desired is then made in the usual manner by making allowances for short-run influences on the speed of adjustment.

Total government current expenditures on goods and services are primarily wages, salaries and pensions of central and local government employees. Given the determination of the overall expenditure it can be subdivided into two components: public administration (referring to administrative and regulatory employees of central and local government, army police and diplomatic service) and the remainder (referring to primary teachers, state industrial employees and local authorities, roads, drainage and sanitation employees, etc.). This breakdown is necessary in order to endogenise output of the public administration sector. If the total expenditure on wages and salaries in public administration is denoted by YWPA, then we can write

$$YWPA = LPA.WPA$$

where WPA is the wage rate and LPA is the number of employees in public administration.[81] Given the type of sector involved it is obviously not amenable to being analysed in the manner of business sectors. The demand for factors of production by government could be treated primarily as a labour requirements approach. This is for two reasons. First, by its nature, which has similarities with much of the service sector, government output is unlikely to be reflected by the standard production function approach to output determination. Second, as measured in the Irish national income accounts, employment is the key factor in measuring output. To provide an endogenous measure of government output in the analysis it is not necessary to have a separate employment function for this sector. A standard procedure in national income accounting is to assume constant labour productivity and zero capital input with gross output measured as the value of labour input, i.e., current year employment valued by base year remuneration per employee. Therefore, the demand for labour input could be taken as a proxy for government output demand, with output derived by identity from this. Throughout the sample period the increase in public administration employment followed a slow trend upward and a time trend was the only variable that explained any of this. For this reason LPA is left exogenous in our analysis. The demand for capital, and hence investment, which as mentioned is officially assumed not to make any contribution to government output in the national accounts, is also exogenous. This implies only the

81. In the national accounts, YWPA is given inclusive of pension payments while the number of pensioners is not included in the published data on LPA.

need for labour services to meet demand for administrative services.[82] Output is, therefore, approximately equal to employment multiplied by a base year wage rate (WPA_b),

$$OPA = \overline{LPA}.\ WPA_b$$

and at current values, it is just the wage bill YWPA which is the product of exogenously determined number of employees and the wage rate which is endogenously determined in the wages sector.

Once the public administration paybill is determined, the remaining part of government current expenditure on goods and services, CGOV, is derived residually as

$$CGOV = CGV - YWPA$$

and in real terms as

$$CGO = \frac{CGOV}{PCGO}$$

where PCGO is the implicit deflator for other current expenditures and is determined in the wage-price sector, and total expenditure, CGV, is explained by an equation based on (6.3.2) above.

An alternative approach to modelling these components of total current expenditure on goods and services follows if it is assumed that all government expenditure is a policy, or exogenous variable in the economy. Then the two elements of government consumption are separately determined and added to form the total, i.e.,

$$CGV = \overline{LPA}.\ WPA + \overline{CGO}.\ PCGO \tag{6.3.3}$$

where LPA and CGO are assumed to be the policy instruments. This gives a degree of autonomy to the public authority decision-makers which, while it may be appropriate over a short-term horizon, may not be in accord with the exigencies of longer-term planning and financing which must take into account the interdependence of the private and state sectors.

82. Alternatively, a relationship determining OPA of form

$$\log OPA_t = a_0 + a_1 \log LPA_t + a_2 t$$

could be used where, given that by definition the change in productivity in public administration is taken to be zero in NIPA, we expect to find a_2 is approximately zero and a_1 is approximately unity. However, the trend could also capture a compositional effect in the components of LPA.

Specification and Validation

Statistical estimation is required only for the case where we adopt the hypothesis that total government expenditure on new goods and services is related to total private consumption. In Table 6.3.1 we show empirical results. Equation 1 is a dynamic model allowing a partial adjustment to the desired public-private trade-off. Equation 2 is a static version of this equation.

Taking Equation 1 it is interesting to note that, while the impact elasticity of public with respect to private consumption is 0.835, the long-run value is 1.336 (very similar to the equilibrium result of Equation 2). Hence, public consumption has been growing at a faster rate than private consumption and use of an equation like 1 in long-run analysis would imply the eventual total dominance of public consumption. Clearly, the equation should be modified in performing such long-run analysis, and the value of the long-run elasticity could become a parameter in studying, say, a period of current expenditure cutbacks. Alternatively, such analysis could be performed using the assumption that all government current expenditure is a policy instrument (Equation 6.3.3). A juxtaposition of the two different approaches yields insights. The utility function route stands back from the administrative details of government consumption and attempts to interpret the trend in the public-private breakdown in terms of a preference function. Whether this preference function reflects the summation of private individual objectives and desires, or the desires of the public authorities themselves, is not addressed here. The alternative route, where government expenditure is assumed exogenous, is, of course, a very convenient analytical one for short-term policy analysis. However, if such an approach is used in a macro-model, *ex-post* analysis of the results of expenditure policies requires the imposition of some explicit

Table 6.3.1: *Government expenditure on goods and services, OLS regressions, 1962-1979*

1.	$\log CGV = -2.404 + 0.835 \log CPERV + 0.375 \log CGV(-1)$ $\quad\quad\quad\quad(3.1)\quad\quad(3.0)\quad\quad\quad\quad(1.7)$			
	$\bar{R}^2 = 0.996$	SER = 0.0399	D.W. = 1.77	RHO = 0.3906
2.	$\log CGV = -3.671 + 1.299 \log CPERV$ $\quad\quad\quad\quad(21.9)\quad\quad(56.3)$			
	$\bar{R}^2 = 0.995$	SER = 0.0421	D.W. = 1.61	RHO = 0.4367

Notation:

CGV = Government current expenditure on goods and services (£m)
CPERV = Personal consumers expenditure (£m)

policy criterion function in order to evaluate the success, or otherwise, of stated government policies.[83]

IV. *RESIDENTIAL INVESTMENT*

The construction of houses is characterised by substantial emphasis on private housing with a large involvement by the state both to encourage private housing investment and as an active supplier of houses itself. Because of the two channels, of private and public housing, residential investment has two aspects of interest. The first is the highly subjective perception of housing needs both by individuals and by the state. This is affected by the desires of, and the ability of, individuals to purchase housing and the socio-political criteria of adequate housing to be achieved at given levels of development. The level and process of economic development is a major influence. The second aspect is the setting of housing construction activity in the context of overall economic activity and, particularly because of the direct involvement of the state in housing construction, its role in demand management and economic policy. For the latter reason especially it is desirable that a structural study includes, however simply, some account of the impact of housing investment on the economy.[84] Priority is given by the government to private enterprise housing construction (Kennedy, 1972, p. 377; Baker and O'Brien, 1979) and the government seeks to supplement this to meet housing which is a very subjective and variable criterion. Furthermore, the curbing of house investment for deflationary purposes (Kennedy, 1972, p. 382) has had serious domestic repercussions because of the low import content of residential and other infrastructural investment. Thus, not only would a comprehensive analysis have to cover private housing investment but would also have to take the highly variable behaviour of the public sector and its phases into account.

The satisfactory analysis of housing investment requires substantial detail which embraces the variety of influences that affect decisions such as demographic factors of population changes, family units and age structure; development aspects related to the growth and distribution of real disposable incomes, urbanisation, government policy, etc.; and the financial market involves savings, availability and cost of loans; government loans, subsidies and other incentives; and construction costs. Since housing is the primary form of low-risk investment and real savings available to a majority of persons

83. Buiter and Owen (1979) present such a study for the Dutch economy using an explicit criterion function and optimal control techniques. Bradley and Ó Raifeartaigh (1982) present an application with a small model of the Irish economy.

84. Useful accounts of the operation and development of housing market are given by Baker and O'Brien (1979) and, on public sector housing expenditure by Kennedy (1972).

the mortgage and financial market is a vital element of the housing sector.[85]

Since a proper submodel cannot be developed here the simplest approach is to use an equation for private investment. Therefore, while it is recognised that any such approach will be unsatisfactory, the economic impact of this sector requires that at least the actual investment expenditure of both the private and public sector be included. The starting point for an equation is to relate the desired private housing stock KHP*, measured by accumulated net investment, to a set of longer-term factors, LT

$$KHP^* = a + b.LT$$

and, by first differencing, a desired net investment relation is obtained

$$IHP^*_n = b\Delta LT$$

The divergence between desired and actual net additions to housing capital is determined by shorter-run influences, ST, and, in the manner of the labour force participation equation, the unobservable variable is replaced such that

$$IHP_n = b\Delta LT + c_1 . ST$$

This dependent variable is net investment. However, only gross residential investment data are available. For simplicity, repairs, replacement and conversion investment is taken to be a function also of ST variables

$$IHP_r = c_2 . ST$$

so that gross investment (IHP) is the total of these two types of investment:

$$IHP = b\Delta LT + (c_1 + c_2). ST \qquad (6.4.1)$$

What variables are likely to influence IHP in the longer term and in the shorter term? For long-term influences it is reasonable to expect real disposable income and income distribution; some demographic variable such as population (NT) as a measure of needs; and a time trend if it is thought that other systematic factors (e.g., urbanisation) are relevant. The shorter-term

85. Recent work on the housing market has been done by Kenneally and McCarthy (1982). This is a quite detailed study at a quarterly level of periodicity which is not readily compatible with the annual macroeconomic study being conducted here.

influences are likely to be factors such as credit availability, government grants for water and housing deflated by the cost of housing construction; possibly the net migration flows (NMA) since this is dominated by the family-rearing and working-age demographic groups; and some measure of individuals' savings and financial assets relevant to housing construction and purchasing.

Government housing investment is assumed to be a policy instrument and, therefore, IHGV is autonomous to the model.[86]

Specification and Validation

For the reasons stated above, it is not our intention to carry out a detailed structural analysis of the housing sector. In Table 6.4.1 we present some estimates of equations which attempt to relate private housing investment to long-term and short-term variables, as in Equation (6.4.1) of the text. In

Table 6.4.1: *Private housing investment, OLS regressions, 1963-1979*

1. $$\underset{}{IHP} = \underset{(5.1)}{-119.21} + \underset{(8.1)}{0.064 YR} + \underset{(2.3)}{0.728\ \Delta NT} + \underset{(2.4)}{5.825\ RHT}$$
$$\bar{R}^2 = 0.961 \qquad SER = 11.34 \qquad D.W. = 1.67$$

2. $$IHP = \underset{(3.7)}{-100.87} + \underset{(4.4)}{0.053\ YR} + \underset{(1.3)}{0.479\ \Delta NT} + \underset{(2.0)}{4.916\ RHT} + \underset{(1.2)}{0.238\ IHP(-1)}$$
$$\bar{R}^2 = 0.963 \qquad SER = 11.14 \qquad D.W. = 1.83$$

3. $$IHP = \underset{(2.2)}{20.10} + \underset{(2.8)}{0.080\ \Delta YR} + \underset{(4.5)}{0.139\ \Delta YR(-1)} + \underset{(2.2)}{1.375\ \Delta NT} + \underset{(1.9)}{1.206\ \Delta NT(-1)}$$
$$\bar{R}^2 = 0.918 \qquad SER = 16.58 \qquad D.W. = 1.83$$

4. $$\log\frac{IHP}{YR} = \underset{(4.1)}{-47.41} - \underset{(2.8)}{0.804 \log UR} + \underset{(3.9)}{5.616 \log NT} + \underset{(1.4)}{0.204 \log RHT}$$
$$-0.321 \log\left(\frac{IPLR}{100\ EPDOT}\right)$$
$$\bar{R}^2 = 0.895 \qquad SER = 0.074 \qquad D.W. = 2.11$$

Notation:

IHP	=	Private residential investment (£m, 75)
YR	=	Personal disposable income (£m, 75)
NT	=	Total population ('000)
RHT	=	Housing transfers from government (£m, 75)
UR	=	Unemployment rate (per cent)
IPLR	=	Prime lending rate (per cent)
EPDOT	=	Two-year average of consumption prices (per cent)
Δ	=	First difference operator

86. The overall approach to the public authority sector is discussed in Chapter 8.

Equation 1 of Table 6.4.1 the long-term explanatory variable is population change, and the income and real housing transfer terms are short term. Equation 2 uses a simple partial adjustment model, but the lagged dependent variable is insignificant. Equations 1 and 3 regard both income and population as long-term determinants. The housing transfer term now becomes insignificant, while retaining its positive sign. We formulate Equation 4 in terms of the average propensity to spend on private housing, and include an income uncertainty proxy (unemployment rate), population, housing transfers and a real interest rate measure. The unemployment rate has the expected negative sign, housing transfers have a weak positive effect (i.e., a 1 per cent increase in real housing transfers leads to a 0.2 per cent increase in the average propensity to invest in housing), and the real interest rate effect has a negative sign.

The preferred equation from this is either Equation 2 or Equation 4. Neither equation is entirely satisfactory. In the case of Equation 2 the SER of 11.14 (£m, 75) is almost 8 per cent of the value of IHP in 1975. However, such large standard errors are simply the price that has to be paid for confining the analysis to a highly aggregative level.

V. *INVENTORIES AND OTHER FIXED INVESTMENT*

The main subject of this section is to examine the behaviour of inventories. Changes in domestically held stocks, together with the foreign trade balance, are part of the mediation process (which also includes prices and delivery lag variations) between *ex ante* and *ex post* demand and supply imbalances. The manner in which these two aspects can be analysed consistently with the other sectors of the economy is circumscribed by the macrosectoral framework and the level of aggregation. The analysis of total demand consists in isolating the determinants of selected categories of gross domestic absorption. Analysis of total supply involves identifying the process whereby the components of domestic production – domestic output and imported supply – are determined. Because of the accounting balance a single item can be determined as a residual on the basis of the output-expenditure identity. There is no unique way of selecting this item and the choice is made on the basis of the type and detail of the particular analytical framework being followed.[87] In some approaches, within the overall framework of economy-wide macroeconometric models, inventories have been determined residually.[88] Although unintended inventory accumulation or decumulation plays

87. This is discussed in the following Section VI.

88. Helliwell *et al.* (1982) and Fanning (1979). In the Central Bank/Department of Finance macroeconometric model the output side of the national accounts is not comprehensively modelled and inventories are included by means of an explicit behavioural relationship (Bradley *et al.*, 1981; FitzGerald and Keegan, 1981).

an important role in the mediation process, and is a key quantity signal affecting short-run production decisions, a medium-term analysis would seem to require an explicit treatment of inventories by means of behavioural relations. While inventories may vary quite widely in the shorter-term, firms do try to maintain certain ratios with output (15-20 per cent) and/or sales (e.g., 30 per cent). The factors influencing firms' holdings of stocks include sales volume, duration of production process, degree of durability of the production material, seasonality, style or "fashion", and credit availability and cost.

Inventories are difficult to explain in macroeconometric analysis, especially using annual data, where the length of periodicity is too long to isolate the short-run signalling role of unintended stock changes. Inventories can indicate excess of supply or demand for a firm's product. There is little information available on the level or determination of desired/intended stocks. Also the physical changes in stocks, which are classified as an expenditure in national accounts — whether the changes are intended or unintended — are only part of the buffer mechanism between *ex ante* demand and supply. For enterprises that do not store physical stocks, and even those that do, the increase or reduction of orders on the books serves the same function. In the absence of data on orders, as well as on desired stock levels, a comprehensive analysis of the role that inventories, rather than prices, play in signalling the need for production changes is not possible. For this reason our approach has to be a fairly simple one.

Theoretical Framework

Non-agricultural stock building is disaggregated into industrial and service inventory investment. A basic model of industry sector inventory behaviour relates desired stocks, i.e., accumulated inventory investment (KII*) to an activity or output variable Q*, i.e.,

$$KII^*_t = a_0 + a_1 Q^*_t$$

Actual stock levels, KII_t are in general not equal to desired stock levels, and a simple partial adjustment mechanism

$$\Delta KII_t = KII_t - KII_{t-1} = \lambda(KII^*_t - KII_{t-1})$$

yields

$$II_t = \Delta KII_t = a_0\lambda + a_1\lambda Q^*_t - \lambda KII_{t-1} \tag{6.5.1}$$

for the short-run inventory behaviour. An alternative approach (discussed in Appendix 6.1 in the context of the consumption function), postulates an equilibrium relationship of the form

$$KII_t^* = \text{const.}\ Q_t^*$$

and a disequilibrium equation of form

$$\log\left(\frac{KII_t}{KII_{t-1}}\right) = k + a_1 \log\left(\frac{Q_t^*}{Q_{t-1}}\right) + a_2 \log\left(\frac{Q_{t-1}}{KII_{t-1}}\right) \qquad (6.5.2)$$

Hence,

$$II_t = KII_{t-1} \log\left(\frac{KII_t}{KII_{t-1}}\right) \qquad (6.5.3)$$

Other explanatory variables can, of course, be used to test for any influence on inventory behaviour, e.g., inflation, cost of maintaining inventories, capacity utilisation. The simple partial adjustment model has been used by McCarthy (1977b) and by Murphy (1979). In the case of the latter reference, a four-way disaggregation of stocks into raw materials, finished goods, other industrial stock, and distribution goods is used. In the empirical work below we apply the above methods in determining industry and service sector inventory behaviour.

National accounts agricultural inventories consist solely of cattle stocks, i.e., breeding stock and other cattle not disposed of on the market. Without getting deeply involved in the cattle production cycle, it is difficult to attempt to model the behaviour of cattle stocks (Walsh, 1982; Casey, 1970/71b). As Casey states: "It seems that once the initial decision to invest in the breeding herd is made, the whole process follows automatically, suggesting that the traditional element in Irish livestock husbandry is very strong" (1970/71b, p. 219). Consequently, we leave agricultural inventories exogenous.

Specification and Validation

In Table 6.5.1 we present estimates for inventory investment in industry and services. Two separate models are tested: a standard model of partial adjustment to a desired stock level and the ECM model discussed in Appendix 6.1. A wide range of additional explanatory variables was tested but none contributed to improvement of the basic models. In the case of the partial adjustment models, the value of λ measures the fraction of the difference between desired stock levels and previous years' stocks which is adjusted

Table 6.5.1: *Inventory investment, OLS regressions, 1962-1979*

(A.)	*Industry: Partial Stock Adjustment Model*							
	$III = a_o + a_1\ OI + a_2\ CURI + a_3\ RIR + a_4\ KII\ (-1)$							
Eq.	a_o	a_1	a_2	a_3	a_4	$\bar{R}^2$	SER	D.W.
1.	0.394 (0.0)	0.198 (3.8)	–	–	–0.402 (3.3)	0.475	13.9	2.30
2.	–19.042 (0.1)	0.216 (2.3)	24.5 (0.1)	–48.9 (0.4)	–0.453 (1.9)	0.400	14.8	2.40
(B.)	*Industry: Error Correction Model*							
3.	$\log\left(\frac{KII}{KII\ (-1)}\right) = -0.312 + 0.391 \log\left(\frac{OI}{OI(-1)}\right) + 0.441 \log\left(\frac{OI(-1)}{KII(-1)}\right)$							
	$\bar{R}^2 = 0.405$ SER = 0.0263 D.W. = 2.00							
(C.)	*Services: Partial Stock Adjustment Model*							
4.	$IIS = \underset{(3.0)}{77.210} + \underset{(3.6)}{0.117}\ OS - \underset{(3.6)}{0.903}\ KIS\ (-1)$							
	$\bar{R}^2 = 0.397$ SER = 11.3 D.W. = 2.04							

Notation:

III	=	Change in industry sector stocks (£m, 75)
OI	=	Industry product (£m, 75)
CURI	=	Capacity utilisation rate in industry
RIR	=	Real rate of interest
KII	=	Change in service sector stocks (£m, 75)
OS	=	Service sector product (£m, 75)
KIS	=	Level of service sector stocks (£m, 75)

within one year. For industry $\lambda_I = 0.402$ and for services $\lambda_S = 0.903$. Hence, stock disequilibrium in the service sector is almost entirely removed in one year while adjustment in industry is somewhat slower. The underlying relationships determining desired stock levels are as follows:

$$KII^* = 0.98 + 0.493\ OI_t$$

$$KIS^* = 85.5 + 0.130\ OS_t$$

Only in the case of industry was it possible to estimate an ECM inventory model (Equation 3 of Table 6.5.1). The underlying equilibrium relationship is

$$KII^* = 0.493\ OI^*$$

i.e., equilibrium industrial stock levels are approximately one half of industry output.

Other Fixed Investment

Since investment expenditures are a major element of domestic absorption, we include here an identity of the form

$$IFT = IFI + IFAFF + IFS + \overline{IFG} + IHP + \overline{IHG}$$

where industry (IFI), agriculture (IFAFF) and service (IFS) sector investment were analysed on a sectoral basis in the supply block, and private housing investment (IHP) was examined in Section IV of this chapter. Government fixed investment (IFG) and public housing investment (IHG) remain exogenous to our analysis.

VI. *EXPORTS*

Theoretical Framework

The macrosectoral framework imposes certain constraints on the manner in which we can approach the examination of exports. This can be brought out by a brief consideration of the usual approach which considers exports in isolation from the other components of aggregate demand and supply. The core of this approach in the specification of two long-run equilibrium behavioural equations such as

$$X^d = f_1(P_x, P_f, Y_w) \qquad (6.6.1a)$$

$$X^s = f_2(P_x, P_d, K_x) \qquad (6.6.1b)$$

where X^d and X^s are demand for and supply of exports, respectively; P_x, P_f, and P_d, are the prices of domestic competing goods, foreign competing goods, and the domestic variable cost of production, respectively; Y_w is the trade weighted world income; and K_x is the production capacity for export goods production. These can be converted into short-run estimating equations by the specification of adjustment processes selected according to whether the tradeables sector of the economy is taken to be most appropriately characterised by the small open economy (SOE) assumption or not.[89] In the case of the SOE assumption, export quantities adjust towards suppliers' desired values and export prices vary in line with demand conditions (Browne, 1982). Equation (6.6.1b) provides the basis for estimating an export supply function and Equation (6.6.1a) provides, by inversion, an equation for the price of exports. The opposite is the case if the non-SOE assumptions, i.e., exports are demand constrained, is made and Equation (6.6.1a) provides the estimating equation for export quantity and Equation (6.6.1b) for export price.

Taking the SOE assumption, which implies estimating an export supply function based on Equation (6.6.1b), it is readily apparent that such an equation cannot be availed of directly and at the same time preserve consistency within the overall supply framework. In Chapters 4 and 5 we examined the overall supply of the economy as it originated from three domestic sources – industry, services and agriculture – and from abroad.[90] The supply of exports is a subset of the total supply, i.e., of the appropriate sectoral supplies. In estimating these aggregate relationships, allowance has to be made for the effect of the small open economy assumption and to the extent that it is relevant. To include an export supply equation as well as these sectoral output relationships would result in duplicating the determination of a portion of output, namely, the part which happened to have been exported. If it were to be included it would require, for consistency, a separation between production for export and production for domestic markets. But, given the level of aggregation of output and factor input data used in this study, this separation cannot be made.[91] This same point also holds for the export price relationship so that the implications of the SOE assumptions must be subsumed into the appropriate price determination equations in Chapter 7.

An alternative approach to estimating an export supply relationship which is consistent with the supply framework employed can be based on taking the production decision, as in our earlier analysis, and specifying the export supply relationship as an equation for allocating output between foreign and domestic markets in a manner analogous to the production-import allocation approach discussed in Chapter 5. Therefore, similar to that approach employed

89. Even at the aggregate level at which our analysis is conducted the choice does not have to be a once-and-for-all dichotomy into SOE and non-SOE but could change depending on the degree of capacity utilisation (O'Connell, 1977; Lynch, 1983). This qualification does not affect the general points to be made here but would affect the implementation of particular equations.

90. The final sector, public administration, was examined above in Section 6.III.

91. And indeed probably also involves a stronger separability assumption than is warranted by the available export data.

for determining the breakdown of supply between domestic and foreign sources, we could postulate a utility function for domestic producers having production for the domestic market, O_d, and foreign markets, O_x, as the arguments. The specific trade-off would reflect factors such as the difficulties and inconveniences of selling in foreign as distinct from domestic markets. Utility (profit) maximisation gives a desired relative proportions equation, similar to that for imports to domestic supply, as a function of expected relative prices, i.e.,

$$\frac{O_x^*}{O_d^*} = f\left(\frac{P_d}{P_x}\right)^* \qquad (6.6.2a)$$

so that for exports we have,

$$O_x^* = f\left(\frac{P_d}{P_x}\right)^* . O_d^* \qquad (6.6.2b)$$

This could be interpreted as showing how output is switched from home to foreign markets as the profitability of doing so improves. This determines the relative proportions but does not directly determine or relate the proportions to the overall level of desired output (O^*). This difficulty can be overcome by simple manipulation using the equality for total output ($O^* = O_x^* + O_d^*$) so that

$$\left(\frac{O_x^*}{O^* - O_x^*}\right) = f\left(\frac{P_d}{P_x}\right)^* = k^* \qquad (6.6.2c)$$

Therefore, using $O_x^* = k^*(O^* - O_x^*)$ the level of production for export can be determined, once overall production is given, by

$$O_x^* = \left(\frac{k^*}{1 + k^*}\right)O^* \qquad (6.6.2d)$$

There is, however, a difficulty in implementing this approach, again within the context of the overall supply framework, because the data available for exports refer to gross exports while those employed for industry, for example, refer to value-added output. Some method is therefore required for "grossing-up" value-added output or "netting-down" export data in order to incorporate exports in the supply side of our analysis.

By contrast, if the non-SOE assumption is valid, so that the export demand Equation (6.6.1a) provides the basis for estimating the export quantity equation, there are no difficulties incorporating an export demand function into the macroeconomic framework. Although it refers to the geographical destination, i.e., expenditure by non-residents on domestic supply, rather than a type of expenditure, such as personal consumption (by residents and non-residents) it is similar in principle to the other expenditure functions that are utilised to explain various components of aggregate demand.[92] Exports are merely the imports of non-residents from Ireland and so that export demand is symmetrical to the import demand. Thus, Equation (6.6.1a) can be used directly as the basis for an export demand relationship. Alternatively, an approach analogous to that for imports of goods and services and imports in Chapter 5 can be used once the appropriate substitutions for domestic and foreign variables have been made. For instance, in the case of goods and services this would give an equation for the desired ratio of exports to foreign (world) output as follows:

$$\left(\frac{XGSO}{GDP_f}\right)^* = \left(\frac{\theta}{\phi}\right)\left(\frac{P_f^*}{P_x^*}\right)^{\epsilon} \tag{6.6.3}$$

where ϵ is the elasticity of substitution of foreign production for Irish exports (i.e., imports from Ireland). This can then be modified to allow for short-run disequilibrium influences as in the manner of the import Equation (5.2.6) and the estimated equations following from it. Finally, as regards the complementary equation for determining export prices based on Equation (6.6.1b) the implication of the non-SOE assumption must again be incorporated into the appropriate aggregate price relationships in Chapter 7.

Table 6.6,1: *Corresponding SOE and non-SOE assumptions for obtaining export and import quantity and price equations.*[a]

		SOE	*non-SOE*
Export	P	demand determined	supply determined
	Q	supply determined	demand determined
Import	Q	demand determined	supply determined
	P	supply determined	demand determined

Note: a. P, Q refer to prices and quantities, respectively.

92. Whether export demand is disaggregated into expenditure on consumption goods, intermediate materials, and capital goods, or according to some other categorisation, is just a matter concerning the degree of detail desired, or made necessary by other sectors, in the study.

Before concluding this subsection there is one final point to be considered. The question about whether or not the SOE assumption is the most appropriate one for exports also raises a question about which assumption is appropriate for imports since, as mentioned in the case of export and import demand, a symmetrical set of assumptions also applies to them. Therefore, a combination of alternatives must be examined based on the two options for estimating empirical relationships for both exports and imports. These are summarised in Table 6.6.1 which shows the alternative routes to providing the basis for estimating empirical relationships for export and import quantities, with which we are primarily concerned here, across the central lines. The combination of these assumptions gives four possibilities for approaching import and export quantity functions as shown in Table 6.6.2. The export and import quantity equations implied by each of these options are identified in the bottom line. For exports these are based on the equilibrium behavioural Equations (6.6.1a) and (6.6.1b), with appropriate SOE and non-SOE assumptions made. They are summarised as X^s (supply determined) and X^d (demand determined) export equations, respectively. A symmetrical pair of equations arise for imports and are also summarised by the equivalent notation M^s and M^d.[93] The most plausible options for the Irish economy would appear to be Options 1 and 3. It is hardly the case that Irish import quantities are supply constrained so that the relevant assumptions for imports is the SOE one which necessitates examining only import demand equations, as we did in Chapter 5. The estimation of export demand functions is the subject of the following subsection and estimates are presented in Table 6.6.3.

Specification and Validation

We present statistical estimates for a pure export demand function, based

Table 6.6.2: *Estimation options for export and import quantities*

Option	*1*	*2*	*3*	*4*
Exports	SOE	Non-SOE	Non-SOE	SOE
Imports	SOE	Non-SOE	SOE	Non-SOE
Equations	X^s, M^d	X^d, M^s	X^d, M^d	X^s, M^d

93. Each pair of these options has, as noted in the case of exports, implications for price determination equations, discussed in Chapter 7, arising from the complementary set of price of export or price of import equations.

on Equation (6.6.1a) above, where the equilibrium demand for a country's exports, X^d, depends on the level of world income, Y_w, and the price of exports relative to the price of competing goods on world markets, P_x/P_f, i.e., in log-linear form

$$X_t^D = a_0 + a_1 \log Y_{w_t} + a_2 \log (P_x/P_f)_t$$

Our expectations are that $a_1 > 0$ and $a_2 < 0$. The equilibrium equation can be written in disequilibrium form by assuming, for example, a simple partial adjustment between long-run demand, X^d, and actual exports, X, i.e.,

$$\Delta \log X_t = \gamma(\log X_t^D - \log X_{t-1})$$

where $0 < \gamma \leqslant 1$. The short-run estimating equation becomes

$$\log X_t = \gamma a_0 + \gamma a_1 \log Y_{w_t} + \gamma a_2 \log (P_x/P_f)_t + (1 - \gamma) \log X_{t-1}$$

In Table 6.6.3 we present statistical estimates for equations determining total exports, XGS; exports of non-agricultural goods and services, XNA; and industrial exports, XI. In all three cases the same world income variable (YW), world price (PW) and exchange rate (RW), are used where the weights are calculated in terms of Irish manufactured exports (exact references are given in Appendix 2.2).

For the static or equilibrium situation, the elasticity results, with respect to world income and relative prices are summarised (with t-ratios in parentheses) below. The elasticity with respect to world income is so high that it would not be safe to assume it would continue indefinitely.

	World income elasticity	*Relative price elasticity*
XGS	2.6 (21.5)	-1.1 (3.3)
XNA	2.9 (29.0)	-1.1 (2.1)
XI	4.0 (46.7)	-1.0 (3.3)

The disequilibrium equations yielded the results for long-run and short-run elasticities with respect to world income and relative prices (with t-ratios in parentheses) which are given below.

	Impact income elasticity	*LR income elasticity*	*Impact price elasticity*	*LR price elasticity*	*Adjustment factor* (γ)
XGS	1.0 (1.4)	2.6	-0.4 (1.0)	-1.1	0.381
XNA	1.7 (2.9)	2.9	-0.6 (1.1)	-1.0	0.577
XI	2.9 (4.6)	4.0	-0.7 (2.1)	-0.9	0.725

Table 6.6.3: *Export demand functions, OLS regressions, 1963-1979*

$$\log X = a_0 + a_1 \log YW + a_2 \log\left(\frac{PX*RW}{PW}\right) + a_3 \log X_{-1}$$

Dep. Variable	a_o	a_1	a_2	a_3	$\bar{R}^2$	SER	D.W.
XGS	7.374 (491)	2.627 (21.5)	−1.085 (3.3)	—	0.985	0.0419	0.68
XGS	2.856 (1.5)	1.006 (1.4)	−0.403 (1.0)	0.619 (2.3)	0.988	0.0366	1.30
XNA	6.996 (398)	2.897 (29.0)	−1.141 (2.1)	—	0.984	0.0523	1.05
XNA	4.073 (3.0)	1.663 (2.9)	−0.599 (1.1)	0.423 (2.2)	0.987	0.0465	1.27
XI	6.700 (457)	4.048 (46.7)	−0.964 (3.3)	—	0.994	0.0442	2.02
XI	4.892 (5.0)	2.897 (4.6)	−0.667 (2.1)	0.275 (1.8)	0.995	0.0408	2.15

Notation:

X: Dependent variable to be specified
XGS: Exports of goods and services (£m, 75)
XNA: Non-agricultural exports (£m, 75)
XI: Industry exports (£m, 75)
PW: Trade-weighted world price index (base 1975 = 1)
YW: Trade-weighted world income (base 1975 = 1)
RW: Trade-weighted exchange rate.

Clearly, the superior statistical results are obtained for the most homogeneous category, industrial exports, which is also the category most appropriate for the weighted world income, price and exchange rate variables used in the estimation. Browne (1982), using quarterly data for manufactured exports, obtained a long-run world income elasticity of 5.2 and a price elasticity of -0.11.

VII. *CONCLUSION*

In the preceding sections we have analysed, by means of single econometric equations, behavioural determinants of private consumption, government consumption, changes in inventories, private housing investment and exports. In the case of exports, two alternative approaches to deriving estimating equations were indicated depending on whether the small open economy assumption was held or not. Following the SOE route resulted in the specification of an export supply function which, while it poses some difficulties for incorporating consistently into the overall macroeconomic framework, is appropriately examined in the context of the supply sectors. With the non-SOE assumption the export quantity equation is based on an export demand function and estimates for this were included in this chapter. In the case of each type of expenditure we have provided a range of estimates, and have indicated which are the most satisfactory according to statistical criteria and theoretical expectations and plausibility. Frequently it was not possible to identify a single superior equation. The somewhat indeterminate position remaining due to a multiciplicity of equally satisfactory equations reflects the limits of this type of highly aggregative analysis.[94]

94. A further evaluation of the different equations for each type of expenditure can be carried out within the context of an integrated operational model of the economy. This is the subject of a separate study following on this one (Bradley, Fanning and Wynne, 1984).

Chapter 7

INCOME DISTRIBUTION – PART I

I. *INTRODUCTION*

In the preceding three chapters the determination of aggregate supply and demand was treated. The final task to be undertaken is to translate the factor based modelling of supply into the pattern of income distribution which results from the interaction of production and demand activities. Our usage of the term "income distribution" is a rather limited one and is taken to mean the incomes accruing according to the sectoral categories in the model, e.g., wage and non-wage incomes, agricultural and non-agricultural incomes, foreign factor income flows, etc. We do not consider the question of the distribution of personal incomes within these sectoral categories, an issue which, although of extreme importance in the analysis of government social policy, does not fall within the ambit of a macrostructural analysis based on the NIPE accounts data.

The major linkages between factor demands and incomes are the prices of factors and products. Prices serve a dual role. First, they fulfil an allocative role where relative factor prices affect the supply and demand of factors of production. This aspect was examined in the three preceding chapters. Second, they fulfil a distribution role where adjustments in relative prices of factors and products alter the pattern of income distribution. The primary task remaining is to make explicit the price based channels of the income distribution process. In an open economy there are three key categories of prices to be considered: the domestic price of labour, the domestic price of goods and foreign prices. The latter category is the combined result of the foreign price of goods and the rate of exchange. Imported goods prices are taken as exogenous and consideration is given to the influence of foreign prices on domestic wage and price formation. There are two interrelated aspects to prices: relativities and levels. Relative price adjustments take place within the context of inflation of the overall price level, i.e., by means of variations in the rate of growth of the price of factors and products. Price inflation – a sustained increase in the overall price level – requires monetary accommodation. Therefore, the modelling of price determination requires consideration of the monetary environment within which price inflation takes place.[94] A second element, in addition to wages and prices affecting income distribution, is the fiscal redistribution of income undertaken by the public authorities. The channels involved are those of the taxation and transfer system and the process of raising and disbursing revenues has allocative and distributional consequences. The pattern of demand for, and supply of, products and factors is changed as a result of these activities. Since not all expenditure is tax-financed, the borrowing of funds from domestic or foreign sources also affects income distribution. These topics are the subject matter of Chapter 8.

The remainder of this chapter is organised into four sections. In Section 7.II an influential model of wage and price determination in the Irish economy is discussed and used to isolate some of the issues for the structural analysis of wages and prices. In Section 7.III the determination of producers' prices of goods and services is examined, and the empirical results relating to producers' prices in the industry and services sector are given. Agricultural prices are considered exogenous, being determined, at present, within the Common Agricultural Policy of the EEC. In Section 7.IV price deflators for major expenditure categories are considered. Finally, in Section 7.V, we analyse wage determination in industry, service and public administration.

II. *PRICE INFLATION AND PRICE SETTING*

By price setting we mean the mechanisms by which prices and wages are set by firms and other agents in particular markets. When we refer to price inflation we mean the processes of continuous increase in virtually all prices, i.e., of the aggregate price level, as measured by some appropriate index. The analysis of price setting behaviour and the overall process of price inflation are generally closely intertwined in empirical macroeconomic studies.

In order to specify a structural macroeconometric description of the pricing processes occurring in Ireland, the specific aspects of price setting, price inflation, and monetary accommodation must be distinguished. The starting point of our discussion is the model of the Irish inflationary process by Geary (1976b)[95] which, together with some related studies, marked a

94. In an open economy price inflationary pressures are not indicated solely by an index of prices but also by balance of payments deterioration and employment.

95. As well as the study by Geary already cited, other recent contributions include the Statistical and Social Inquiry Society of Ireland symposium on inflation (1974/75), which also includes a paper by Geary; Geary (1976a and 1976b); Kennedy and Vaughan (1979); and most recently the small open economy characterisation of Ireland has been re-examined by Honohan (1982). An early statement of a small open economy model of wage and price determination in an Irish context was given by O'Mahony (1965). Although this study apparently played no role in the debate during the 1970s, it emphasised the labour market channels in particular as well as distinguishing between a sector exposed to external competition and a sheltered sector (1965, pp. 10-12, 41).

watershed in the formal analysis of the price-inflation and price-setting aspects of the Irish economy. The Geary study serves to isolate three important areas for consideration:

(i) the mechanisms by which prices are set, which can be classified into two polar types of market structure – auction markets (price taking) and administered markets (price making);
(ii) the openness of the Irish economy, which is central to the analysis of both price inflation and price setting;[96] and
(iii) the interrelation between price setting and price inflation which involves the process of monetary expansion.

Geary's Model of Price Determination

In the analysis of the Irish economy one of the most influential formal macro studies of Irish wage-price formation is that by Geary (1976b) which was based on a study by Lipsey and Parkin (1970). Geary's object was to study the role of world prices in the inflationary process of the Irish economy. His starting point was a highly aggregate two-equation wage-price model:

$$\dot{W} = f_1\ (\dot{P}, UR) \tag{7.2.1}$$

$$\dot{P} = f_2\ (\dot{W}, \dot{q}, \dot{P}_m) \tag{7.2.2}$$

where $\dot{W}$ is the rate of growth of the wage (or earnings) rate, UR is the rate of unemployment, $\dot{q}$ is the rate of growth of labour productivity and $\dot{P}$ and $\dot{P}_m$ are the rate of growth of the domestic and import price indices, respectively. Geary was concerned with the rather limited measure of "openness" in the above model, where import prices were the only external price influences incorporated. To permit more general responses, Geary used a world price variable, proxied by either the UK Retail Price Index or the OECD aggregate consumption deflator (P_w).

In linear rate-of-change form, his model was stated as

$$\dot{W} = a_0 + a_1 \dot{P} + a_2 UR \tag{7.2.3}$$

$$\dot{P} = b_0 + b_1 \dot{W} + b_2 \dot{q} + b_3 \dot{P}_w \tag{7.2.4}$$

96. As mentioned above, price setting and relative price adjustments occur in the context of the overall increase in prices and are therefore likely to be interrelated. A recent study by Fischer (1981) analyses this relationship between inflation and price variability in the United States, Germany and Japan.

The domestic inflation – world inflation multiplier is

$$\frac{\partial \dot{P}}{\partial \dot{P}_w} = \frac{b_3}{1-a_1 b_1}$$

which one expects to be unity in the long run. If there is no money illusion in the labour market and the adjustment period is less than one time period, then

$$a_1 = 1$$

If, in addition, both b_1 and b_2 are positive, then

$$b_1 + b_3 = 1, 0 < b_1, b_3 < 1$$

Geary found that these long-run restrictions are, indeed, satisfied by the data, using the UK RPI price measure for P_w. In some of his price equation estimates he found insignificant wage coefficients (b_1), consistent with an extreme recursive version of the price equation, i.e.,

$$\dot{P} = b_o + b_3 \dot{P}_w \tag{7.2.5}$$

indicating some evidence for the direct influence of P_w on P, rather than an indirect influence through the labour market. Finally, no significant unemployment effect on wages was detected. In a subsequent paper Geary and Jones (1975) examined this point in more detail and concluded that the unemployment rate was not a good measure of excess demand in the Irish economy. This model was then extended to incorporate a labour supply and migration element in a small macroeconometric model (Geary and McCarthy, 1976). The issue of the actual speed of transmission of inflation into an SOE was the subject of separate examination by Geary (1976a) and Bradley (1977).[97]

Geary's wage equation, (7.2.3), is a version of the standard Phillips curve. Such a curve states a trade-off relationship between the rate of change of money wages and the rate of unemployment, which is taken as a measure of the state of excess demand for labour. If allowance is made for expectations about future price changes, the relationship is usually written as

97. A disaggregated version of the Geary-type model, where prices are disaggregated by expenditure and output categories and where wages are examined by sector, has been included in most of the recent economy-wide macroeconometric models of the Irish economy.

$$\dot{W} = f(UR) + \alpha_1 \dot{P}^e \tag{7.2.6}$$

where $\dot{P}^e$ is the expected rate of inflation. This relationship can be converted into one determining prices by introducing an explicit price-setting mechanism. For example, if prices (P) are based on a constant mark-up on unit labour costs (assuming, say, that labour is the only variable factor of production), then

$$\dot{P} = \dot{W} - \dot{q} \tag{7.2.7}$$

where W is the nominal wage rate and q measures labour productivity. Substitution yields

$$\dot{P} = f(UR) + \alpha_1 \dot{P}^e - \dot{q} \tag{7.2.8}$$

Equations such as (7.2.6) and (7.2.8), or variations on these, are standard approaches to modelling wage-price aspects in small aggregate macro models. The Phillips curve, in addition to providing an empirically useful relationship for wage determination also removed the strict dichotomy between the behaviour of wages/prices at full employment and behaviour at less than full employment (Lipsey, 1978, p. 49), a dichotomy which was a feature of some standard macro models. However, the Phillips curve is not a self-contained theory of inflation. For example, it involves the unemployment rate, UR, an endogenous variable which itself needs to be explained. The usual interpretation of the Phillips curve is that it describes the trade-off possibilities which are available to an economy between the two endogenous variables, price stability and unemployment. In the large disaggregated economy-wide models, this trade-off is diffused over a number of wage-price-activity relations rather than incorporated by means of a single aggregate equation. Therefore, although the actual specification of the price inflation and price setting processes may be quite different in larger macroeconometric models, reflecting the specific features of each sector, the disaggregated relations fulfil the same overall function as the simple Phillips curve does in small macro models such as Geary's model.[98]

A further problem with the isolated Phillips curve "theory" of inflation is that it abstracts from issues related to the accompanying expansion of the money supply.[99] In the Geary model, the implicit assumption being made is

98. In an overview of a number of price-wage systems in macroeconometric models Tobin (1972) showed the underlying similarity in all except the monetarist models.

99. Depending on the particular causal viewpoint taken, monetary expansion may either be viewed as the causal impetus into the inflationary process, or a necessary accommodation for price inflation to occur.

that monetary expansion occurs passively to validate price increases. In the case of the Irish economy over the period 1960 to 1979 the stylised facts of monetary policy (i.e., a fixed exchange rate with dominant trading partner and free mobility of capital) underlie such an assumption. We shall return to other aspects of this issue in Chapter 8 when we describe the behaviour of the monetary authority.

A final point raised by the Geary model relates to the mechanisms of price and wage setting. In that approach wages are determined by an excess demand function and goods prices are determined by a mark-up on unit labour costs, modified by foreign price influences. In disaggregated structural analysis other wage and price-setting mechanisms must be examined and it is to these considerations that we now turn.

III. *PRODUCERS' PRICES OF GOODS AND SERVICES*

The two polar approaches to price determination mentioned above were administered (price-making) and auction (price-taking) markets. The theoretical framework for analysing producers' prices by each of these approaches is set out in turn.[100] Following this the effect of the openness of the economy to foreign competition on producer price setting is considered.

Theoretical Framework

Administered Markets

There is a number of different elements involved in stylised analysis of price setting behaviour in administered markets. First, whether the approach will be based on an explicit production technology underlying the firm's output and factor demand decisions and hence the firm's cost structure.[101] Second, what assumption is to be made concerning firms' behaviour, i.e., profit maximisation or cost minimisation. Third, the time horizon involved, e.g., whether long run or short run. In Appendix 7.1 we consider the type of price equations that emerge from long-run pricing models based on explicit underlying technology assumptions and behavioural postulates. We also examine a short-term mark-up model which is not based on technology and behavioural assumptions but is empirically based and allows for differing measures of unit costs. In this appendix it is shown, for example, that a firm facing a value-added two factor Cobb-Douglas technology, using a criterion of profit maximisation, and facing a product market under conditions of imperfect competition (with a demand equation log-linear in price and

100. This is based on the work of Nordhaus (1970 and 1972).

101. Chapter 3 contained an exposition of the issues involved in production technology.

income), will determine its output price, P, in an equation of the form

$$\log P = a_0 + a_1 \log C + a_2 \log W + a_3 t \tag{7.3.1}$$

Here, P is the output price, C is the user cost of capital and W is the wage rate. The coefficients a_1 and a_2 sum to unity if the Cobb-Douglas technology has constant returns to scale (CRS). The coefficient a_3 is related to the measure of technical progress used in the production function. Generalisations, using CES value-added production functions or multifactor gross output production functions are straightforward, if a little complicated algebraically.

If the firm faces the same CD technology, but follows a goal of cost minimisation, no specific assumptions need to be made about the competitive nature of the output market. However, if a firm pursues a cost minimising strategy the issue of price settings remains open as such an approach does not permit the explicit derivation of an optimal pricing rule. The usual procedure is to assume that prices are based on a mark up of some measure of expected long-run or "normal" unit costs derived from factor demand systems. Assuming once again a Cobb-Douglas technology, the total cost of producing the desired level of output Q is

$$TC = W.L + c.K \tag{7.3.2}$$

and after substitution for L and K from the factor demand equations (Appendix 3.1) and dividing by Q, we obtain the average cost formula:

$$AC = A_o C^{\alpha} W^{1-\alpha} \exp(-\gamma t) \tag{7.3.3}$$

If the desired price is now assumed to be a mark up (θ) on average cost, then

$$P = (1 + \theta) AC \tag{7.3.4}$$

or, if the mark up is assumed to be parametric in demand pressure (proxied by the capacity utilisation rate in industry, CUR_I), we can write

$$p = (1 + \theta). CUR_I^{\delta} AC \tag{7.3.5}$$

Other influences on the rate of mark up may include foreign prices and business financial constraints (OECD, 1982b, pp. 13-17). Different production functions lead to alternative versions of (7.3.3) and to a set of cost-minimisation based price-setting equations equivalent to those for profit maximisation (shown in Appendix 7.1).

A variation on the long-run mark-up model has been given by Nordhaus (1974, p. 195) where the derivation of average cost is based on "normal" historical costs rather than the underlying production function. This approach is an intermediate stage between the long-run and technology based models of administered price setting and short-run cost mark-up models. Some technical details are given in Appendix 7.1.

The above models of long-run price setting were derived on the assumption that firms are not prevented from pursuing such a course of optimisation. The only constraints on pricing behaviour are such as to introduce adjustment lags of actual to desired price.[102] A second approach to price setting is based on the view that short-run price-setting decisions may not, or cannot, be consistent with the long-run models above. This also gives rise to a family of price-setting rules which vary according to the elements of cost included (Nordhaus, 1974, pp. 183-189) and are listed in Appendix 7.1.

The basics of the short-run approach to price determination can be briefly outlined as follows. For a given level of demand, technology, capital stock, wages, etc., actual profits (π) are defined residually as the value of output less wage costs, material costs, depreciation, interest charges and taxation. The basic assumption is that firms set prices as a mark up on normal (cyclically corrected) average costs. In the short run, sales are determined by price and cyclical conditions. According to this model, production and employment, rather than price, are adjusted in the face of short-run variations in demand. Profits emerge as the residual factor because prices are set on the basis of long-run profitability and firms face contractually determined wages.

The simplest mark-up approach is to include only labour costs, i.e.,

$$P = (1 + \theta) W \frac{L_n}{Q_n} \tag{7.3.6}$$

A range of options can be set out as successively more comprehensive measures of costs are used (refer to Appendix 7.1 for details). The two issues involved in operationalisation concern (i) the elements of cost to be included in the cost base variable and (ii) the procedure for normalising the variables.[103]

102. That is the above long-run (or equilibrium) price-setting models must be related to short-run (disequilibrium) price setting by means of appropriate adjustment mechanisms (e.g., partial or adaptive adjustment). The need for these adjustments arises because it is unlikely that firms can adjust prices instantaneously due to such factors as uncertainty, market interdependencies, and costs of adjustments. These are discussed by Nordhaus (1972, pp. 31-34).

103. Nordhaus outlines some techniques for normalising variables (1974, pp. 185-188) as well as discussing a number of difficulties with this model of pricing (1974, pp. 184-185).

Auction Markets

The principles underlying auction market models of price determination are the classical principles of competitive supply and demand. The interaction of demand and supply determine the equilibrium price in a market characterised by price flexibility. Although widely used as a basis for Phillips curve wage models, as discussed above, these characteristics are more appropriate to commodity, including agricultural, markets and securities markets rather than to labour markets. The elements of an auction market model are a demand schedule, a supply schedule, and a reaction function which gives the speed of price adjustment when the market is in disequilibrium, i.e., excess demand or supply at the prevailing price.[104] These basic features can be stated as,

(i) demand and supply functions:

$$D = D(P; Z_1) \tag{7.3.7}$$

$$S = S(P; Z_2) \tag{7.3.8}$$

(ii) definition of excess demand:

$$X^d = D - S \tag{7.3.9}$$

(iii) price adjustment mechanism:

$$\Delta P = \lambda . X^d = \lambda (D - S) \tag{7.3.10}$$

where the demand (D) and supply (S) schedules are functions of price and other variables (Z_1 and Z_2); X^d is defined as excess demand; and the reaction function – the speed with which price adjusts – is stated in Equation (7.3.10) where λ is the adjustment coefficient.[105] Godley and Nordhaus (1972), in their study of industrial pricing in the UK, consider a model of price setting which combines the cost pricing (administered) and competitive (auction) mechanisms, i.e.,

$$P = \delta_0 (\hat{P})_1^{\delta} \ (X^d)^{\lambda} \tag{7.3.11}$$

104. The *non-tâtonnement* equilibrating process underlying these models is outlined by Nordhaus (1972, pp. 17-19) and Laidler and Parkin (1975, pp. 766-767).

105. It is assumed in this formulation that the speed of adjustment does not change if the market situation is one of excess supply. It should also be noted that in Phillips curve applications the rate of unemployment is taken as the measure of X^d but the theoretically correct measure should also take job vacancies into account.

where $\hat{P}$ is the predicted price based on a constant mark up on a measure of historical normal unit costs and X^d is a measure of excess demand. In order that the normal cost hypothesis is not rejected, it is necessary for $\delta_0 = \delta_1 = 1$ and $\lambda = 0$, where λ is the speed of adjustment coefficient of prices to excess demand pressure in the auction market model.[106]

Openness in the Goods Market

In extending pricing mechanisms discussed above to an open economy, at issue is the extent to which the determination of producers' prices is influenced by foreign prices and markets.[107] In the extreme small open economy case, producers' prices are simply taken as equal to foreign prices.[108] This may occur with a lag, allowing room for short-run divergences, as in Geary's estimated model. In the long run, changes in the relationship between local and foreign prices cause inter-industry shifts, while in the short run they mainly affect profits. A widely used disaggregated approach is the Scandinavian model of inflation where the economy is divided into two sectors, exposed and sheltered.[109] The exposed sector produces commodities which are traded goods and, since the world market is (infinitely) large relative to domestic suppliers and purchasers, the exposed sector is a price-taker. In this case the price which is taken by individual producers — the entire exposed sector at the level of aggregation here — is the foreign price, so that in equilibrium

$$P_o = P_f \tag{7.3.12}$$

where P_o is domestic producers' price of output and P_f is the foreign price for equivalent commodities. In a situation of rising unit costs of production such a sector is constrained in adjusting prices upward by the ceiling of world prices. The sheltered sector, on the other hand, has scope to pass on cost increases into prices, especially if price elasticity of demand is quite low. In this sector prices are determined by internal costs and demand. This disaggregation is difficult to operationalise with existing data sources as it

106. But the results and their interpretation in the Nordhaus and Godley study is somewhat conflicting. The coefficient on predicted price in their preferred estimate (1972, p. 869) was significantly less than unity. Godley and Nordhause emphasise that the most important aspect is the insignificant coefficient in the excess demand variable (1972, pp. 869-870). In contrast, Laidler and Parkin (1975, p. 768) interpret the test as refuting the normal cost hypothesis. Smith (1978) discusses some of these conflicting interpretations.

107. The effect of openness on the other aspect of prices — price inflation and monetary accommodation — will be considered below.

108. Denominated in terms of the currency of the SOE.

109. Branson and Myhrman (1976) and Calmfors and Herin (1980).

requires a categorisation into tradeable (exposed) and non-tradeable (sheltered) goods.[110] In the aggregated approach followed in our study we cannot classify goods or sectors so clearly. The final producer price is then a weighted average of the two approaches where prices are set according to domestic conditions or are determined by world market conditions, i.e.,

$$P_0 = \hat{P}^{\delta} P_f^{(1-\delta)} \qquad (7.3.13)$$

where P_0 is the domestic producers' price, $\hat{P}$ is output price predicted on the basis of, say, mark up on normal unit costs – such as equation (7.3.8), and δ is the estimated weight. This model of price determination allows, depending on the estimated value of δ, for three possibilities: the extreme SOE ($\delta = 0$), extreme closed economy ($\delta = 1$), and a mixed mode of price determination ($0 < \delta < 1$).[111]

Specification and Validation

Administered Markets

The models of producer price determination discussed in the theory section, included cases where very specific technological and behavioural assumptions were made. For example, a profit maximising firm with a two-factor constant returns to scale Cobb-Douglas technology, facing a log-linear demand schedule in income and price, has the following "optimal" pricing equation:

$$\log P = a_0 - \gamma t + \alpha_1 \log C + (1 - \alpha_1) \log W$$

where P is the product price, γ the (disembodied) rate of technical progress, C the user cost of capital and W the wage rate. However, this "optimal" pricing rule is observationally indistinguishable from the rule followed by a cost-minimising firm who applies a constant mark up on average costs (Equations (7.3.3) and (7.3.4)). Such approaches, while necessary for isolating likely explanatory variables for long run equilibrium, price determination, are not usually used as tools of investigation into the technological and behavioural assumptions. Rather, they are used to motivate the derivation of mark up price-setting equations to which we now turn.

110. Calmfors and Herin (1980) conduct such an exercise for Sweden.

111. Driehuis *et al.* (1975) use this approach in the study of sectoral price determination in the Netherlands. Schwartz and Kooyman (1975) use an extended framework to integrate the basic two-sector model into a multi-country model of the international interaction of price determination.

We examine in Table 7.3.1 a range of variations on the short-run mark-up pricing model. Of the range of models possible (differing from each other by the comprehensiveness of the cost measures uses), we concentrate on the very simplest, where price is determined as a mark up on unit labour cost.[112] Such a model takes the form

$$P^* = (1 + \theta^*)\text{UCL} \tag{7.3.14}$$

where P* is the desired price, θ^* the desired mark up, and ULC equals the labour cost. The adjustment of actual price (P) to desired price (P*) is assumed to be a standard partial adjustment mechanism:

$$\log P = (1 - \lambda)\log P^* + \lambda \log P \tag{7.3.15}$$

where λ, the adjustment factor, equals unity if P adjusts completely to P* within one time period. We examine some empirical variants of Equation (7.3.14), and consider whether demand pressure and external trade prices affect the mark up θ^*. We do this by making θ^* parametric in CUR_I (the rate of industrial capacity utilisation) and in relative prices, as follows. Assuming that the rate of mark up, θ^*, is small relative to unity, we can write

$$\log(1 + \theta^*) \approx \theta^* \tag{7.3.16}$$

Hence, from Equations (7.3.14) and (7.3.15)

$$\log P = (1 - \lambda)\log \text{UCL} + \theta^* + \lambda \log P_{-1} \tag{7.3.17}$$

Hence, if we assume that

$$\theta^* = a_0 + a_1\,\text{CUR}_\text{I} + a_2\,\frac{\text{PMG}}{\text{POI}} + \frac{\text{PXG}}{\text{ULC}} \tag{7.3.18}$$

then

$$\log P = \lambda \log P_{-1} + (1-\lambda)\log \text{ULC} + (1-\lambda)a_0 + a_1\,\text{CUR}_\text{I} + a_2\frac{\text{PMG}}{\text{ULCI}} + a_3\frac{\text{PXG}}{\text{ULCI}} \tag{7.3.19}$$

The justification for the inclusion of capacity utilisation as a possible influ-

112. As mentioned, the mark-up pricing model is characteristic of an oligopolistic market, but is often used as the best empirical rule which firms can apply when they do not know the shape of the demand curve facing them and are unable to maximise profits.

Table 7.3.1: *Industry producers' (value-added) prices, variable mark-up models, OLS regressions 1962-1979*

$$\log POI = \lambda \log POI_{-1} + (1-\lambda) \log ULCI + (1-\lambda)\, a_0 + a_1\, CURI + a_2 \frac{PMG}{ULCI} + a_3 \frac{PXG}{ULCI}$$

Equation No.	λ	a_0	a_1	a_2	a_3	$\bar{R}^2$	SER	D.W.
1.	0.304 (4.6)	0.260 (15.0)	–	–	–	0.998	0.0247	2.49
2.	0.373 (4.6)	0.551 (2.6)	–0.326 (1.4)	–	–	0.998	0.0240	2.52
3.	0.0	0.0065 (0.0)	0.348 (1.3)	–	–	0.995	0.0361	1.02
4.	0.0	0.349 (3.2)	–	–0.010 (0.1)	–	0.995	0.0377	0.76
5.	0.304 (4.5)	0.288 (3.2)	–	–	–0.017 (0.3)	0.998	0.0254	2.49

Notation:

POI = Deflator of value added in industry
ULCI = Unit labour costs in industry
CURI = Capacity utilisation rate in industry
PMG = Deflator of goods imports
PXG = Deflator of goods exports

ence on θ^* (the desired mark up) is self-evident. In including the import and export prices into the mark up, we are examining the direct effect of rising or falling trade prices on domestic producer prices and not the induced effect via wage formation, balance of payments and money supply. In the case of import prices, domestic producers may, in an effort to preserve their share of the home market, adjust their prices to the price charged by their competitors, i.e., import prices. In the case of export prices, price-taking behaviour in world markets may inhibit the degree of manufacturing cost pass-through to domestic producer prices. In Table 7.3.1 we present some statistical estimates based on Equation (7.3.19) above. In no case do the utilisation and relative price terms achieve statistical significance. The dominant equation is the simple constant mark up one where the partial adjustment coefficient, λ, takes the value 0.3, indicating over two-thirds adjustment to the desired price within one year. At such a high level of aggregation it is not entirely surprising that the relative price (competitive) terms failed to be significant. A closer examination, using disaggregated price data, may yield different results.

In Table 7.3.1 we examined variants of a simple mark-up model where only the cost of labour inputs was included as a variable cost. In Table 7.3.2 we present estimates of the mark-up model where the costs of labour and capital are included. We consider the special cases of labour alone, capital alone, and the imposition of constant returns to scale. The best statistical fit is given by Equation 3, where the sum of the labour and capital costs equals 0.951. As in the case of Table 7.3.1, the mark up was not parametric in capacity utilisation, imposition of constant returns to scale leads to deterioration of the fit (Equation 4) and no significant technical progress effect was detected.

If data were available for gross output of the industry sector (QI) and for material inputs (MATI), then price equations of the form

$$\log PQI = a_0 + a_1 \log ULCI + a_2 \log UCCI + a_3 \log PMATI \qquad (7.3.20)$$

Table 7.3.2: *Industry producers' (value-added) prices, constant mark up models, OLS regressions, 1962-1979*

1.	$\text{Log POI} = \underset{(21.8)}{0.305} + \underset{(67.3)}{0.964} \log \text{ULCI}$ $\bar{R}^2 = 0.996$ SER = 0.032 D.W. = 1.08
2.	$\text{Log POI} = \underset{(4.1)}{-0.046} + \underset{(59.9)}{0.928} \log \text{UCCI}$ $\bar{R}^2 = 0.995$ SER = 0.036 D.W. = 2.15
3.	$\text{Log POI} = \underset{(2.2)}{0.171} + \underset{(2.8)}{0.593} \log \text{ULCI} + \underset{(1.8)}{0.358} \log \text{UCCI}$ $\bar{R}^2 = 0.997$ SER = 0.030 D.W. = 1.67
4.	$\text{Log POI} = \underset{(4.1)}{0.321} + \underset{(4.3)}{0.958} \log \text{ULCI} + (1-0.958) \log \text{UCCI}$ $\bar{R}^2 = 0.995$ SER = 0.038 D.W. = 0.79

Notation:
POI = Deflator of value-added in industry
ULCI = Unit labour costs in industry
UCCI = User cost of capital in industry

Table 7.3.3: *Industry producers' (gross output) prices, constant mark up models, OLS regressions, 1962-1979*

1. $$\log PQTIG = \underset{(12.7)}{0.328} + \underset{(38.9)}{1.028} \log ULCI$$

$\bar{R}^2 = 0.989$ SER = 0.059 D.W. = 0.48

2. $$\log PQTIG = \underset{(1.3)}{-0.134} - \underset{(0.9)}{0.243} \log ULCI + \underset{(4.6)}{1.226} \log UCCI$$

$\bar{R}^2 = 0.995$ SER = 0.0393 D.W. = 0.57

3. $$\log PQTIG = \underset{(0.4)}{-0.025} - \underset{(0.1)}{0.012} \log ULCI + \underset{(2.7)}{0.540} \log UCCI + \underset{(5.5)}{0.476} \log PMGS$$

$\bar{R}^2 = 0.998$ SER = 0.023 D.W. = 1.70

4. $$\log PQTIG = \underset{(1.5)}{0.041} + \underset{(2.7)}{0.194} \log ULCI + \underset{(8.3)}{0.503} \log PMGS + \underset{(4.4)}{0.295} \log PQAG$$

$\bar{R}^2 = 0.999$ SER = 0.0183 D.W. = 1.80

5. $$\log PQTIG = \underset{(2.8)}{0.054} + \underset{(3.7)}{0.220} \log ULCI + \underset{(8.9)}{0.513} \log PMGS + (1-0.220-0.513) \log PQAG$$

$\bar{R}^2 = 0.999$ SER = 0.0179 D.W. = 1.69

Notation:

PQTIG = Price of gross and output of transportable goods industries
ULCI = Unit cost of labour in industry
UCCI = User cost of capital in industry
PMGS = Deflator of imports of goods and services
PQAG = Deflator of gross agricultural output

would be appropriate. Using the deflator of gross output of transportable goods industries (PQTIG) as a proxy for the unavailable PQI, and using the imports deflator (PMGS) and the deflator of gross agricultural output (PQAG) as proxies for the unavailable PMATI, we present estimation results in Table 7.3.3. The explanation for the insignificance of the unit labour cost variable in Equations 2 and 3 probably lies in the extreme multicollinearity due to the high correlation between UCCI and PMGS. In Equation 4 (and the constant returns to scale version, Equation 5) we suppress the capital term (including it implicitly in PMGS). The actual distribution of gross output of transportable goods industries was as follows:

	Labour	*Materials*	*Other*
		per cent	
1958	16	71	13
1973	17	63	20

For net output, the distribution was

	Labour		*Other*
		per cent	
1958	54		46
1973	38		62

Hence, Equations 4 and 5 broadly reflect the actual labour-non-labour decomposition of gross output. Neither technical progress nor capacity utilisation exercised significant influences on price formation. No dynamic or lagged effects were found.

In the above three tables we have explored the mark-up model of industrial producer price formation. A constant mark up on the components of output, both for value-added deflators and gross output deflators, appears to be consistent with the actual price evolution. Given the sources of multicollinearity in these price equations, consideration could be given to imposing some of the coefficient values from factor shares, derived by CIP or I/O sources.[113]

Finally, in Table 7.3.4 we present estimates of the mark-up model of price determination in the service sector. The best overall statistical fit is given by Equation 3 which includes a dynamic adjustment mechanism. The short-run elasticity of service prices to unit labour costs is 0.415 and to capital costs is 0.125. The corresponding long-run elasticities are 0.807 and 0.243. The long-run effect of a one per cent change in labour and capital costs is 1.05. In Equation 5 it is seen that increases in the rate of capacity utilisation (in industry) have positive effects on price formation. The capacity utilisation effect has the *a priori* expected sign. Given that the service sector is broadly "sheltered" compared with the more "exposed" industrial sector, it is to be expected that service sector output prices will be sensitive to domestic conditions, while no such sensitivity was found for industry.

In summary, in this sector we have presented two approaches to the determination of producer prices: the administered market model and the auction market model. Using a simple Cobb-Douglas technology, we have

113. This approach has been used quite successfully by Driehuis *et al.* (1975) for The Netherlands.

Table 7.3.4: *Services producers' (value-added) prices, constant mark-up models, OLS regressions, 1962-1979*

1.	$\log POS = \underset{(16.0)}{0.439} + \underset{(41.5)}{0.962} \log ULCS$
	$\bar{R}^2 = 0.990$ SER = 0.026 D.W. = 1.35 RHO = 0.6803
2.	$\log POS = \underset{(4.3)}{1.273} + \underset{(5.5)}{0.639} \log ULCS + \underset{(2.8)}{0.369} \log UCCS$
	$\bar{R}^2 = 0.995$ SER = 0.021 D.W. = 1.34 RHO = 0.5587
3.	$\log POS = \underset{(3.7)}{0.586} + \underset{(6.8)}{0.415} \log ULCS + \underset{(1.9)}{0.125} \log ULCS + \underset{(6.3)}{0.486} \log POS{-}1$
	$\bar{R}^2 = 0.999$ SER = 0.013 D.W. = 1.64
4.	$\log POS = \underset{(1.5)}{0.398} + \underset{(10.8)}{0.755} \log ULCS + \underset{(3.0)}{0.233} \log UCCS + \underset{(4.0)}{0.595}\ CURI$
	$\bar{R}^2 = 0.999$ SER = 0.018 D.W. = 1.70

Notation:
POS = Deflator of value-added in service sector
ULCS = Unit labour costs in services
UCCS = User cost of capital in services
CURI = Capacity utilisation rate in industry

shown that the separate approaches are observationally very similar and can be interpreted most conveniently in terms of variable mark-up models. We have estimated producer price equations for the industrial and for the services sectors. In the case of the industrial sector we have further examined the distinction between value-added price determination, where import prices play no direct role, and gross output producer prices, where import prices play a major direct role, accounting for over half the observed price changes. The incorporation of a CES technology is possible (thus bringing it into line with the technology used in Chapter 4 in examining supply). However, for simplicity one can regard the Cobb-Douglas equations as providing a good first approximation to the processes of price formation.

IV. *EXPENDITURE PRICES*

The pricing mechanisms considered so far have concerned the determination of prices by, or for, producers. These must now be translated into the prices facing purchasers, so that two classes of prices are distinguished: output (value-added) prices and (final) expenditure prices.

Theoretical Framework

The number of expenditure prices is quite large in view of the moderate level of disaggregation used in the domestic absorption block, Chapter 6. However, for simplicity, the basic approach we use to study them is quite uniform, in that they are "explained" in terms of their component prices. In other words, any such expenditure price simply incorporates the prices of all goods and other factors (such as indirect taxes) which go to make it up, i.e.,

$$P_{ex} = P_Q^{w_1} . TIR^{w_2} . P_m^{w_3} \tag{7.4.1}$$

where P_{ex} is some expenditure price index, P_Q is an output price index, TIR the index of indirect taxation, P_m is an index of import prices, and w_1, w_2, w_3 are the appropriate weights. This approach essentially involves estimating the weights on the components of the expenditure price. It identifies a second channel by which foreign goods prices affect domestic prices. Domestic prices will vary with import prices with an elasticity that approximately equals the share of imports in a particular category of goods. Therefore, as Equation (7.4.1) shows, this influence of the openness of the economy on domestic prices is obvious and direct. This relationship between expenditure prices and foreign prices has no behavioural implications, provided the mark up is constant.

Specification and Validation

Equation (7.4.1) shows how each expenditure price can be expressed in terms of its components. At a high level of aggregation, three components can be distinguished:

(i) Output prices, measured by the deflator of gross domestic product at factor cost (PGDPF);
(ii) net indirect taxes (i.e., taxes on expenditure net of any subsidies TINR); and
(iii) import prices (taken as the deflator of imports of goods and services, PMGS).

In addition to the direct effect of import prices on expenditure prices (proportional to the import content of the particular expenditure category), import prices also exercise an induced or indirect effect via the process of wage formation, balance of payments and money supply. In the above model we are concerned with the direct effect. Hence, denoting any expenditure price by P_{ex}, our model becomes

$$\log P_{ex} = a_0 + a_1 \log PGDPF + a_2 \log PMGS + a_3 \log TINR \qquad (7.4.2)$$

OLS estimations are shown in Table 7.4.1 for the range of expenditure categories covered in this study, which are as follows:

Label	*Expenditure category*
PCPER	Private consumption (CPER)
PCGO	Public consumption (CGO)
PIFI	Industrial sector investment (IFI)
PIFS	Service sector investment (IFS)
PIFA	Agricultural sector investment (IFA)
PIFG	Government investment (IFG)
PIH	Housing investment (Total) (IH)
PXGS	Exports of goods and services (XGS)

Since the bulk of expenditure taxes are levied on private consumption, one expects the tax variable, TINR, to be significant only in the explanation of CPER. However, since some VAT is payable on other components of expenditure, the tax variable was included in all categories. The empirical results are quite satisfactory from a statistical point of view. Ranking the expenditure categories by the size of the coefficient on imports (MGS) gives XGS (0.55), IFS (0.48), IFG (0.41), IFI (0.32), CPER and CGO (0.26), IFA (0.21) and IH (0.17), a ranking which is broadly in line with a ranking of expenditure categories by import content. Apart from the rather anomalous significant tax effect on CGO, only private consumption exhibits a significant coefficient on TINR. In terms of this very aggregate net indirect tax measure,[114] a 1 per cent rise in net indirect taxes gives a 0.17 per cent rise in consumption prices. In other approaches to quantifying the impact of indirect taxes on consumption prices, a net-of-tax price variable is sometimes defined and tax influences measured by means of identities rather than behaviourally, as in Table 7.4.1.[115]

In summary, we have chosen to explain the determination of expenditure prices by means of a components approach, isolating output prices, taxes and import prices as the three main components. The output price can, in

114. Details of its derivation are given in Appendix 2.2.

115. Examples of this approach are used in Norton (1975), and in Bradley *et al.* (1981).

Table 7.4.1: *Expenditure prices (components model), OLS regressions, 1962-1979*

General form: $\log Y = a_o + a_1 \log PGDPF + a_2 \log PMGS + a_3 \log TINR$

Y	a_o	a_1	a_2	a_3	$\bar{R}^2$	SER	D.W.	RHO
PCPER	−0.513	0.642	0.261	0.170	0.999	0.0106	1.81	–
	(3.8)	(14.0)	(6.0)	(3.8)				
PCGO	−0.796	0.792	0.233	0.255	0.999	0.0198	1.07	–
	(3.2)	(9.2)	(2.9)	(3.0)				
PCGO	−0.618	0.774	0.260	0.196	0.996	0.0173	1.45	0.6381
	(2.3)	(11.0)	(3.9)	(2.2)				
PIFI	0.196	0.642	0.315	−0.058	0.999	0.0162	2.04	–
	(1.0)	(9.2)	(4.8)	(0.9)				
PIFS	−0.231	0.495	0.476	0.083	0.999	0.0189	2.13	–
	(1.0)	(6.0)	(6.2)	(1.0)				
PIFA	0.325	0.876	0.209	−0.100	0.998	0.0284	2.49	–
	(0.9)	(7.1)	(1.8)	(0.8)				
PIFG	−0.481	0.610	0.410	0.159	0.998	0.0235	1.74	–
	(1.6)	(6.0)	(4.3)	(1.6)				
PIH	−0.318	0.838	0.171	0.108	0.996	0.0342	1.72	–
	(0.7)	(5.7)	(1.2)	(0.7)				
PXGS	0.183	0.478	0.510	−0.055	0.998	0.0215	1.39	–
	(0.7)	(5.1)	(5.8)	(0.6)				
PXGS	0.0168	0.433	0.552	–	0.999	0.0210	1.29	–
	(2.3)	(8.0)	(10.0)					
PXGS	0.0129	0.455	0.525	–	0.997	0.0198	1.75	0.3850
	(1.3)	(7.4)	(8.4)					

Notation:

PGDPF = Deflator of GDP at factor cost
PMGS = Deflator of imported goods and services
TINR = Net indirect taxes
Refer also text for expenditure price definitions.

turn, be expressed in terms of its components (labour, capital, materials), and progressively more sophisticated models developed. Such an interpretation of expenditure prices points to the global importance of the correct determination of output prices since the tax effect is usually regarded as a policy instrument (treated in more detail in Chapter 9) and import prices are exogenous (other than for an exchange rate element, to which we return in Chapter 8). Examination of the interaction between output and expenditure prices requires a fully integrated operational model where economy-wide feedbacks can be traced and quantified.

V. *PRICES OF LABOUR*

In Ireland, wage determination over the 1960s and 1970s has been characterised by "national wage agreements" or "wage rounds" negotiated by union representatives via the Irish Congress of Trades Unions, by employers via the Federated Union of Employers, and by the Government as an employer, but with a growing interest in the implications of agreements for economic policy. In many respects the government plays the role of employers' representative in its various statements about competitiveness and productivity. The institutional process of wage determination has been described by O'Mahony (1964 and 1965), and together with three surveys (Behrend, 1973; McCarthy, O'Brien and Dowd, 1975; and O'Brien, 1981) provide the general background for examining wage behaviour. The McCarthy *et al.*, study is a major survey of the wage determination process in Ireland, with emphasis on the key wage bargains. The highly aggregate nature of our study limits the scope of wage analysis to the overall determinants, and eliminates issues of comparability and wage-leadership, which have been studied by Mulvey and Trevithick (1973; 1974) and McCarthy *et al.* Not surprisingly, however, the disaggregated survey data shows that the most important variable in wage bargaining is the cost of living (McCarthy *et al.*, 1975, pp. 165-166, Tables 27 and 28). McGinley (1976, p. 88), in his account of pay settlements in the public sector, states that the "arguments in support of general increases have typically centred around the rise in the cost of living, increases in GNP, and the need to keep pace with general pay trends in the economy".

As discussed in Section 7.II above, a common approach to analysis of wage determination is by means of a Phillips curve relationship. Here, the proportionate rate of change of wages is assumed to be a function of the rate of unemployment and the rate of change of some price index (usually consumption prices). One rationale for the process underlying a Phillips curve has been given by Lipsey (1960) in terms of a Walrasian price adjustment relationship of the form

$$\dot{W} = f\left(\frac{D-S}{L}\right) + \dot{P}^e \tag{7.5.1}$$

where D and S are the demand for and supply of labour, L is the numbers employed and P^e is the expected price. But

$$D = L + V$$

$$S = L + U$$

where V is the number of unfilled vacancies and U the number unemployed. Hence, the identity

$$\frac{D-S}{L} = \frac{V-U}{L} \tag{7.5.2}$$

so that the excess demand for labour relative to employment relates to the difference between the vacancy rate (V/L) and the unemployment rate (U/L). Most empirical literature uses the unemployment rate only, mainly due to the non-existence, or poor quality, of vacancy data.

Theoretical Framework

Auction Markets

In this approach, market wage rates result from the interaction of independent supply and demand schedules for labour, which are aggregations of those of individual agents. A common element of all labour market models is a demand for labour schedule. For example, based on profit maximising behaviour by the firm this takes the form

$$L^{*d} = f_1(W, P_q, Q) \tag{7.5.3}$$

where L^{*d} is the (unobservable) demand for labour, W is the nominal wage rate, P_q the output price and Q is real output. Labour is supplied by individuals who seek to maximise utility in the context of given money wage rates (W), transfer benefits (TB) and consumer prices (P_c), i.e.,

$$L^{*s} = f_2(W, P_c, TB) \tag{7.5.4}$$

Equation (7.5.4) can be solved to yield the reservation wage, W*, at which a particular quantity of labour is supplied, i.e.,

$$W^* = f_3(L^{*s}, P_c, TB) \tag{7.5.5}$$

Individuals, not supplying labour, decide whether to register as unemployed, and will do so depending on the benefits levels, rules, etc., and whether registration aids job search, which will also depend on the probability of finding employment. The registered labour force is then the labour supplied to firms plus those choosing to register as unemployed. In the competitive/auction market model, measured labour force and unemployment do not influence unemployment and real wages (Cooley and Smith, 1982, p. 7). For a given level of output, prices, and benefits, wages adjust so as to equilibrate labour supply and demand. These are then measured by observed employment, i.e.,

$$L^{*d}(W^*) = L^{*s}(W^*) = L$$

and

$$W^* = W$$

Therefore, since registration does not measure labour supply, equilibrium is consistent with measured unemployment.[116]

In such models, wage rates may not adjust instantaneously to yield equilibrium in the labour market. For example, a simple model would be to postulate that real wages adjust according to the relation

$$\Delta\left(\frac{W}{P_c}\right) = \lambda\,(L^{*d} - L^{*s}) \tag{7.5.6}$$

which is the process underlying the Phillips curve. In this model, labour demand determines employment (L) and labour supply depends on unemployment, benefits, etc. Labour supply is measured by the labour force (LF), so that

$$L^{*d} = L$$

$$L^{*s} = LF$$

Therefore, there is a quite different correspondence between the unobservable schedules and the observable indicators.

A recent application of a disequilibrium competitive model along these lines has been given by Economou and Panareton (1976) for Greece during

116. Further details and extensions are given in the recent survey of the area by Cooley and Smith (1982) on which we draw heavily at this point.

a period of rapid industrialisation. This study emphasises aspects of wage formation which are specific to a developing economy and encompasses many of the empirical aspects of the Irish situation. The wage equation so derived is of the following form:[117]

$$\log W = a_0 + a_1 \log P_c + a_2 \log P_Q + a_3 \log q + a_4 \log CUR + a_5 \log (W^H/W) \qquad (7.5.7)$$

where W is the wage rate, P_c the consumption expenditure deflator, P_Q the producer price of output, q the average productivity of labour, CUR the rate of capacity utilisation, and W^H the wage rate in a high productivity sector of the economy. Our expectations about the coefficients are as follows:

(i) $a_1 + a_2$ to be approximately unity;
(ii) a_3 to be positive and less than or equal to unity;
(iii) a_4 capacity utilisation coefficient, to be positive and less than unity, given the expected rigidity of wage rates during economic recessions; and
(iv) the sign on a_5 depends on the particular trend followed by (W^H/W).

Administered Markets

In the case of goods, prices in an administered market were determined by the supplier on the basis of some price-setting rule devised by the firm itself. However, in the case of labour prices in administered markets both the supplier and demander play a role in setting price. Thus, bargaining is the manifestation of an administered pricing process in labour markets.

Bargaining models of wage determination are based on the assumption that wage rates are determined by negotiation between employers and employees, with the outcome dependent on the relative strengths of the competing groups. The basic theoretical framework is the variable bargaining power game model. An objective or utility function of the firm is assumed and held to reflect the joint behaviour of the two groups negotiating – owners and employees – who attempt to maximise utility. Within this overall framework a number of different operational models have been developed. A recent example by Svejnar (1982a; 1982b) is based on the assumption that workers, in bargaining for the highest possible wage, take the next best alternative wage (W^a) into account, which reflects the net advantages of alternative

117. The derivation is outlined in Appendix 7.2 below.

employment (or, indeed, unemployment). In a situation where workers are willing to leave if settlement is not reached, then the two parties bargain over "net profit" π. If the division of π between the two parties is determined by their relative bargaining power, then by defining labour's share (α) of π, as a measure of its strength, the negotiated wage rate is

$$W = W^a + \alpha\left(\frac{\pi}{L}\right)$$

The estimate of $\alpha(0 \leqslant \alpha \leqslant 1)$ reflects the bargaining power, and ranges from a situation where employees have no power ($\alpha = 0$) to one where employers have no power ($\alpha = 1$).

There are a number of difficulties in operationalising this model and these become greater at the highly aggregative level at which this study is being conducted. For instance, the variable π is unobservable and one possibility of approximating it by assuming it varies proportionately with ($W^a L$) or with gross revenue, as suggested by Svejner (1982b, pp. 296-297), does not appear suitable for use at the entire industry level of aggregation. Also there is the added difficulty of identifying the alternative wage, although the openness of the labour market, discussed below, allows for the possibility that foreign wages indicate an aggregate alternative wage if mobility is high.[118] Therefore, for our level of aggregation, there is a need to develop a simpler approach which abstracts from the microeconomic channels involved in wage bargaining. One approach to providing an economic core for macro-level bargaining model is to assume that workers have a target level of real wages, $(W/P_c)^*$, which they seek to attain. Actual money wages then adjust to give the target real wage:

$$\Delta W = \lambda \left[\left(\frac{W}{P_c}\right)^* - \left(\frac{W}{P_c}\right)^*\right] \tag{7.5.8}$$

where λ is the adjustment parameter. The target real wage may be based on labour productivity,

$$\left(\frac{W}{P_c}\right)^* = f\left(\frac{Q}{L}\right) \tag{7.5.9}$$

and other factors which parameterise their ability to attain the target. A specific model of this type due to Sargan (1964; 1971) has been applied successfully to the UK by Henry *et al.* (1976) and to Ireland by Fanning (1979, Parts I and II). This approach recognises that unions bargain in

118. In specifying models of wage determination a distinction has to be made between wage *rates*, negotiated or otherwise, and wage *earnings* which is the measure usually used but reflects variations in hours worked, overtime, etc.

money wage terms but, as the McCarthy *et al.*, survey shows, the real wage is the concern of the negotiators. The Sargan model is based on achieving a desired increase in real wages by a target rate of increase in money wages, taking into account expected price changes. Formally,

$$\frac{W_t}{W_{t-1}} = \left[\frac{P^e_t}{P_{t-1}}\right] \left[\frac{(W/P)^*_t}{(W/P)_{t-1}}\right]^{\alpha} \qquad (7.5.10)$$

Expected inflation (P^e_t/P_{t-1}) and the target real wage $(W/P)^*_t$ relative to last periods realised real wage, $(W/P)_{t-1}$, imply a target money wage increase, (W/W_{t-1}). The parameter α can allow for bargaining strength, etc., to affect the outcome of negotiations. Since we are using annual data, it may be acceptable to assume that expected and actual inflation coincides, i.e.,

$$\frac{W}{W_{t-1}} = \left[\frac{P}{P_{t-1}}\right] \cdot [W/p]^{*\alpha} \cdot [\frac{W}{P}]_{t-1}^{-\alpha} \qquad (7.5.11)$$

The desired real wage level is unobservable and can be removed by assuming a constant growth rate, γ, yielding

$$\log\left(\frac{W_t}{W_{t-1}}\right) - \log\left(\frac{P_t}{P_{t-1}}\right) = -\alpha \log \frac{W_{t-1}}{P_{t-1}} + \alpha\gamma t \qquad (7.5.12)$$

Possible modifications include the parameterisation of the bargaining strength parameter, α, by such cyclical indicators as the capacity utilisation rate and the unemployment rates which affect the relative bargaining strength of unions. In bargaining models of this type labour supply plays no direct role and is measured, as in the disequilibrium model, by the observed labour force (Cooley and Smith, 1982, p. 9).

Openness in the Labour Market

A feature of the Irish economy is the relative openness of its labour market. Until the current sustained recession in the UK severely curtailed job opportunities, there were significant, if varying, flows of labour between Ireland and the UK. In earlier years (i.e., prior to 1970) these resulted in a net outflow, while for a period during the 1970s this was reversed to become a net inflow. The extent to which conditions in alternative labour markets affect domestic wage determination is almost as important an issue as the foreign price influence on domestic prices. O'Mahony's (1965) early statement of a small open economy model emphasised the channel of labour market openness on labour supply and wage determination, the effects of which then feed through to product prices and employment. This does not mean, as

O'Mahony pointed out, that there will be identical rates or earnings in purely monetary terms, but rather that the interdependence of the Irish labour market with that of the UK tends to bring about equality of the net advantages of working in Britain rather than Ireland: "Where the essential unity of the Anglo-Irish labour market shows itself most clearly is in the long-run tendency for wages in Ireland and Britain to change at very much the same rate and for the change in Irish wages to be more closely related to changes in British wages than to changes in output per head in Ireland" (1965, p. 10). That is, of course, if other factors remain unchanged.

The channels through which external factors enter into the structural wage determination models are the adjustment coefficients, alternative wage standards, the cost-of-living, and the relative bargaining strength parameter. Specifically, the openness can affect wage determination in two ways. First, the alternative employment options available to Irish workers abroad strengthen the position of unions in wage negotiation. Employers must compete with an alternative, higher wage, employment option. Such an effect might operate through a variable representing tightness of the labour market such as declining unemployment.[119] Second, wages may be externally constrained because employers face external price competition in foreign markets or domestically against import competition. They have, therefore, to control costs and may resist wage demands so that wage inflation moves with foreign prices plus the rate of productivity growth (if the mark up is constant) in the competitive sector of the economy. The transmission of this influence to the sheltered sector is then dependent on the process of wage comparability and the strength of unions *vis-à-vis* employers in that section. If costs in the competitive sector are increasing, with the consequence that prices rising relative to foreign prices are reducing demand or declining profitability is reducing production activity, then the resulting decline in employment and outward flow of capital from that sector may weaken union wage pressure. Thus, in this case, it is the increase in unit labour costs "permitted" by external prices which influences wage determination. The relevance of these factors to Ireland are obvious considering the openness of both the goods, and, until recently the labour market, combined with a fixed exchange rate environment.

119. Aggregate measures, however, may not indicate the tightness for particular types of labour for which there is competition and which may provide the impetus for spill-over effects via the process of wage comparability or "solidarity".

Specification and Validation

Auction Market Model

Our empirical investigations are confined to statistical estimates of the model derived in Equation (7.5.7) above. This equation was derived from assumptions of a profit maximising firm, with product and factor markets operating under conditions of imperfect competition, and where labour supply responded positively to real wages. The equation is, of course, compatible with other sets of assumptions and can be considered as representative of auction market models of wage determination. Statistical estimates for the industry sector are presented in Table 7.5.1, where this sector has been given a certain primacy in the issue of wage determination. In Equation 1 of Table 7.5.1, both consumption (PCPER) and output (POI) prices are included, and the sum of the price coefficients is 1.159, i.e., slightly greater than unity. The labour productivity (PRI) coefficient, 0.894, is as expected,

Table 7.5.1: *Industry wage determination (auction market model), OLS regressions, 1962-1979*

	Dependent Variable: log WI							
	Intercept	*log PCPER*	*log POI*	*log PQTIG*	*log PRI*	*log UR_{-1}*	$\bar{R}^2$	*D.W.*
1.	0.068 (0.4)	0.837 (4.1)	0.322 (1.7)		0.894 (10.5)	−0.154 (2.6)	0.999	0.85
2.	0.139 (0.6)	1.298 (4.9)		−0.100 (0.5)	0.810 (4.9)	−0.140 (2.2)	0.999	1.06
3.	0.057 (0.3)	1.166 (24.8)			0.879 (10.0)	−0.143 (2.3)	0.999	1.10
4.	0.049 (0.2)		1.101 (17.8)		0.987 (8.2)	−0.142 (1.6)	0.998	1.53
5.	−0.792 (3.4)			0.846 (14.6)	1.531 (12.6)	−0.132 (1.3)	0.997	1.35

Notation:

WI = Average annual earnings in industry (£'000)
PCPER = Consumption deflator
POI = Deflator of value-added in industry
PQTIG = Deflator of gross output in industry
PRI = Labour productivity in industry
UR = Unemployment rate (%)

less than unity but quite large. The implication is that almost 90 per cent of any increase in labour productivity goes in wage increases. In Equation 2 a gross output price (PQTIG) (for transportable goods industries) is used in place of the value-added deflator, while in Equations 3, 4 and 5 only a single price variable is included, i.e., consumption, value-added and gross output, respectively.

In all the equations of Table 7.5.1, the measure of pressure in the labour market is taken to be the unemployment rate, UR, lagged one period. In Equations 1, 2 and 3 this variable is significant at the 95 per cent level and has the expected negative sign in all equations. Use of the rate of capacity utilisation in industry as the pressure variable yielded perverse signs.

In Table 7.5.2 we present estimates of the wage model for services, public administration and for the hired-labour wage in agriculture. For services, although the coefficient of price (PCPER) is approximately unity, the coefficient on the productivity term is considerably greater than unity and highly significant. This may be due to an understatement of service sector productivity in the national accounts, but may quite simply be capturing the gradual convergence of service sector annual earnings to those in industry. We return to this matter below. For public administration (where, by definition,

Table 7.5.2: *Services, public administration and agriculture wage determination (auction market model), OLS regressions, 1962-1979*

1.	$\log WS = -0.762 + 1.148 \log PCPER + 1.582 \log PRS - 0.213 \log UR_{-1}$ $\qquad\qquad (3.9) \quad (26.0) \qquad\qquad (12.9) \qquad\qquad (3.8)$ $\bar{R}^2 = 0.999 \qquad SER = 0.0208 \qquad D.W. = 1.60$
2.	$\log WPA = 2.015 + 1.439 \log PCPER - 0.424 \log UR_{-1}$ $\qquad\qquad (8.2) \quad (21.4) \qquad\qquad (3.1)$ $\bar{R}^2 = 0.993 \qquad SER = 0.0522 \qquad D.W. = 0.95$
3.	$\log WAH = 1.204 + 1.763 \log PCPER - 0.611 \log UR_{-1}$ $\qquad\qquad (1.9) \quad (10.1) \qquad\qquad (1.7)$ $\bar{R}^2 = 0.969 \qquad SER = 0.136 \qquad D.W. = 0.50$

Notation:

WS	=	Average annual earnings in services (£'000)
WPA	=	Average annual earnings in public administration (£'000)
WAH	=	Average annual earnings of hired labour in agriculture (£'000)
PCPER	=	Consumption deflator (Base 1975 = 1.0)
UR	=	Unemployment rate
PRS	=	Average productivity in services.

productivity growth is zero), the coefficient on price is significantly greater than unity, a result in agreement with the very rapid growth of average annual earnings in the public sector over the 1960s and 1970s. For agriculture hired labour, the coefficient of 1.76 on prices may be due to the growth of agriculture wages from a very low base, and is further examined below.

Given the very heterogeneous nature of the service sector, and the fact that a "technological" explanation of wage developments in public administration and agriculture is hardly likely to be plausible, we examine the role of the industry sector as "wage leader" and consider the manner in which average annual earnings in the other sectors adjust to those in industry. The general approach is to make the sectoral earnings relative to industry earnings a function of unemployment and time. Statistical estimates are presented in Table 7.5.3. In the case of services and agriculture, the relative earnings rates are positive functions of time, i.e., service and agriculture earnings rates are converging from below to the industry rate. In the case of public administration, the relative earnings rate is a negative function of time, showing that the differential of public administration over industry is being eroded over time.

Administered Markets Model

The bargaining model of wage determination has been presented in Equation (7.5.12), and is of form

Table 7.5.3: *Services, public administration and agriculture wage determination (inter-sectoral wage adjustment model), OLS regressions, 1962-1979*

1.	$WS/WI = \underset{(40.0)}{0.794} - \underset{(2.0)}{0.0140}\, UR_{-1} + \underset{(3.0)}{0.00536}t$
	$\bar{R}^2 = 0.319$ SER = 0.021 D.W. = 1.72
2.	$WPA/WI = \underset{(23.6)}{1.950} - \underset{(1.9)}{0.047}\, UR_{-1} - \underset{(2.0)}{0.0134}t$
	$\bar{R}^2 = 0.669$ SER = 0.0619 D.W. = 1.77 RHO = 0.3646
3.	$WAH/WI = \underset{(16.4)}{0.382} - \underset{(3.7)}{0.030}\, UR_{-1} + \underset{(4.9)}{0.010}t$
	$\bar{R}^2 = 0.573$ SER = 0.0250 D.W. = 1.47

Notation: Refer Tables 7.5.1 and 7.5.2 above.
t = Time (1953 = 1.0)

$$\log\left(\frac{W}{W_{-1}}\right) - \log\left(\frac{P}{P_{-1}}\right) = \alpha \log\left(\frac{W_{-1}}{P_{-1}}\right) + \alpha\gamma t$$

where the parameter α measures bargaining strength and γ is the (assumed) constant growth rate of desired real wages. In Table 7.5.4 we present statistical estimates for industry, services and public administration. The model was not appropriate to the public administration sector (Equation 3 of (Table 7.5.4) and the following are the implied parameter values for industry and services:

	α	γ
Industry	0.590	0.043
Services	0.218	0.040

This indicates that while the bargaining strength measure in industry is greater than in services, both sectors are motivated by the same desired real wage growth rate (i.e., 4 per cent per annum).

In summary, both the auction and administered market approaches to wage determination have been presented. Specific examples of each have been estimated for industry, service and public administration. The auction

Table 7.5.4: *Industry, services and public administration wage determination, (administered market model), OLS regressions, 1962-1979*

1. $$\log\left(\frac{WI}{WI_{-1}}\right) - \log\frac{PCPER}{PCPER_{-1}} = \underset{(2.9)}{-0.590} \log\frac{WI_{-1}}{PCPER_{-1}} + \underset{(3.1)}{0.0255t}$$

$\bar{R}^2 = 0.180$ SER = 0.0212 D.W. = 1.86

2. $$\log\left(\frac{WS}{WS_{-1}}\right) - \log\frac{PCPER}{PCPER_{-1}} = \underset{(3.0)}{-0.218} \log\frac{WS_{-1}}{PCPER_{-1}} + \underset{(4.0)}{0.0087t}$$

$\bar{R}^2 = 0.103$ SER = 0.0267 D.W. = 1.88

3. $$\log\frac{WPA}{WPA_{-1}} - \log\frac{PCPER}{PCPER_{-1}} = \underset{(0.7)}{0.043} \log\frac{WPA_{-1}}{PCPER_{-1}} - \underset{(0.3)}{0.0013t}$$

$\bar{R}^2 = -0.11$ SER = 0.475 D.W. = 2.02

Notation:

WI	=	Average annual earnings in industry (£'000)
WS	=	Average annual earnings in services (£'000)
WPA	=	Average annual earnings in public administration (£'000)
PCPER	=	Deflator of private consumption expenditures (base 1975 = 1.0)
t	=	Time (1953 = 1.0)

market (disequilibrium competitive) model provided reasonable statistical fits (Table 7.5.1), but the administered market (wage bargaining) model (Table 7.5.4) also provided plausible results in terms of underlying parameter values. The results do not allow a clear choice between the two models.[120]

120. The methodologically correct approach is to incorporate each separately in an overall model structure (as a maintained hypothesis) and to examine the economy-wide linkages and feedbacks arising. This is the subject of a subsequent study.

Chapter 8

INCOME DISTRIBUTION – PART II

I. *INTRODUCTION*

In this chapter we continue the analysis of the income distribution process by analysing the role of the public (monetary and fiscal) authorities. In our discussion of the relativity and level aspects of prices, in Sections 7.I and 7.II, we pointed out that price determination takes place in the context of overall price inflation which introduces the monetary environment into the pricing process of income distribution. Furthermore, there is a second channel, as was also mentioned, by which the public authorities affect the income distribution process, namely, the fiscal channel which comprises taxation, grants and subsidies. A number of points of entry into this process have already occurred in the sectoral analysis so far, e.g., current expenditure on goods and services, subsidies and indirect taxes entering into expenditure prices, and the effect of grants, subsidies and taxes on user costs of factors of production. In this chapter we analyse the outstanding areas of public authorities' behaviour as they relate to our aggregate analysis of income distribution. In the following section we examine the monetary aspects, namely, monetary instruments (credit, exchange rate, money supply) and the finance of the budget deficit. In Section 8.III we consider the redistribution of incomes via the fiscal instruments of taxation and spending, both in terms that directly relate to incomes taxation and transfers as well as via indirect taxes and subsidies. Finally, in Section 8.IV we summarise the outcome of the entire income distribution process in a set of macroeconomic accounts that highlight a number of the key results from private and public sector activities.

II. *MONEY SUPPLY AND EXCHANGE RATE*

For more than 153 years, until March 30, 1979, there was a *de facto* monetary union between Ireland and the United Kingdom. Indeed, until 1971 the Irish pound was both legally and operationally equivalent to the pound sterling, and to change the exchange rate of the Irish pound would have required amending legislation. The eventual discontinuance of the link with sterling came shortly after Ireland's adherence to the European Monetary System (EMS), and the circumstances leading up to the break, together with *ex ante* analysis of the expectations of what the break would bring, are discussed by Murray (1979) and McCarthy (1979b). The long maintenance of this monetary union reflected, among other factors, the high degree of economic interdependence between Ireland and the UK. High trade ratios[121] and a high degree of factor mobility provided rational justification for monetary union: the period up to 1979 was characterised by an almost complete freedom of capital and labour movements between Ireland and the UK. As a consequence, the scope for autonomous domestic monetary policy was severely restricted. Under such a regime, Irish and UK interest rates could be expected to move in line with each other and detailed empirical analysis by Browne and O'Connell (1978b) bears out this prediction. Their policy conclusion was that the scope for autonomous monetary policy in Ireland as an instrument of stabilisation policy was very constrained by virtue of the high degree of integration of Irish and UK financial markets. Honohan (1982) cautions against the "over-interpretation" of the Browne-O'Connell analysis, and holds that the maintenance of orderly financial markets and other structural objectives of monetary policy were clearly important tasks which were not ignored in the sterling link period, as is evidenced by the considerable degree of interest rate variation which is not explained by UK interest rates. In addition, the range of financial institutions operating in Ireland is limited, and four retail banking groups (two of which are subsidiaries of UK companies), together with a small range of wholesale banks, account for over 70 per cent of total deposits. This fact, combined with the characteristics of the monetary union with the UK, has resulted in a simple analysis of the monetary sector over the period before EMS.

Theoretical Framework

There has been relatively little analysis of the Irish monetary sector within the context of an economy-wide analytic framework. Where previous empirical macromodels include monetary sectors[122] they reflected the model of a small, open, fixed exchange rate economy. In such models, the public's demand for money is always in equilibrium because they can engage in external capital transactions (directly or through financial intermediaries)

121. Illustrative values for the period 1960-1980 are shown below:

	1960	*1965*	*1970*	*1975*	*1980*
			per cent		
Imports/GNP	39.9	45.0	50.7	48.5	67.6
Exports/GNP	39.8	39.7	46.2	43.3	57.8

Data Source: Ireland, *National Income and Expenditure*, Stationery Office, Dublin, various years.

122. Most, however, do not, as the survey of macromodels showed (Fanning and Bradley, 1982).

to offset any restrictive actions by the monetary authority. Hence, in the case of perfect capital mobility, the Central Bank cannot control the nominal quantity of money, even in the short run. However, the level of domestic credit can be regulated (and enforced by means of variations in the liquidity ratios and special deposit requirements at penal interest rates).[123] Hence, the instrument of monetary control should be credit, and the target of the monetary authorities should be external reserves. If external reserves are deemed to be inadequate for the task of maintaining a fixed exchange rate, the Central Bank restricts domestic credit, an action which results in the private sector executing capital inflows in order to maintain desired money balances. Conversely, an expansionary domestic credit policy results in a rundown of reserves. Should the Central Bank require to exercise some control over the domestic money stock, then a diminution in the mobility of capital would be necessary. However, the enhancing of the efficacy of monetary policy necessarily diminishes the efficacy of fiscal policy in affecting income. In the perfect capital mobility case we are implicitly assuming that for given government taxation and spending policies, the accompanying monetary policy is to adjust the domestic interest rate sufficiently to finance the current account deficit at an unchanged interest rate. In particular, the empirical SOE assumption is then that this policy leads to small enough changes in interest rates that their effects on domestic spending and prices can be ignored (Helliwell, Boothe and McRae, 1982). If, however, interest rates can change, expansionary fiscal policy action can be financed through non-monetary means only by increasing interest rates in order to encourage the public to increase its holdings of government bonds. Any increase in interest rates will cause private expenditure to fall (or, at least, interest sensitive elements such as investment, stock building, consumption of durables), and thereby "crowd out" private activity. Such an increase in monetary autonomy has been brought about to some extent in the very recent past by exchange controls on capital movements between Ireland and the sterling area (where prior to 1979 none existed), and by a policy of domestic credit expansion bearing more heavily on the personal sector (i.e., less credit-mobile borrowers). In addition, from late 1980, credit guidelines were extended to include foreign currency borrowings.

A further manifestation of the integration of the Irish and UK money markets, which has been touched on in the treatment of inflation in Section 7.II above, is that the Irish inflation rate did not deviate from the UK rate, other than for short-run deviations induced by lags and net indirect taxation

123. A useful tabular summary of stated monetary policy objectives, means of implementation, and outturn has been provided in Bacon *et al.* (1982, pp. 60-61) for the period 1976 to 1982.

(Geary, 1976a; Bradley, 1977). Joining the EMS it was widely suggested, would quickly bring about a period of low inflation (McCarthy, 1979b). Subsequent events have not borne out this view and post-EMS developments are the subject of continuing analytical controversy (Walsh, 1981) as well as exchange rate adjustments in its operation.

Finally, there is the connection between fiscal and monetary policy. By fiscal policy we mean an increase in government expenditure or a reduction in taxation financed by the issue of non-monetary debt – exchequer bills or government bonds – that can be bought by domestic nationals or foreigners (McKinnon, 1976). An extension of this definition to include monetary financing is often made. A theoretical analysis of the issues involved has been given by Sloane (1977) and Murray (1980a and 1980b). Under the assumption of perfect capital mobility, the effect of an increase in government expenditure on short-run equilibrium income is expansionary regardless of the mode of finance, i.e., bond or monetary. However, both methods of financing the deficit are unstable in the sense that there is no tendency for the deficit to close over time in a static economy. With bond financing, the deficit tends to increase; with money financing the size of the budget deficit remains constant but the country runs out of external reserves. In the long run the assumption of perfect capital mobility is untenable since no country could continue to borrow forever at a fixed, externally determined, interest rate. Continual borrowing will eventually force up the effective interest rate as risk of possible default increases. Hence, any model based on the assumption of perfect capital mobility should be viewed as an approximation to reality which may be valid only in the short to medium term.

In presenting the conventional small open economy model of the monetary sector in algebraic form, it is convenient to embed it within a simplified reduced form model of the economy. In such a perspective, the monetary sector has the following five component parts:

(i) A reduced form equation summarising the real side of the model showing equilibrium in the goods market, i.e.,

$$\begin{aligned} GNPV = {} & CPERV + IFV + CGV + IIV + XGSV - MGSV \\ & + YFN \end{aligned} \tag{8.2.1}$$

where we have suppressed the determinants of the expenditure components. For the present we will assume that the only monetary sector explanatory variable is the interest rate, RPL, which is assumed to be externally determined.

(ii) The second element is a demand for money equation which, if money is defined broadly as the sum of currency, current accounts and deposit accounts, (MON), takes the general form

$$MON = f(GNPV, \overline{RPL}) \qquad (8.2.2)$$

The existence and stability of the demand for money equation is an important one for the monetary authorities irrespective of whether policy is conducted within a closed economy or within an extremely open economy with a fixed exchange rate dominated by external financial markets. With perfect capital mobility there is no scope for altering the domestic interest rate, since any attempt to do so will be frustrated by capital flows, as discussed above. A stable demand for money function in this case implies that if the monetary authority carries out policy actions intended to change the domestic component of the money stock (i.e., domestic credit), there will be equal and offsetting changes in the foreign component. Hence, in an open economy with virtually perfect capital mobility, a stable demand for money function enables the authorities to adapt domestic credit policy to attain an external reserves target. A series of rigorous stability tests have been carried out by Browne and O'Connell (1978a) and the empirical results showed that MON was a stable function of the variables determining money holdings. The authors of the study conclude that:

> While in its extreme form, by suggesting that a disequilibrium in the money market will be removed by capital movements in the balance of payments, the monetary approach [to the balance of payments] tends to play down the implications of such a disequilibrium for the markets for goods and other financial assets, in the Irish context [with very high capital mobility] the monetary approach does provide a useful framework for balance of payments analysis. This implies that, given a stable demand for money function and high capital mobility, the monetary authorities can affect external reserves, one counterpart to the money stock, by operating on the other, domestic credit, counterpart (Browne and O'Connell, 1978a, pp. 240-241).

(iii) The third element is the government's budget constraint where the financing of the deficit plays an important role in the determination of money supply.[124] This takes the following form:

$$-GBR = \Delta SECBG + \Delta SECHG + \Delta SECHGO + \Delta SECCBG + LBFGN \quad (8.2.3)$$

where

GBR	=	Public authorities' borrowing requirement
SECBG	=	Banks holdings of government securities
SECHG	=	Non-bank public's holding of government securities
SECHGO	=	Other government borrowing from non-bank public
SECCBG	=	Government indebtedness to the Central Bank
LBFGN	=	Government net borrowing abroad.

It is usual to leave all elements on the right hand side exogenous except LBFGN. Since GBR is determined in the public authorities fiscal block (Section 8.III), it is assumed that LBFGN is endogenised as the residual financing component. In particular, the empirical assumption being made is that, given GBR, the deficit can be financed domestically (the first four terms on the right above) or abroad (LBFGN) by changes in interest rates which are small enough that their effects on domestic spending can be ignored (Helliwell, Boothe and McRae, 1982). In using a model such as this over a period of sustained deficits by the public sector, the implications of this assumption must be closely monitored, particularly aspects related to debt accumulation and resulting debt service payment problems (Bruton, 1978, pp. 51-61).

(iv) The fourth element is the balance of payment equation. The following identity relates the balance of payments and changes in the official external reserves:

$$\Delta GFX = BPCV + \Delta NFLB + FGN + LBFGN + FPN \quad (8.2.4)$$

where

GFX	=	Official external reserves
BPCV	=	Balance of payments deficit on current account
NFLB	=	Net foreign liabilities of the commercial banks
FGN	=	Net capital receipts by government from abroad
LBFGN	=	Government net borrowing in foreign currencies
FPN	=	Net capital inflow of non-bank private sector.

The balance of payments on current account emerges from the

124. In the following section we describe and analyse the actions of the fiscal authorities, but do not consider the financing side of the resulting borrowing requirement.

trade side of the economy. Items two and three on the right hand side are assumed to be exogenous (or autonomous), while LBFGN has been determined residually in the government's budget constraint. Since GFX is determined in the money components definition below, this identity is used to endogenise FPN, and is at the core of the perfect capital mobility assumption.

(v) Finally, the sources of money supply are

$$\Delta GFX + \Delta DC = \Delta MON + \Delta ONLB \tag{8.2.5}$$

where

GFX = Official external reserves
DC = Private sector domestic credit
MON = Broad money supply
ONLB = Other net liabilities of banking system.

This identity simply states the two sources of the money supply — domestic credit (DC) and external reserves (GFX).[125] Underlying parts (ii) above and (v), i.e., money demand and money supply, is the implicit equilibrium relationship

$$MON^D = MON^S = MON$$

The specification (i) to (v) is highly recursive. National income is determined in the real sector of the economy, and when inserted into the demand for money, Equation (8.2.2), yields MON. Given a level of domestic credit (DC), either the specific value desired by the monetary authorities or any other value, the level of external reserves is determined by Equation (8.2.5).

In the case where the only monetary instrument in the monetary sector model is domestic credit (DC), or at least the statutory instruments used by the Central Bank to control/influence domestic credit (e.g., reserve ratios, penal rediscounting, etc.), and domestic credit is not incorporated into any of the real sector behavioural equations (e.g., output supply equations, consumer demand), then it follows directly that the Central Bank would appear to be able to control the level of reserves (and, hence, the exchange rate) without affecting real sector activity. Such a situation is unlikely to be the case in the real world. However, demonstrating this empirically is fraught with problems of theory and measurement which go beyond the level of time disaggregation and structure detail suitable for this model. Hence,

125. The sources of money supply can be further decomposed, if required, into the underlying balance sheets of the Central Bank and the combined commercial banks.

any use of this framework for the analysis of medium-term economic policy must pay particular attention to the dangers of assuming away real effects of domestic credit policy and to the problems with the assumption of perfect capital mobility raised in earlier pages, even if such effects cannot be quantified.

Finally, there are two further points concerning income distribution, prices, and the money supply that need to be drawn together. These are (i) the relationship between monetary accommodation and price inflation in an open economy and (ii) the relationship between monetary expansion and the models of price determination outlined in Section 7.III. The first concerns the manifestation of inflationary pressures in an open economy with fixed exchange rates as a combination of price inflation unemployment, and balance of payments deterioration. The second concerns the relation between the growth of the price level and monetary accommodation raised at the outset. A situation in which prices of particular goods or categories of labour are increased need not necessarily be one of an increase in the overall price level, i.e., of price inflation. The increase of some prices could be offset by a fall in other prices. In practice the adjustment stake place within the context of an increase in the overall price level made possible by the accommodating expansion of monetary supply. This then raises the question about the direct influence of money supply on the determination of particular prices. The price determination models discussed in Section 7.III were structural models in the sense that they sought to identify the approach which, for example, firms would take in setting prices. Money supply is not a variable that is likely to enter into whatever formulation individual firms may use to set price. As Nordhaus points out, the distinction between structural and reduced form modelling of prices is an important one in identifying appropriate variables. In properly specified price equations money should not be significant. In administered markets the channel for monetary influences is via factor prices and in auction markets via excess demand. In reduced form models, on the other hand, money enters as an important determinant of aggregate demand and excess demands (Nordhaus, 1976, pp. 62-63).[126]

Specification and Validation

Given the simple model of monetary sector behaviour discussed above,

126. In small scale, reduced-form, monetarist models, such as Anderson and Carlson (1972) money stock explains nominal GNP which then enters into price equations. Behrman (1977, Chapter 6) estimated "quasi reduced-form" price equations for the highly inflationary Chilean economy and found that changes in the nominal money supply (endogenous in his model) was a significant determinant of some prices.

there is only one behavioural equation to be specified and estimated, i.e., the demand for money equation. In this we follow the work of Browne and O'Connell (1978a) and in Table 8.2.1 we report on various estimates. Since annual data are being used, the ability to model complex lag structures is quite limited. In addition, no significant intrest rate effects were detected. Taking Equation 1 as a typical example, there is essentially a unitary elasticity of nominal money demand with respect to nominal gross national product.

As discussed in the theory section, the particular monetary model used is highly recursive and it is within a planning framework rather than a structural/behavioural model framework that one must evaluate the role of the demand for money equation. Having prepared forecasts of future nominal GNP, the Central Bank uses a relationship like Equation 1 of Table 8.2.1 (or a more sophisticated sub-annual version) to project the likely total demand for money. Such an exercise would usually be carried out by disaggregating the broad money supply (MON) into its constituents, i.e., currency, current

Table 8.2.1: *Demand for money function, OLS regression, 1962-1979*

1.	$\log MON = -0.551 + 1.018 \log GNPMV$ $\qquad\qquad (3.1) \qquad (44.7)$			
	$\bar{R}^2 = 0.992$	SER = 0.0425	D.W. = 1.48	RHO = 0.4271
2.	$\Delta MON = -6.526 + 0.731\ \Delta GNPMV$ $\qquad\qquad (0.1) \qquad (7.1)$			
	$\bar{R}^2 = 0.754$	SER = 115.8	D.W. = 1.71	RHO = 0.2262
3.	$\Delta \frac{MON}{PGNP} = -58.16 + 1.235\ \Delta GNPM$ $\qquad\qquad (1.1) \qquad (3.4)$			
	$\bar{R}^2 = 0.392$	SER = 106.9	D.W. = 1.85	RHO = 0.1255
4.	$\Delta \frac{MON}{PGNP} = -46.15 + 1.148\ \Delta GNPM - 3.00\ \Delta PGNPDOT$ $\qquad\qquad (0.7) \qquad (2.6) \qquad\qquad (0.5)$			
	$\bar{R}^2 = 0.349$	SER = 113.6	D.W. = 1.82	RHO = 0.1350

Notation:

MON	=	Broad money supply (£m)
GNPMV	=	GNP at market prices (£m)
PGNP	=	Deflator of GNP (base 1975 = 1.0)
GNPM	=	GNP at constant market prices (£m, 75)
PGNPDOT	=	Rate of change of PGNP (%)
Δ	=	First difference operator

accounts and deposit accounts. The Central Bank would then draw up domestic credit guidelines to ensure that the domestic component of the money supply is of such a magnitude as to ensure the availability of "adequate" foreign reserves (GFX of Equation (8.2.5)). In such an exercise, the stability of the demand for money equation is an important factor in the planning and control function of the Central Bank.

In the absence of a stable demand for money function, the monetary sector could be closed by assuming that the net capital inflow of the non-bank private sector (FPN of Equation (8.2.4)) was exogenous to the model. Hence, foreign reserves (GFX) would be determined by the balance of payments, government foreign borrowing and private net capital inflows (Equation (8.2.4)), and the money supply (MON) would simply emerge as the sum of the (exogenous) domestic and foreign components (Equation (8.2.5)).

Hence, the analytical framework applied to the monetary sector, is not entirely a structural model of the behaviour of the Central Bank and the banking sector. The conduct of such a study would require a more disaggregated approach and is not attempted here. When such analysis has been performed, and the post-EMS monetary environment is more fully understood and quantified, then the simple assumptions underlying our approach can be relaxed.

III. *FISCAL REDISTRIBUTION*

The operation and role of the public authorities can be illustrated by means of two diagrams. In Figure 8.1 we show the structure of fiscal activity (revenue and expenditure) and the derivation of the government budget deficit. In Figure 8.2 we illustrate the relationship between fiscal and monetary activity and the financing of the budget deficit and the balance of payments deficit which were discussed in Section 8.II. There are broadly three aspects to public authority fiscal policy: allocation, distribution and stabilisation. Although macroeconomic analysis yields limited insights into the first two aspects, the main usefulness of macroeconometric models is in analysing the final one. For example, in the analysis of fiscal policy by Kennedy and Dowling (1975) the concentration was on the role of the government in providing a stable environment, which was considered a prerequisite for the first two objectives alone. The four traditional targets of fiscal stabilisation policy are employment (or unemployment), prices, income growth and the balance of payments. An investigation of the degree of success of stabilisation policy in achieving stated targets is of interest given the degree of scepticism about the ability to "fine-tune" the economy[127] and the more disturbing problems

127. McCarthy (1979a) questions the scope for stabilisation policy in Ireland. Three studies which attempted to quantify the impact of fiscal policy on the Irish economy are Norton (1975), Dowling (1978) and Irvine (1974).

Figure 8.1: *Taxonomy of fiscal authorities' redistribution and expenditure activities*

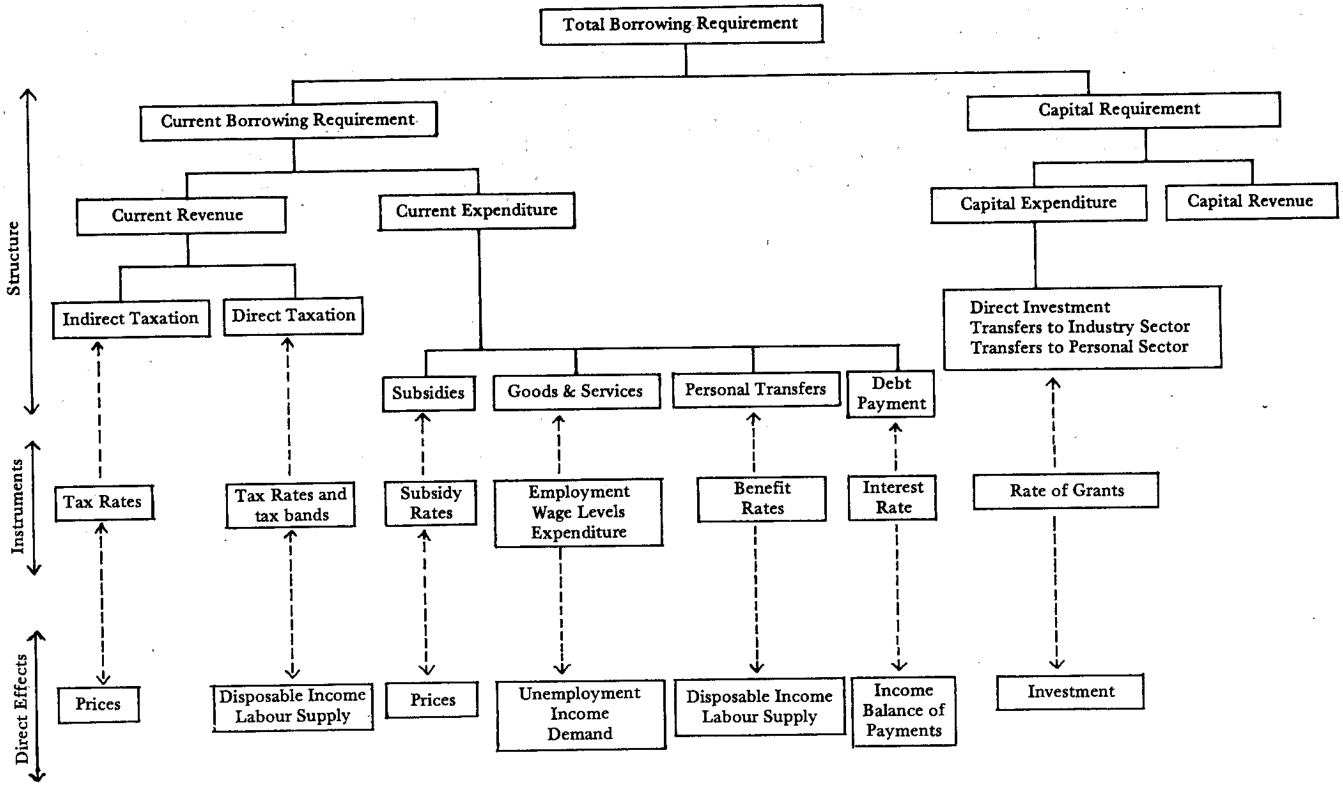
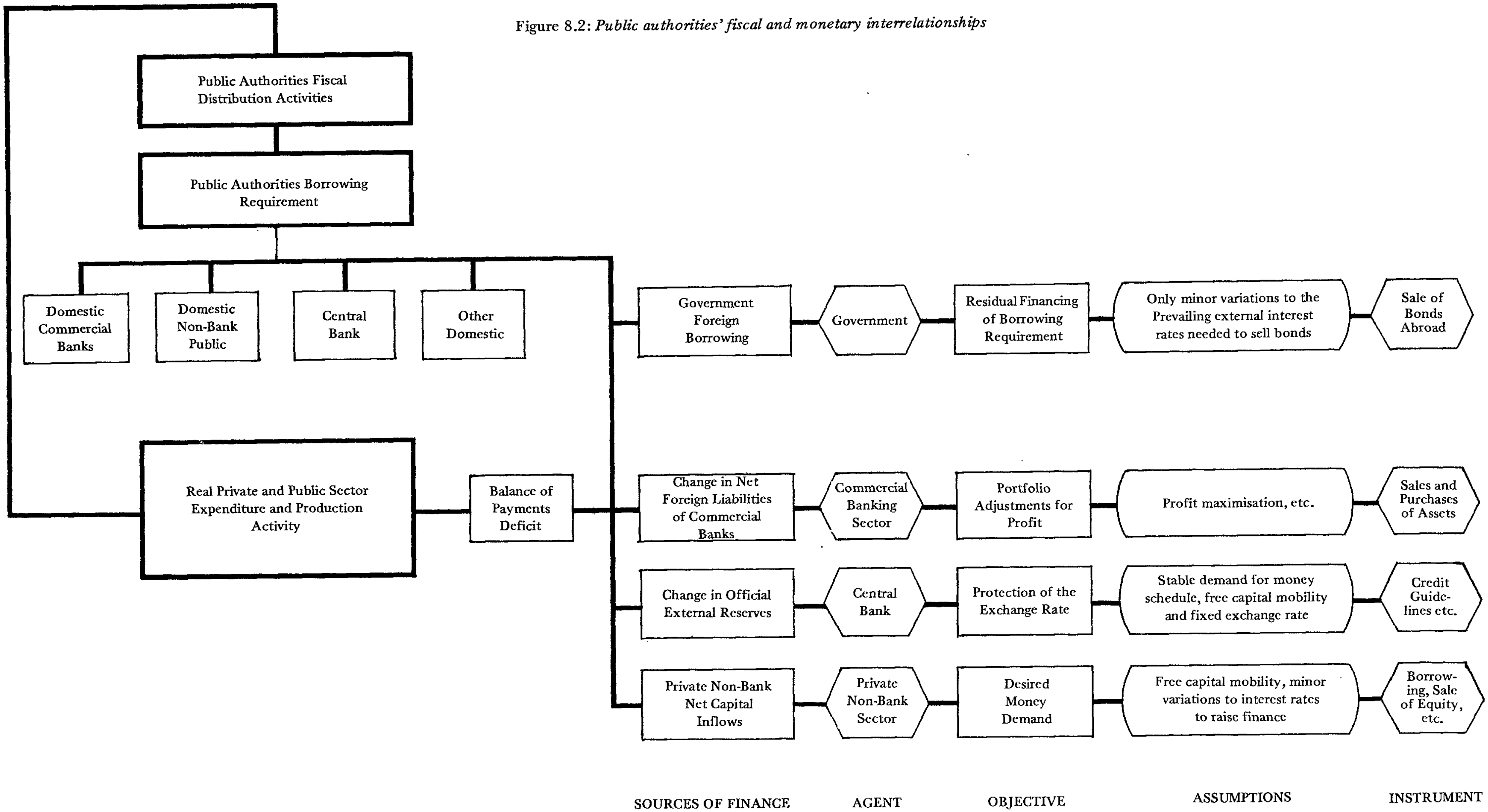


Figure 8.2: *Public authorities' fiscal and monetary interrelationships*



concerning the very existence of optimal stabilisation policies in a world of rationally formed expectations.[128]

In conducting a macroeconometric analysis of the economy we are concerned with (i) the redistribution process via taxes and expenditures and (ii) the derivation of the government budget deficit as the difference between revenues and expenditures, and the monetary consequences of the financing of the necessary borrowed funding, a process illustrated in Figure 8.2. The latter topic was examined in the preceding section and here we concentrate on government revenue and spending. The basic approach for modelling both sides of the account is the same and involves the specification of appropriate rates and bases.[129]

In the case of the fiscal authorities, we illustrate in Figure 8.1 the main activities of revenue and expenditure. The upper part of this figure is simply a taxonomy of the government's finances and activities and provides a useful framework for modelling these activities. In the middle of the figure we indicate some of the types of instruments available for use by the fiscal authorities, and in the lower part of the figure we indicate some of the more important *direct* impacts associated with changes in the instruments. Missing from Figure 8.1 is an indication of the manner in which private sector magnitudes affect government expenditures and revenues. Nor does it indicate anything about how government actions or intentions affect private sector intentions, expectations, decisions or out-turn. On the current side of the Irish public authorities' fiscal sector many of the major influences have been well explored and documented. For example, the manner in which indirect taxes affect prices and the influence of direct taxes on tax revenue, and hence on disposable income, have been quantified in a reasonably satisfactory way in previous economy-wide studies (Fanning and Bradley, 1982). However, some issues which are not so well explored include the effects of employers' pay-related social insurance contributions on employment, the influence of direct taxes and unemployment benefits on labour supply and the manner in which corporation tax and allowances and investment grants influence private sector investment.

128. Briefly, given a suitable framework for analysing public authorities' behaviour, the effectiveness of stabilisation policy is usually evaluated by comparing the trajectories of the endogenous target variables which result from the historical values of the policy instruments with their time paths under a variety of alternative assumptions. Such scenario analysis can be performed informally by means of simulations with an economy-wide model and by using its multipliers. It can also be performed more formally by using the techniques of control theory (Chow, 1975) which was followed by Buiter and Owen (1979) in a study of the Dutch economy and Bradley and Ó Raifeartaigh (1982) in a study of the Irish economy.

129. Public authority expenditure on current consumption of new goods and services and on investment was included in Chapter 6. The remaining items of the government account are grouped under this section on redistribution.

Theoretical Framework

Tax Revenues

The tax revenue equations are based on the following identity:[130]

$$T_j = \sum_{i=1}^{n} t_{j,i}\, TB_{j,i} \tag{8.3.1}$$

where

T_j	=	revenue from source j, where j refers to any of the range of direct and indirect taxes
$t_{j,i}$	=	statutory tax rates, where i denotes a specific income bracket or expenditure category
n	=	the number of tax brackets or expenditure categories
$TB_{j,i}$	=	the tax base, distributed by income bracket or expenditure category, and measured net of deductions and exemptions.

With a sufficiently detailed disaggregation of TB, in principle it would be possible to reproduce the above identity and no statistical estimation would be required. However, for many reasons such a level of disaggregation would be impracticable, and the identity is usually replaced by an equation of the form

$$T_j = \hat{t}_j^{a}\, TB_j^{b} \tag{8.3.2}$$

where $\hat{t}_j$ is a representative or average statutory rate and TB_j an aggregate proxy for the tax base. The rate elasticity, a, gives some indication of how representative $\hat{t}_j$ is, as values below unity would imply that only part of the tax base is "covered" by the chosen rate. The base elasticity, b, measures the progressivity of the rate schedule as well as the effect of changes in the distribution of income or in the composition of aggregate expenditure occurring in response to tax base variations. A distinction between real and nominal changes can be introduced as follows:

$$\log T_j = a \log \hat{t}_j + b_1 \log \left(\frac{TB_j}{PCPER}\right) + b_2 \log PCPER \tag{8.3.3}$$

where b_1 measures the revenue effect of real income/expenditure changes and b_2 gives an indication of inflation induced fiscal drag.

Alternatively, the revenue equation may be transformed into an average tax rate ($\bar{t}_j$) equation and estimated as

130. Our approach follows that outlined in OECD (1982a).

$$\log \bar{t}_j = \log (T_j/TB_j) = a \log \hat{t}_j + (b-1) \log TB_j \qquad (8.3.4)$$

with an identity determining tax revenue,

$$T_j = \bar{t}_j TB_j$$

In order to link the tax revenue equations with the rest of our analysis, the tax bases, TB_j, need to be defined in terms of the appropriate income and expenditure concepts. For example, for household and company income taxes,

$$TB_j = Y_j - ALLOW_j \qquad (8.3.5)$$

where

Y_j = household or company incomes, as determined in the income distribution block

$ALLOW_j$ = allowances, deductions, exemptions.

For indirect taxes, total private consumption is the most representative tax base. For pay-related social security contributions, the tax base is proxied by the total wage bill as determined in the supply block and the wage-price sector. Details of empirical results are given in the estimation section below.

Transfer Expenditures

Four broad categories of current expenditure can be distinguished: expenditure on goods and services (CGV); income transfer payments (TRPER); subsidies (SUB); and interest payments on national debt (TRDI). Expenditure on goods and services (CGV) has two components: public administration wages and salaries and expenditure by the state and state-sponsored organisations other than public administration. This has already been treated in Chapter 6 as an element of the domestic absorption block, where it was explained by a relationship to personal consumption expenditure. In this section we concentrate on transfer expenditures. Income transfer payments consist of unemployment payments (assistance, benefit and pay-related) and other social security and social welfare and educational transfers (TRPO). These expenditures are subject to discretionary policy changes as well as endogenous real and nominal developments in the private sector. Unemployment transfers are separated out and analysed in terms of the level of unemployment and representative rates of payment. The other categories can either be left as exogenous or approximated by equations of the form

$$\log TRPO = a_0 + a_1 \log W_{av} + a_2 \log TRPO_{t-1} \qquad (8.3.6)$$

representing the automatic (or semi-automatic) indexation of payments to average wage rates (W_{av}) and the high degree of "inertia" characterising TRPO. Subsidies are either omitted from the analysis or examined by an identity in terms of a subsidy rate (SUBR) and a base of expenditure being subsidised (CBASE) i.e.,

$$SUB_i = SUBR_i^* CBASE_i \qquad (8.3.7)$$

The final category of expenditure is national debt interest payments (TRDI) which comprise interest on £IR debt (TRDID) and interest on foreign currency debt (TRDIF). If SECGNL is the stock of £IR national loans outstanding and RSECGNL is the interest rate payable, then we model TRDID as

$$TRDID = f(RSECGNL^* \Delta SECGNL) \qquad (8.3.8)$$

Interest payments on foreign currency debt (TRDIF) can either be left exogenous or explained by means of identities linking the interest payments with exchange rates, capital repayments, foreign interest rate, etc. Hence, total debt interest (TRDI) is

$$TRDI = TRDID + TRDIF \qquad (8.3.9)$$

For administrative reasons, fiscal activities are classified as current account and capital account. The current account activities (expenditure and taxation) are the subject of annual review in the budgetary process, while activities on the capital account are the subject of the annual Public Capital Programme. However, these are by no means self-contained categories and are subject to frequent cross-classification and redefinitions, particularly in the recent period of current account deficits. Capital revenue (GREVK), which is left exogenous, consists of capital taxes, repayments received from the intervention agency, capital receipts from abroad, etc.

On the capital expenditure side, there are three items representing direct public authorities' investment in housing (IHGV), other building and construction (IFBCGV) and machinery and equipment (IFMEGV). Capital transfers are made to industry (TRKI), the rest of the company sector (TRKC), to the personal sector for housing (TRKHH), and for other purposes (TRKHO), and a residual capital expenditure item (payments made to the intervention agency, other loans and purchases of share capital, and capital transfers abroad). All the above capital expenditure items are taken to be policy instruments under the direct control of the public authorities.

Hence, although total capital expenditure is exogenous, the separate elements are included to permit the analysis of their differing channels of influence on private sector activity.

Specification and Validation

In presenting specifications for the fiscal redistribution block we follow the schematic chart of the taxonomy of the public authorities' fiscal accounts, shown in Figure 8.1. Hence, consideration is given in turn to

(i) indirect taxation
(ii) direct taxation
(iii) subsidies
(iv) personal transfers
(v) debt payment.

Expenditure on goods and services has been treated in the domestic absorption block and the capital side of the accounts is left exogenous.

Indirect Taxation

Three types of indirect taxation are considered: a major grouping of excise duties (TED), value-added tax (TAV) and a residual class of other indirect taxation (TIO). The equation specifications follow (8.3.2) above with the following specific definitions, explained in detail later.

Tax	*Rate*	*Base*	*Price*
Excise duties (TED)	TEDR	CPER	PCPER
Value-added tax (TAV)	TAVR	TAVB	PCPER
Residual indirect taxes (TIO)	TIOR	CPER	PCPER

Statistical estimation yielded the results presented in Tables 8.3.1 to 8.3.3. In estimation, the fact that there is approximately three months lag between VAT collection and payment to the Revenue Commissioners is allowed for by introducing an interpolated quarter year lag in the last two explanatory variables. By statistical criteria, and by the criteria discussed above in the context of Equation (8.3.2), the three indirect tax equations are satisfactory. The three elasticities are summarised below.

Tax	*Rate elasticity*	*Base elasticity*	*Price elasticity*
TED	0.757	0.935	0.322
TAV	1.068	1.280	1.070
TIO	0.487	1.212	0.612

Table 8.3.1: *Excise duties (TED), OLS regression, 1961-1979*

$$\log TED = -1.519 + 0.757 \log TEDR + 0.935 \log CPER + 0.322 \log PCPER$$
$$(3.7) \quad (19.2) \qquad (17.8) \qquad (9.2)$$

$\bar{R}^2 = 0.999$ SER = 0.0143 D.W. = 1.63

Notation:

TED	=	Excise duty on alcohol, tobacco, light oil and heavy oil
TEDR	=	Weighted average excise duty rate index
CPER	=	Personal consumption (£m, 75)
PCPER	=	Deflator of personal consumption (base 1975 = 1.0)

Table 8.3.2: *Value added tax (TAV), OLS regression, 1964-1979*

$$\log TAV = -1.856 + 1.068 \log TAVR + 1.280 \log TAVB + 1.070 \log PCPER$$
$$(0.5) \quad (11.3) \qquad (3.1) \qquad (12.8)$$

$\bar{R}^2 = 0.998$ SER = 0.052 D.W. = 1.71

Notation:

TAV	=	Revenue from value-added tax (£m)
TAVR	=	Weighted average VAT rate (%)
TAVB	=	VAT base (i.e. consumption plus tourism exports)
PCPER	=	Deflator of personal consumption (base 1975 = 1.0)

Table 8.3.3: *Other indirect taxes (TIO), OLS regression, 1961-1979*

$$\log TIO = -5.632 + 0.487 \log TIOR + 1.212 \log CPER + 0.612 \log PCPER$$
$$(5.8) \quad (6.8) \qquad (9.8) \qquad (12.9)$$

$\bar{R}^2 = 0.997$ SER = 0.0333 D.W. = 1.58

Notation:

TIO	=	Residual indirect taxes (stamp duty, motor vehicle duty, etc.) (£m)
TIOR	=	Imputed tax rate

In the case of TED, a price elasticity of 0.322 is plausible given that these excise duties are specific rather than *ad valorem*. In the case of TIO, the low rate elasticity casts doubt on the representative nature of the tax rate being used. However, this is a rather heterogeneous tax.

Direct Taxation

Four types of direct taxation are considered: direct income tax on personal non-agricultural income (TYPER), flat rate social welfare contributions (SOCFL), pay-related social welfare contributions (SOCYW) and company taxation (TYC).

Before estimating equations for direct taxation it is necessary to define taxable income (YPERT). Because of changes in the tax code, the definition of taxable income has different forms, as follows:

1961 to 1974: $YPERT = YWNA + YWPA_{-1} - YWPA + OYP_{-1} - SOCE$
1975 to 1979: $YPERT = YWNA + OYP_{-1} - SOCE$

where
YWNA = Non-agricultural wages and salaries
YWPA = Public administration wage-bill
OYP = Other (non-wage) income subject to income tax (defined below)
SOCE = Employers' social insurance contributions
and

$$OYP = YC - YCU + YASA - YGTI + TRDI + YFN - YAFS$$

where
YC = Company profits
YCU = Undistributed company profits
YASA = Adjustment for stock appreciation
YGTI = Government trading and investment income
TRDI = National debt interest
YFN = Net factor income from abroad
YAFS = Adjustment for financial services.

Initially, the general formulation of Equation (8.3.3) for direct income taxation was not followed due to difficulties in picking a representative tax rate. Instead the approach of Dowling (1977) was first used where the tax equation takes the form shown in Table 8.3.4. The estimated allowance elasticity of -0.420 is reasonable given that only part of any increase in personal allowances is likely to be claimed due to low income earners falling outside the tax net. The income elasticity of 1.657 is expected to be greater than unity in a situation where the marginal tax rate is usually greater than the average tax rate.[131] A second approach was then tried, where the income

131. The practical difficulties with using this equation for policy analysis have been discussed in FitzGerald and Keegan (1981).

Table 8.3.4: *Direct income tax (TYPER-model 1), OLS regressions, 1961-1979*

$$\log TYPER = \underset{(18.1)}{-4.432} - \underset{(3.4)}{0.420} \log TYPAL + \underset{(17.3)}{1.657} \log YPERT$$

$\bar{R}^2 = 0.992$ SER = 0.0623 D.W. = 1.55 RHO = 0.4113

Notation:
TYPER = Income tax paid by personal (non-farm) sector (£m)
TYPAL = Average personal allowances claimable (£m)
YPERT = Taxable income (£m)

tax base was defined using Equation (8.3.5), and assuming that all personal allowances claimable (i.e., TYPAL) were actually claimed, this yielded the two estimates reported in Table 8.3.5. In the first estimate, the composite tax base was used, while in the second estimate the tax base was split into two independent effects: real taxable income and real allowances claimable. Given that TYPAL overstates the allowances actually claimed, the real tax base elasticity of 0.797 is probably too large. The elasticity of 1.412 on the price index is a measure of the inflation-induced fiscal drag. Since the representative tax rate, $\hat{t}_j$, is contained in the intercept of the estimated equation (as in Equation (8.3.3)), any simulation which involves changing $\hat{t}_j$ can be approximated by altering the equation intercept.

Table 8.3.5: *Direct income tax (TYPER-models 2 and 3), OLS regressions, 1961-1979*

1. $$\log TYPER = \underset{(0.4)}{-0.198} + \underset{(11.6)}{0.797} \log\left(\frac{YPERT\text{-}TYPAL}{PCPER}\right) + \underset{(21.1)}{1.412} \log PCPER$$

$\bar{R}^2 = 0.997$ SER = 0.059 D.W. = 1.35

2. $$\log TYPER = \underset{(1.6)}{-4.314} + \underset{(6.6)}{1.686} \log\left(\frac{YPERT}{PCPER}\right) - \underset{(3.1)}{0.472} \log\left(\frac{TYPAL}{PCPER}\right) + \underset{(7.9)}{1.225} \log PCPER$$

$\bar{R}^2 = 0.996$ SER = 0.0684 D.W. = 1.18

Notation:
TYPER = Income tax paid by personal (non-farm) sector (£m)
YPERT = Taxable income (£m)
TYPAL = Average personal allowances claimable (£m)
PCPER = Deflator of private consumption expenditures (base 1953 = 1.0)

Finally, a version of Equation (8.3.4) was estimated, yielding the results reported in Table 8.3.6. This implies a (nominal) base elasticity (b of Equation (8.3.4)) of 1.108. However, the equation is seriously autocorrelated, probably due to a combination of non-constant "representative" tax rate and varying degrees of take-up of claimable allowances over the period of estimation.

Table 8.3.6: *Direct income tax (TYPER-model 4), OLS regression, 1961-1979*

$$\log \frac{\text{TYPER}}{\text{YPERT-TYPAL}} = \underset{(17.4)}{-2.522} + \underset{(5.0)}{0.108} \log (\text{YPERT-TYPAL})$$

$\bar{R}^2 = 0.583$ SER = 0.0886 D.W. = 0.88

The estimated equation for flat-rate social insurance (SOCFL) is of standard form, and results are shown in Table 8.3.7.

The single observation for 1979 seriously biases the estimated equation. As 1979 was the last year of operation of the flat-rate social welfare contribution scheme, it was necessary to exclude this observation and estimate over the period 1962 to 1978.

Table 8.3.7: *Flat-rate social insurance (SOCFL), OLS regression, 1961-1978*

$$\log \text{SOCFL} = \underset{(2.7)}{-8.83} + \underset{(18.6)}{0.929} \log \text{SOCFLR} + \underset{(2.4)}{1.284} \log \text{LNA} + \underset{(3.1)}{0.180}\ \text{D74}$$

$\bar{R}^2 = 0.999$ SER = 0.0639 D.W. = 2.02

Notation:

SOCFL	=	Flat rate social insurance contributions (£m)
SOCFLR	=	Weighted average social insurance rate (£ p.a.)
LNA	=	Non-agricultural employment ('000)
D74	=	Dummy variable for change in regulations in 1974

The system of Pay-Related Social Insurance (SOCYW) was introduced in 1974, and has now completely replaced the flat rate system. Since so few observations exist, statistical estimation is difficult. Nevertheless, the equation, reported in Table 8.3.8, was estimated using data for 1975 to 1979. Given the cut-off point in income above which no contributions are payable, one would expect an elasticity of less than unity. However, the equation is too crude to draw any statistical inferences and must be used with care out-of-sample.

Table 8.3.8: *Pay-related social insurance (SOCYW), OLS regression, 1975-1979*

$$\log SOCYW = \underset{(6.8)}{-1.990} + \underset{(19.4)}{1.183} \log (YW^{*}SOCYWR)$$

$\bar{R}^2 = 0.989$ SER = 0.0956 D.W. = 1.28

Notation:

SOCYW	=	Pay-related revenue (£m)
SOCYWR	=	Rate of contribution (weighted) (%)
YW	=	Non-agricultural wage bill (£m)

Turning to company taxation, (TYC), no attempt was made to grapple with the complexities of the corporate tax system. The simple equation in Table 8.3.9 was estimated as an alternative to leaving company tax revenue unexamined:

Table 8.3.9: *Company taxation (TYC), OLS regression, 1961-1979*

$$\log TYC = \underset{(2.9)}{-0.668} + \underset{(19.1)}{0.739} \log YC$$

$\bar{R}^2 = 0.958$ SER = 0.108 D.W. = 1.84 RHO = 0.1362

Notation:

TYC	=	Revenue from company taxation (£m)
YC	=	Non-agricultural profits (£m)

Hence, a one per cent rise in company profits gives rise to a 0.74 per cent rise in company taxation. This equation can at best be regarded as a rough rule-of-thumb pending data analysis and testing at a more disaggregated level of detail.

Subsidies

Subsidies are of three types: subsidies on personal consumption (SUBC), EEC subsidies (SUBEC) and a residual category (SUBO). The latter two are left exogenous and the consumption subsidy is handled by defining a subsidy "rate",

$$SUBCR = SUBC/CPER$$

and regarding SUBCR as an exogenous variable under the control of the public authories. Hence,

$$SUBC = \overline{SUBCR}\ CPER$$

Personal Transfers

Three types of personal transfers are analysed: unemployment assistance plus benefit (TRU), pay-related unemployment benefit (TRUYW) and a residual category of personal transfers (TRPO).

An equation of standard form was estimated for unemployment assistance plus benefit (TRU) yielding the equation given in Table 8.3.10. The statistical fit is good, and the base elasticity (0.707) is expected to be less than unity since, at the margin, not all those becoming unemployed are entitled to unemployment compensation.

Table 8.3.10: *Unemployment transfers (TRU), OLS regression, 1961-1979*

$$\log TRU = \underset{(3.4)}{-2.132} + \underset{(25.2)}{1.167} \log TRUR + \underset{(5.9)}{0.707} \log U$$

$\bar{R}^2 = 0.998$ SER = 0.0519 D.W. = 1.77

Notation:

TRU = Unemployment assistance and benefit paid (£m)
TRUR = Weighted average rate of assistance and benefit (£ p.a.)
U = Numbers unemployed ('000)

As with pay-related social insurance contributions, only a short data sample (1975 to 1979) is available for pay-related unemployment benefits (TRUYW) and the standard form equation in Table 8.3.11 was estimated more with a view to obtaining reasonable parameters than to testing the model. The "estimated" coefficients are plausible, but the equation would have to be used with care out-of-sample.

A wide and heterogeneous category of personal transfers is represented by TRPO. These range from old age pensions, health benefits, children's allowances, to secondary teachers' salaries. An explanation along standard lines (expenditure related to a base and a rate) is impossible. We restrict ourselves to a simple equation where real *per capita* transfers are a function of time and the estimated equation is given in Table 8.3.12. We index

Table 8.3.11: *Pay-related unemployment benefits (TRUYW), OLS regression, 1975-1979*

$$\log TRUYW = \underset{(0.5)}{-0.477} + \underset{(13.0)}{1.097} \log WNA_{t-1} + \underset{(2.0)}{0.462} \log U$$

$\bar{R}^2 = 0.978$ SER = 0.0458 D.W. = 2.56

Notation:

TRUYW	=	Pay-related benefit paid (£m)
WNA	=	Non-agricultural average annual earnings (£'000 p.a.)
U	=	Numbers unemployed ('000)

Table 8.3.12: *Other personal transfers (TRPO), OLS regression, 1961-1979*

$$\log\left(\frac{TRPO}{PCPER_{-1} \cdot NT}\right) = \underset{(25.0)}{-3.952} + \underset{(10.4)}{0.082t}$$

$\bar{R}^2 = 0.862$ SER = 0.060 D.W. = 1.00 RHO = 0.7444

Notation:

TRPO	=	Other personal transfers (£m)
NT	=	Total population ('000)
PCPER	=	Deflator of personal consumption (base 1975 = 1.0)
t	=	time (1975 = 1.0)

TRPO to previous years' prices, since this captures the manner in which the budgetary process works. The equation was corrected for autocorrelation, but the D.W. statistic remains low, indicating misspecification. Real *per capita* transfers appear to have grown at an average rate of 8.2 per cent over the sample period.[132]

Debt Payment

In order to explain payment of debt interest on national loans (SECGNL), we use an equation of form (8.3.8), i.e., debt interest (TRDID) is a function of a rate of interest (RSECGNL) times the change in loans outstanding (ΔSECGNL). To allow for delays in the initial payment of debt, we include a lag of one period. The estimated equation is presented in Table 8.3.13. It is to be expected that the sum of the coefficients on the interest on new

132. In using equations like this for out-of-sample analysis the coefficient on time will become a "policy" variable, allowing real transfers to grow or decline according to any prespecified policy scenario.

Table 8.3.13: *Change in debt payments (ΔTRDID), OLS regression, 1961-1979*

$$\Delta TRDID = \underset{(2.4)}{2.035} + \underset{(5.4)}{0.00285}\ RSECGNL^{*}\Delta SECGNL + \underset{(9.4)}{0.00706}\ RSECGNL_{-1}^{*}\Delta SECGNL_{-1}$$

$\bar{R}^2 = 0.988$ SER = 2.844 D.W. = 1.93

Notation:

TRDID	=	Interest payments on national loans (£m)
RSECGNL	=	Rate of return on government stock (%)
SECGNL	=	National loans outstanding (£m)
Δ	=	First difference operator

debt in the current and previous year should sum to unity. In fact they sum to 0.991, when interest rates are expressed in fractional form (i.e., RSECGN/100). The treatment of debt interest payments on debt denominated in foreign currencies (TRDIF) can either simply be treated as exogenous for the purpose of forward planning or can be endogenised by means of an approach used by FitzGerald and Keegan (1982). There it is recognised that foreign debt interest has an important effect on the balance of payments and that changes in exchange rates affect interest payments directly and via their effects on the valuation of the stock of foreign debt oustanding.[133]

IV. *MACROECONOMIC SUMMARY ACCOUNTS*

In this final section of the macrosectoral analysis we bring together, in aggregate summary accounts, the aggregate supply, demand and income distribution implications of the process analysed in Chapters 4-8. This sub-section develops two themes. First, the sectoral details of the overall accounting balance between aggregate supply and demand, which has served as the data organising framework for our analysis, are identified. Second, the incomes generated by these supply activities and the distribution of these to foreign and domestic recipients are set down. These sections can be brief because

133. For any particular base year forecasts can be prepared, assuming base year foreign debt and exchange rates, of the timing and magnitude of future foreign interest payments. In addition, a forecast of future capital repayments, also conditional on a base year assumption, can be prepared. Hence, what remains to be estimated is the foreign debt interest payable on debt incurred since the base year. On the assumption that such debt has an infinite maturity, this latter debt interest equals the interest on the new debt in the previous year, adjusted for exchange rate changes since the base year, plus last year's foreign interest rate multiplied by last year's gross borrowing abroad. In this manner, the effects of exchange rate changes and the effects of foreign debt accumulation can be endogenised.

they are largely a re-statement of the relevant accounting identities discussed in Chapter 2 or are simply stating aspects of the supply and expenditure processes implicit in the preceding sectoral analyses.

The starting point for any summary of the macroeconomic pattern of income distribution is the organisation of sectoral supply information so as to obtain a definition of overall incomes earned from production activities. The basic accounting identity is that which adds up the value of output produced by the four domestic sectors of production, i.e., sectoral outputs multiplied by sectoral prices of output:

$$GDPV = OI.POI + OAFF\ .\ POAFF + OS.\ POS + LPA*WPA$$

where the previously undefined terms are LPA, i.e., employment in public administration and WPA, i.e., the rate of remuneration of employees in public administration. This is total domestically-earned income at factor costs. Net indirect taxes have to be added to value it at market prices:

$$GDPMV = GDPV + (TI - SUB)$$

where (TI - SUB) is the factor cost adjustment. Income from productive activity is also earned, and of course paid, abroad and a further adjustment has to be made to show the income received from productive activity by domestic residents, gross national product at market prices:

$$GNPV = GDPMV + YFN$$

where YFN is net factor income from abroad.

The uses to which this income is put are domestic absorption and net foreign purchases. First, gross domestic absorption is made up of current, capital and stock expenditures by the private and public sectors:

$$GDAV = CPERV + CGV + IFV + IIV$$

Second, there are two aspects to the foreign element. A large part of the value of domestic production goes abroad but at the same time a large part of the value of domestic supply comes from abroad. Therefore, it is necessary to calculate the net purchases abroad, i.e., the balance of payments on trade account (BPTV):

$$BPTV = XGSV - MGSV$$

which as we saw in Chapter 2, is the same as the excess of gross domestic absorption over the value of gross domestic product, i.e.,

$$BPTV = GDPMV - GDAV$$

Finally, we consider the net amount of profits and remuneration of employees received from, and paid, abroad (YFN). Taking these three items together shows the overall use of gross national product,

$$GNPV = GDAV + BPTV + YFN$$

In other words, this is a second method of defining gross national product.

Two other expenditure related magnitudes in the macroeconomic accounts, can also be calculated using the above categories. These are gross final demand (GFDV) defined as

$$GFDV = GDAV + XGSV$$

and gross domestic expenditure (GDEV), which nets out the expenditure on the imported part of supply and involved payment abroad for goods and services:

$$GDEV = GDAV + BPTV$$

The corresponding magnitudes are defined by the summation of the appropriate components in deflated terms.

By taking gross national product at factor cost as the starting point we can follow through the distribution of aggregate income as it is affected by fiscal activities and how it is split among labour and non-labour factors of production at the economy level. Two deductions are made from GNPV to derive national income. First, a certain portion (CCAV) has to be set aside to maintain capital assets and so is not available for current use. Second, net indirect taxes (TI - SUB) do not constitute income to persons. Therefore national income (Y) is calculated as

$$Y = GNPV - CCAV - (TI - SUB)$$

From this, four other income identities show further distributional consequences. These are listed in turn, with the notation defined where necessary.

(i) Private income (YP)

$$YP = Y - YASA - YGTIN + TRDI + TRPER + FSPFN$$

where

YASA = Adjustment for stock appreciation
YGTIN = Public authorities net trading and investment income
TRDI = National debt interest payments
TRPER = Personal transfer income
FSPFN = Net private transfers from abroad.

(ii) Personal income (YPER)

This is private income less the retained earnings of the company sector (YCU):

$$YPER = YP - YCU$$

The derivation of profits and the determination of retained profits will be outlined in (iv) below.

(iii) Personal disposable income (YPERD)

The part of personal income which is available for personal disposal is derived by deducting all taxes on personal income, i.e.,

$$YPERD = YPER - (TYPER + SOCFL + SOCYW + TYA + TYW + TYMVDP)$$

where

TYPER = Personal income tax (non-agricultural)
SOCFL = Flat-rate social welfare contributions
SOCYW = Pay-related social welfare contributions
TYA = Agricultural income tax
TYW = Wealth tax
TYMVDP = Motor vehicle duties paid by households

(iv) Company profits (YC)

These are calculated residually as follows:

$$YC = Y + YAFS + YASA - YFN - YAFF - YWNA$$

where

YAFS = Adjustment for financial services
YAFF = Income for agriculture, forestry and fishing

YWNA = Non-agricultural wages and salaries.

Finally, since the construction of a detailed disaggregated model of the company sector was not attempted,[134] we determine undistributed profits as a simple proportion of total profits in a regression equation of form

$$\underset{}{YCU} = \underset{(0.8)}{2.843} + \underset{(31.9)}{0.281}\ YC$$

$$\bar{R}^2 = 0.984 \qquad SER = 9.15 \qquad D.W. = 1.66$$

The recorded data for a number of years for these income variables were given in Chapter 2 in Tables 2.2, 2.3, and 2.4 and are not repeated here.

134. Vaughan (1978) treats some of the data and other problems in this area.

PART THREE: *CONCLUSION*

Chapter 9

SUMMARY AND FUTURE RESEARCH

The purpose of this study was to conduct an empirical analysis of the Irish economy within a consistent, macrosectoral framework, namely, the framework provided by the balance between the sources and uses of aggregate supply. In the first three chapters we examined the rationale for, and aspects of, this study, the data organising framework and source, and the techniques to be employed in the examination of supply and factor demands at an aggregate level. In the following five chapters we analysed the determination of aggregate supply, aggregate demand and income distribution. In this final chapter we provide a brief overall summary of the study and present an evaluation of its results and conclusions in terms of the three areas used for analysis, i.e., supply, absorption and income distribution. We then discuss issues and problems which arise in and are relevant to this study, but cannot be dealt with because of space reasons and represent a range of research activities which follow logically from the present investigations.

In Chapter 1 we discussed how our emphasis on medium-term aspects of the economy originated from the general absence of these aspects in Irish analysis. Study of the medium term with a view towards the development of an operational medium-term economy-wide model, raised issues beyond those facing short-term demand-management analysis. These issues related both to the examination of the subsections of the economy — the subject of this study — and to the testing, validation and use of a fully integrated operational economy-wide model — the subject of the next stage of the project. In Chapters 2 and 3 we examined two broad areas of vital importance to the development of medium-term analysis, i.e., (i) the data source and the guiding macrosectoral framework and (ii) production functions, technology and factor demand systems. The framework laid down in Chapter 2 allowed us to integrate the treatment of output, expenditure and income measures of national product, and suggested the organisation of the areas of subsequent inquiry into three blocks, i.e., aggregate supply, domestic absorption and foreign demand, and income distribution. In Chapter 3 we surveyed a major component of the aggregative Neo-classical approach, i.e., the nature and role of production functions, and derived results used in subsequent chapters.

In the treatment of supply, in Chapters 4 and 5 we used a three sector division of the domestic production activities of the economy: industry, agriculture and services. Completing the aggregate supply block were two sections concerned with imports and labour supply. In the case of the three domestic production sectors identified, we provided an overview of the main characteristics of each and a theoretical schema to guide empirical analysis. In the case of agriculture and services, the familiar problems of missing data, sectoral heterogeneity and theoretical inadequacy resulted in less satisfactory, but nevertheless useful, results. Our treatment of imports was a standard application of the utility approach and used a fairly aggregate level of data. In the case of labour supply, we distinguished population growth, education participation, labour force participation and migration in an integrated schema. We examined the issue of migration in detail in order to clarify some conceptual problems which arise when the usual net migration equations are integrated into a macromodel.

Our treatment of the second main area of study, domestic absorption and foreign demand, was quite conventional, and we have provided standard consumption, inventory changes, and residential housing investment equations. In this context we reviewed in some detail a number of the currently used approaches to aggregate consumption expenditures. A simple model of government consumption using a utility function relating private and public consumption expenditure was examined as a means for endogenising current public expenditure on goods and services. Finally, we looked at the role played by the export function within a macrosectoral framework.

The third main area of study, income distribution, had three aspects: price of goods and services and wage determination, money supply and exchange rate, and fiscal redistribution. In developing price-wage models it is particularly important to avoid inconsistencies between this and other subsectors. Given the cost-minimisation characteristics of our supply analysis, our industrial and service producer price equations are variants of the mark-up model where the dependence of the mark up on domestic and external circumstances is explored. Our monetary sector is a conventional "text-book" small open economy type and we have tried to indicate some conceptual difficulties with the role of the demand for money equation within an overall structural model. Finally, in the fiscal redistribution section we examined how the aggregate income flows are adjusted by the taxing and transfers activities of the government.

We present in Figure 9.1 a schematic block structure of the overall macrosectoral framework. In this figure we do not illustrate interrelationships which, of course, exist between or within blocks.[135]

135. To give such an illustration of system-wide interdependencies would require a very complex diagram which would be difficult to follow and of little practical use. An example of such a diagram for the US Brookings model is given in Duesenberry (1965, pp. 24-25).

Figure 9.1: *Block structure for an economy-wide model*

BLOCK I: SUPPLY	
Output Capacity Utilisation Demand for Capital Demand for Labour Imported Supply Supply of Labour	INDUSTRY AGRICULTURE SERVICES
GDSV = OIV + OAFFV + OSV + MGSV + OPAV GDPV = OIV + OAFFV + OSV + OPAV L = LI + LAFF + LS + LPA U = LF − L	

Note: OPAV is included in Block II

BLOCK II: ABSORPTION
Domestic Absorption Personal Consumption Public Authories Consumption Housing Investment Fixed Investment Inventory Investment *Foreign Demand* Exports
GDAV = CPERV + CGV + IFV + IIV + IHV GFDV = GDAV + XGSV GDEV = GDAV + (XGSV − MGSV)

Note: Fixed Investment includes demand for capital from Block I

BLOCK III: PRICES AND INCOME DISTRIBUTION		
Prices	*Public Authorities*	*Income Distribution*
Sectoral Labour Prices Sectoral Output Prices Expenditure Deflators	Tax Revenue Subsidies, Grants, and Transfers Public Debt Charges Domestic Credit, Money Supply and Exchange Rate	National Income Private Income Disposable Personal Income Profits-Wages
Macroeconomic Accounts GDPV = OIV + OAFFV + OSHV + OPAV GNPV = GDPV + (TI − SUB) + YFN Y = GNPV − CCAV − (TI − SUB)		

Two methods can usefully be used to explore the economy-wide systems properties of the macrosectoral framework. A verbal exposition of the main paths of causality and the major themes can be presented, isolating key assumptions and empirical magnitudes. Alternatively, the empirical equations can be assembled into an operational macromodel (thus involving a process of selection and closure), and numerical experiments can be carried out to explore the properties of the system. Both approaches are obviously complementary. We restrict ourselves to the first method for reasons already covered in Chapter 1 but will briefly return to this aspect at the end of this chapter.

We start with the supply block and for the moment ignore the individual sectors (i.e., industry, agriculture, services). The core of this block involves the determination of long-run output, O*, and long-run factor inputs (capital, K* and labour, L*). Long-run output is assumed to be determined by long-run expected absorption (both domestic, GDA* and foreign, XGS*). This simple empirical relationship is absolutely central to the properties of the relationship between the supply and demand blocks. In the case of a small open economy, it encompasses aspects of the process of multinational investment and production location. Our limited empirical results in this area will need to be extended to include better measures of relative profitability, but our basic approach represents a useful "breaking into the circle" of what is obviously a highly complex problem.

Long-run output, together with measures of expected relative factor prices, are used to determine long-run factor demands. The crucial aspect here is the imposition of a technology assumption which underlies the long-run factor demands. Hence, capital and labour inputs cannot, in the long term, diverge and become inconsistent with the technology assumption, a very important requirement in any medium-term analysis.

The translation to actual factor inputs involved a choice between, on the one hand, a simple process of adjustment, using the very flexible error-correction mechanism (ECM) and, on the other, a separate process of short-run profit maximisation determining actual employment and capacity *utilisation* against the background of an existing capital *stock*. In the first case, actual output, O, is not determined in the supply block, but is defined to be identical with the summation of the elements of expenditure examined in Block II. In this case, the identity

$$CUR = O/O^*$$

provides a measure of capacity utilisation. In the second case, actual output and capacity utilisation are analysed behaviourally.

In terms of the three sectors, industry, agriculture and services, it was possible to implement the above schema almost completely for the industry sector only. For agriculture and services a less complete implementation of the schema was operationalised. For example, in agriculture it was recognised that employment and investment decisions are unlikely to derive from models more appropriate to an industrial sector exposed to international competitive forces and relatively capital intensive. Rather, institutional, governmental and demographic forces become dominant and any econometric study at an aggregate level must recognise this. Also, the services sector, being a heterogeneous mixture of public and various types of private components, is simply not tractable in terms of a formal decision-based framework. It was modelled in terms of a demand-driven output, an accelerator model of investment, and a derived demand for labour.

The supply block includes the determination of imported supply and labour supply. These have been treated in a fairly conventional way and schematic diagrams showing their relationship to the rest of the overall framework have been included in Chapter 5.

Absorption is treated in Block II in terms of conventional expenditure functions. In this block, personal consumption, private housing investment, inventory investment and exports are modelled behaviourally, and combined with other fixed investment (from Block I) and a partially exogenous government consumption and investment, to form total absorption. The main driving force for domestic absorption is a measure of real disposable income, determined in Block III, and for exports is a measure of world income, which is exogenous. In addition, aspects of the fiscal redistribution system play a role, and the elements of simultaneity in determining income and expenditure are apparent.

In the prices Block III we have aimed at presenting a coherent determination of prices and wages, perhaps at the expense of a certain simplicity of approach. The producer (value-added) prices – which in themselves are a rather artificial concept – nevertheless are required if Block I is modelled in a value-added way. These value-added producer prices then play a crucial role in determining the (gross) expenditure deflators when they are combined with import prices and tax variables. Finally, wage rates are determined in two ways: either as the reduced form of the demand-supply relationships in the labour market or as the result of a process of bargaining which is not directly related in a technological sense to the processes of supply and demand. In the former case, wage rates are determined by output and expenditure prices (representing demand and supply factors, respectively), by labour productivity and modified by a Phillips curve effect due to unemployment. The overall properties of the system obviously depend on which approach is adopted.

The fiscal redistribution elements are treated in terms of conventional tax revenue and expenditure equations. The level of disaggregation was chosen so as to permit a reasonably detailed examination of fiscal activities but stopped far short of the level of detail required for the exact examination of all budgetary elements.

If our three blocks are now considered from the viewpoint of constructing an operational macro model, further important issues of detailed internal consistency arise. For example, the two basic identities in such a model relate output with expenditure and output with income. The latter identity is normally used to determine total corporate profits as a residual. The former identity can be used in a variety of ways to determine imports, stock changes or output itself. The implications of any such "closure" rules must be examined both from a theoretical point of view and from the point of view of operational performance and simulation properties. Furthermore, the actual choice of behavioural equations in a model also raise consistency problems, e.g., for price-wage relations and for output-export relations. To attempt to include a stylised version of any such model would take us too deeply into these issues. Hence, our Figure 9.1 remains merely a "taxonomy" and the operational model structure will be presented in a future work (Bradley, Fanning and Wynne, 1984).

In facing into the next phase of this macrosectoral analysis project one must also consider how to deal with the failure in some of the sectors to operationalise a theoretically consistent schema. Two approaches, at least, are possible:

(i) use the best empirical results, even if these are not based on theoretically satisfactory formulations. For example, in agriculture it proved difficult to operationalise the theoretical schema of Figure 4.3, even for the output-materials subset. Hence, output and materials input could not be formulated as deriving from our integrated theoretical schema; or

(ii) impose theoretical restrictions on relationships to force the results to be consistent.[136]

Neither approach is entirely satisfactory. In the first, the tracking performance within-sample is likely to be good, but *ex-ante* policy analysis is likely to be of limited value, particularly over a medium-term time horizon. With the second, the within-sample tracking record is likely to suffer in comparison with the first approach, but the *ex-ante* policy analysis may be based more consistently on a theoretical framework. Given the emphasis on the medium term, the second approach may be the more satisfactory.

Two possible criticisms of our overall approach are of immediate relevance. First, there are a number of analytical traditions, for example that associated with Kaldor and other Cambridge economists, which eschew any use of

136. This approach has been used by Helliwell and McRae (1981) in a medium-term model of the Canadian economy.

production function methodology. In the absence of a technological production function approach, the Cambridge school make extensive use of reduced form models to explain, for example, productivity growth, as with the so-called Verdoorn-Kaldor "law" which has been used extensively in Ireland. This approach to medium-term analysis has undoubtedly provided many insights and raised very important questions about economic progress. However, we believe that it can usefully be complemented by the alternative Neoclassical-Keynesian specification (NKS) which has been the dominant one in large-scale macroeconometric model-based analysis of growth such as Hickman and Coen (1976) for the United States and Helliwell and McRae (1981) for Canada. However, the philosophical and technical differences between the two schools of thought run far deeper than could be analysed at this stage of the project. Second, and from a different perspective, we could be criticised for the simplistic nature of the production functions used in our study, i.e., Cobb-Douglas, Constant Elasticity of Substitution, and bundled CD-CES. Recent studies in Ireland, as mentioned in Chapter 3, have made use of the more general translog production functions and the extensive duality theory linking production and cost functions. While such approaches are useful for testing the assumptions of Neo-classical production theory (e.g., convexity, bias of technical change, etc.), they are of less use in conducting macrosectoral analysis and constructing economy-wide models. In addition, and at a practical level, the simpler CD and CES based technologies, if statistically rejected by the data, are often sufficiently close to the more general technology as to make little difference. This is particularly so if data availability at our aggregate level restricts us generally to two, and occasionally three, factor inputs. Clearly, further work remains to be done in this area. But even these more sophisticated production functions would be regarded by many as still too simplistic for examining the process of economic growth. The issue becomes one of whether they provide sufficiently useful insights commensurate with the costs, i.e., the erroneous or irrelevant information involved.

Finally, in the study and application of economic policy through the use of econometric models, and even in pure forecasting, it is important to be able to "get inside" the equation system in order to make adjustments, amendments and extensions (Klein, 1980). This cannot be done efficiently in reduced form systems or in anonymous equations. It is for these reasons that theory-based systems are much more meaningful.

REFERENCES

d'ALCANTARA, G. and A. ITALIANER, 1982. *European Project for a multinational macrosectoral model*, Document MS 11 (XII/750/82), Brussels: Commission of the European Communities.

ANDERSON, LEONALL C. and KEITH M. CARLSON, 1972. "An Econometric Analysis of the Relation of Monetary Variables to the Behaviour of Prices and Unemployment", in Otto Eckstein, (ed.) *The Econometrics of Price Determination: Conference*, Washington, D.C. Board of Governors, Federal Reserve System, pp. 166-183.

ANDO, ALBERT K. *et al.*, 1974. "On the Role of Expectations of Price and Technological Change in an Investment Function", *International Economic Review*, Vol. 15, No. 2, pp. 384-414, June.

ATTWOOD, E.A., 1978. "Growth in Irish Agriculture: Fact or Fiction?", *Irish Banking Review*, pp. 14-25, September.

ATTWOOD, E.A., 1982. "The Nature and Causes of the Farm Income Problem", *Mimeo, Journal of the Statistical and Social Inquiry Society of Ireland*, forthcoming.

BACON, PETER, *et al.*, 1982. *The Irish Economy: Policy and Performance 1972-1981*, Dublin: The Economic and Social Research Institute.

BACON, PETER, *et al.*, 1982. *Quarterly Economic Commentary*, May.

BAKER, T.J., 1966. *Regional Employment Patterns in the Republic of Ireland*, General Research Series No. 32, Dublin: The Economic and Social Research Institute.

BAKER, T.J. and L.M. O'BRIEN, 1979. *The Irish Housing System: A Critical Overview*, Broadsheet No. 17, Dublin: The Economic and Social Research Institute.

BAKER, T.J., R. O'CONNOR and R. DUNNE, 1973. *A Study of the Irish Cattle and Beef Industries*, General Research Series No. 72, Dublin: The Economic and Social Research Institute.

BAKER, T.J. and M. ROSS, 1975. *Employment Relationships in Irish Counties*, General Research Series No. 81, Dublin: The Economic and Social Research Institute.

BARTEN, A.P., G. d'ALCANTARA and C.J. CARRIN, 1976. "COMET A Medium-Term Macroeconomic Model for the European Economic Community", *European Economic Review*, Vol. 7, pp. 63-115.

BECKER, G.S., 1965. "A Theory of the Allocation of Time", *Economic*

Journal, Vol. 75, pp. 493 and 517.

BECKERMAN, W., 1962. "Projecting Europe's Growth", *Economic Journal*, Vol. 72, pp. 912-924.

BEGG, DAVID K.H., 1982. *The Rational Expectations Revolution in Macro-economics: Theories and Evidence*, Oxford: Philip Allan.

BEHREND, HILDE, 1973. *Incomes Policy Equity and Pay Increase Differentials*, Edinburgh: Scottish Academic Press.

BEHRMAN, JERE R., 1977. *Macroeconomic Policy in a Developing Country: The Chilean Experience*, Amsterdam: North-Holland.

BERNDT, E. and B. FIELD (eds.), 1982. *Modelling and Measuring Natural Resource Substitution*, Cambridge, Mass: M.I.T. Press.

BERNDT, E. and D. WOOD, 1975. "Technology, Prices and the Derived Demand for Energy", *Review of Economics and Statistics*, Vol. 57, No. 3, pp. 376-384.

BODKIN, RONALD G., 1974. "Additively Consistent Relationships for Personal Savings and the Categories of Consumption Expenditures, U.S.A., 1949-1963", *Eastern Economic Journal* 1 (1): 20-51, January.

BOSKIN, M.J., 1973. "The Economics of Labour Supply", in G.G. Cain and H.W. Watts, (eds.), *Income Maintenance and Labour Supply*, pp. 163-181, Chicago: Rand McNally.

BOWEN, W.A. and T.A. FINEGAN, 1969. *The Economics of Labour Force Participation*, Princeton, N.J.: Princeton University Press.

BOWERS, JOHN and DAVID DEATON, 1980. "Employment Functions and the Measurement of Labour Hoarding", *The Manchester School of Economic and Social Studies*, Vol. 2, pp. 157-186, June.

BOYLAN, T., M. CUDDY and I. Ó MUIRCHEATAIGH, 1979. "The Irish Aggregate Imports Demand Equation: the 'Optimal' Functional Form", *The Economic and Social Review*, Vol. 10, No. 2, pp. 147-156, January.

BOYLAN, T., M. CUDDY and I. Ó MUIRCHEARTAIGH, 1980a. "The Functional Form of Fertilizer Demand Equations and Long-Run Price Elasticities", *Irish Journal of Agricultural Economics and Rural Sociology*, Vol. 8, No. 1, pp. 37-43.

BOYLAN, T., M. CUDDY and I. Ó MUIRCHEARTAIGH, 1980b. "The Functional Form of the Aggregate Import Demand Equation: A Comparison of Three European Economies", *Journal of International Economics*, Vol. 10, No. 4, pp. 561-566, November.

BOYLE, G., 1981. "Input Substitution and Technical Change in Irish Agriculture – 1953-1979", *The Economic and Social Review*, Vol. 12, No. 3, pp. 149-161.

BOYLE, G. and J. SHERINGTON, 1980. "Estimation Problems in Evaluating Long-Run Elasticities of Demand for Fertilizer", *Irish Journal* *of Agricultural Economics and Rural Sociology*, Vol. 8, pp. 137-146.

BOYLE, G.E. and P.D. SLOANE, 1982. "The Demand for Labour and Capital Inputs in Irish Manufacturing Industries, 1953-1973", *The Economic and Social Review*, Vol. 13, No. 3, pp. 153-170.

BRADLEY, JOHN, 1977. "Lags in the Transmission of Inflation", *The Economic and Social Review*, Vol. 9, No. 2, pp. 149-154.

BRADLEY, JOHN, 1979a. "The Investment Sector of the Central Bank's Econometric Model", *Technical Paper No. 1/RT/79*, Dublin: Central Bank of Ireland.

BRADLEY, JOHN, 1979b. "A Note on the Estimation of Disaggregated Consumption Functions", *Technical Paper 8/RT/79*, Dublin: Central Bank of Ireland, August.

BRADLEY, JOHN, CONNELL M. FANNING and MARK WYNNE, 1984. *Medium-Term Policy Options in Ireland: A Macroeconometric Model Based Study*, *Mimeo*, Dublin: The Economic and Social Research Institute.

BRADLEY, JOHN, COLM McCARTHY and THOMAS O'CONNELL, 1978. "The Central Bank's Macro-econometric Model: Structure, Estimations and Application", *Central Bank of Ireland Quarterly Bulletin*, pp. 73-98, Winter.

BRADLEY, J. *et al.*, 1981. "Description, Simulation and Multiplier Analysis of the MODEL-80 Econometric Model of Ireland", *Research Paper No. 2/81*, Dublin: Department of Finance, March.

BRADLEY, JOHN and CONNELL M. FANNING, 1982. "Modelling Aggregate Supply for a Medium Term Macroeconometric Model", *Mimeo, Journal of the Statistical and Social Inquiry Society of Ireland*, forthcoming.

BRADLEY, JOHN and CONNELL M. FANNING, 1983. "A Survey of Irish Macromodels: 1958-1981", *Memorandum Series No. 155*, Dublin: The Economic and Social Research Institute, March.

BRADLEY, JOHN and CONNOR Ó RAIFEARTAIGH, 1982. "Optimal Control and Policy Analysis with a Model of a Small Open Economy: The Case of Ireland", *Proceedings of the 3rd IFAC/IFORS Conference on Dynamic Modelling and Control of National Economies*, London: Pergamon Press.

BRADLEY, JOHN and MARK WYNNE, 1983. "Estimation of the Production Block of HERMES for Three Sectors of the Irish Economy", *Mimeo*, Dublin: The Economic and Social Research Institute.

BRANSON, WILLIAM H. and JOHAN MYHRMAN, 1976. "Inflation in Open Economies", *European Economic Review*, Vol. 7, pp. 15-34.

BRECHLING, FRANK, 1975. *Investment and Employment Decisions*, Manchester: Manchester University Press.

BROWNE, FRANCIS X. and THOMAS O'CONNELL, 1978a. "The Demand for Money Function in Ireland: Estimation and Stability", *The Economic and Social Review*, Vol. 9, No. 3, pp. 227-248.

BROWNE, FRANCIS X. and THOMAS O'CONNELL, 1978b. "A Quantitative Analysis of the Degree of Integration between Irish and U.K. Financial Markets", *The Economic and Social Review*, Vol. 9, No. 4, pp. 283-300.

BROWN, R. and L. CHRISTENSEN, 1981. "Estimating Elasticities of Substitution in a Model of Partial Static Equilbrium: An Application to US Agriculture 1947 to 1974", in E.R. Berndt and B.C. Field, (eds.), *Measuring Natural Resource Substitution*, Mass: M.I.T. Press.

BRUTON, RICHARD, 1978. *Irish Public Debt*, General Research Series No. 94, Dublin: The Economic and Social Research Institute, July.

BUITER, WILLIAM H. and ROBERT F. OWEN, 1979. "How Successful has Stabilization Policy been in the Netherlands? A Neo-Keynesian Perspective", *De Economist*, Vol. 127, No. 1, pp. 58-104.

BURGESS, DAVID F., 1974a. "Production Theory and the Derived Demand for Imports", *Journal of International Economics*, Vol. 4, pp. 103-117.

BURGESS, DAVID F., 1974b. "A Cost Minimization Approach to Import Demand Equations", *Review of Economics and Statistics*, Vol. LVI, No. 2, pp. 225-234.

BUTTIMER, D.F. and J. MacAIRT, 1971. "Supply Response in the Irish Creamery Herd, 1951-70", *Irish Journal of Agricultural Economics and Rural Sociology*, Vol. 3, No. 3, pp. 247-278.

CAIN, G.G. and H. WATTS, (eds.), 1973. *Income Maintenance and Labour Supply*, Chicago: Rand McNally.

CALLENDER, ROSHEEN, *et al.*, 1982. *Jobs and Wages: The True Story of Competitiveness*, Private publication, Dublin, May.

CALMFORS, LARS and JAN HERIN, 1980. "Domestic and Foreign Price Influences: A Disaggregated Study of Sweden", in Assar Lindbeck, (ed.), *Inflation and Employment in Open Economies*, Amsterdam: North-Holland, pp. 269-306.

CASEY, M.G., 1970-71a. "A Preliminary Study of Crop Production in Ireland", *Irish Journal of Agricultural Economics and Rural Sociology*, Vol. 3, No. 3, pp. 227-246.

CASEY, M.G., 1970-71b. "A Simple Recursive Model of Population and Disposals of Cattle in Ireland, 1952-1967", *Irish Journal of Agricultural Economics and Rural Sociology*, Vol. 3, No. 3, pp. 213-226.

CENTRAL BANK OF IRELAND, 1982. *Folder of Irish Economic Statistics 1979*, Economic Affairs Department, Dublin: Central Bank of Ireland, June.

CHOW, GREGORY, C., 1975. *Analysis and Control of Dynamic Economic Systems*, New York: John Wiley.

CHRISTENSEN, L.R. and D.W. JORGENSON, 1970. "U.S. Real Product and Real Factor Input, 1929-1967", *Review of Income and Wealth*, Vol. 16, No. 2, pp. 19-50.

CLARK, COLIN, 1960. *The Conditions of Economic Progress*, London: Macmillan, Third edition.

COEN, ROBERT M., 1973. "Labour Force and Unemployment in the 1920s and 1930s: A Re-Examination Based on Post-War Experience", *Review of Economics and Statistics*, Vol. 55, pp. 46-55, February.

COGAN, D.J., 1978. *The Irish Services Sector: Productive Efficiency*, Dublin: Stationery Office.

CONNIFFE, D. and L. KILLEN, 1977. "Irish Consumer Expectations and the Adaptive Expectations Model", *The Economic and Social Review*, Vol. 9, No. 1, pp. 71-78, October.

COOLEY, THOMAS F. and RON SMITH, 1982. "Alternative Models of the Market for Labour in the U.K.", *Discussion Paper No. 114*, London: Birbeck College, March.

CORNWALL, JOHN, 1977. *Modern Capitalism: Its Growth and Transformation*, London: Martin Robertson.

CUDDY, MICHAEL P., 1982. "Response of Irish Creamery Milk Supply to Price Changes", *The Economic and Social Review*, Vol. 13, No. 2, pp. 101-110, January.

DAVIDSON, JAMES E.H. *et al.*, 1978. "Econometric Modelling of the Aggregate Time-Series Relationship Between Consumers' Expenditure and Income in the United Kingdom", *Economic Journal*, Vol. 88, No. 352, pp. 661-692, December.

DEATON, ANGUS, 1977. "Involuntary Saving through unanticipated Inflation", *American Economic Review*, Vol. 67, No. 5, pp. 899-910, December.

DIGBY, CAROLINE, 1980. "A Review of Consumption Studies in Ireland", *Mimeo*, Dublin: Central Bank of Ireland.

DIXON, R. and A.P. THIRLWALL, 1975. "A Model of Regional Growth Rate Differences on Kaldorian Lines", *Oxford Economic Papers*, Vol. 27, pp. 201-214.

DOWLING, BRENDAN R., 1973-74. "The Development of the Financial Sector in Ireland, 1949-72", *Journal of the Statistical and Social Inquiry Society of Ireland*, Vol. XXIII, Part 1, pp. 57-107.

DOWLING, BRENDAN R., 1977. *The Income Sensitivity of the Personal Income Tax Base in Ireland, 1947-1972*, General Research Series No. 86, Dublin: The Economic and Social Research Institute, January.

DOWLING, BRENDAN R., 1978. "Budget Deficits and Fiscal Policy", in B.R. Dowling and J. Durkan, (eds.), *Irish Economic Policy: A Review of Major Issues*, Dublin: The Economic and Social Research Institute, pp. 151-189.

DRIEHUIS, W., *et al.*, 1975. "Price Formation and the Inflationary Process in a Small Open Economy (The Netherlands)", *De Economist*, Vol. 123, No. 4, pp. 680-722.

DUESENBERRY, J.S. *et al.*, (eds.), 1965. *The Brookings Quarterly Econometric Model of the United States*, Amsterdam: North-Holland.

DURKAN, J. and R. KELLEHER, 1975. "Short-term Forecasting: A Review of Recent Experience", *The Economic and Social Review*, Vol. 6, No. 2, pp. 167-186.

ECONOMOU, GEORGE and F. PANARETON, 1976. "An Approach to the Wage Level Determination for a Developing Economy", *European Economic Review*, Vol. 7, pp. 119-141.

EUROSTAT, 1978. *Input-Output Tables: The Nine and the Community*, Luxembourg: Statistical Office of the European Communities.

EUROSTAT, 1979. *European System of Integrated Economic Accounts*, ESA, Luxembourg.

EUROSTAT, 1983. *Input-Output Tables: The Nine and the Community*, Luxembourg: Statistical Office of the European Communities.

FAIR, RAY C., 1971. "Labour Force Participation, Wage Rates and Money Illusion", *Review of Economics and Statistics*, Vol. 53, pp. 164-168, May.

FANNING, C.M., 1979. "The Irish Economy: An Econometric Description of Structures and Processes, 1954-1974", *Working Papers 7902, 7903, and 7904*, Cork: Department of Economics, University College, Cork.

FANNING, CONNELL and JOHN BRADLEY, 1982. "Twenty Five Years of Macromodelling the Irish Economy – Retrospect and Prospect", *mimeo, Journal of the Statistical and Social Inquiry Society of Ireland*, forthcoming.

FARLEY, NOEL J., 1973. "Outward-Looking Policies and Industrialization in a Small Economy: Some Notes on the Irish Case", *Economic Development and Cultural Change*, Vol. 21, No. 4, Part 1, pp. 610-628, July.

FISCHER, STANLEY, 1981. "Relative Shocks, Relative Price Variability and Inflation", *Brookings Papers on Economic Activity*, Vol. 2, pp. 381-441.

FITZGERALD, JOHN D., 1978. "Estimation of a Consistent Set of Trade Data on a Balance of Payments Basis", *Mimeo*, Dublin: Department of Finance.

FITZGERALD, JOHN D., 1979. "The Determinants of Irish Imports", *Mimeo*, Dublin: Department of Finance.

FITZGERALD, JOHN D. and OWEN KEEGAN, 1982. "The Behavioural Characteristics of the MODEL-80 Model of the Irish Economy", *Mimeo, Journal of the Statistical and Social Inquiry Society of Ireland*, forthcoming.

FITZGERALD, JOHN D. and KEVIN KIRWAN, 1981. "Department of Finance/Central Bank Data Bank of Economic Time Series", *Mimeo*, Dublin: Department of Finance, January.

FLYNN, JOHN and PATRICK HONOHAN, 1982. "Notes on the Cost of Capital in Ireland", *Technical Paper No. 6/81/82*, Dublin: Central Bank of Ireland.

GEARY, P.T., 1973. "Demand for Petrol and Tobacco", *The Economic and Social Review*, Vol. 4, No. 2, pp. 201-207, January.

GEARY, PATRICK T., 1976a. "Lags in the Transmission of Inflation: Some Preliminary Estimates", *The Economic and Social Review*, Vol. 7, No. 4, pp. 383-389, July.

GEARY, PATRICK T., 1976b. "World Prices and the Inflationary Process in a Small Open Economy – the Case of Ireland", *The Economic and Social Review*, Vol. 7, No. 4, pp. 391-400, July.

GEARY, P.T., 1977. "Wages, Prices, Income and Wealth", in Norman J. Gibson and John E. Spencer, (eds.), *Economic Activity in Ireland: A Study of Two Open Economies*, Dublin: Gill and Macmillan, pp. 149-189.

GEARY, PATRICK T. and RODERICK M. JONES, 1975. "The Appropriate Measure of Unemployment in an Irish Phillips Curve", *The Economic and Social Review*, Vol. 7, No. 1, pp. 55-64, October.

GEARY, PATRICK T. and JOHN KENNAN, 1982. "The Employment-Real Wage Relationship: An International Study", *Journal of Political Economy*, Vol. 90, No. 4, pp. 854-871.

GEARY, PATRICK T. and EDWARD J. McDONNELL, 1977. "Utility Maximization, Domestic Demand Pressure and Import Demand: An Application to Ireland 1954-1972", *Mimeo*, Dublin: Department of Political Economy, University College, Dublin, n.d., c.

GEARY, P.T. and E. McDONNELL, 1979. "The Cost of Capital to Irish Industry: Revised Estimates", *The Economic and Social Review*, Vol. 10, No. 4, pp. 289-300.

GEARY, P.T. and E.J. McDONNELL, 1980. "Implication of the Specification of Technologies: Further Evidence", *Journal of Econometrics*, Vol. 14, pp. 247-255.

GEARY, P. and C. McCARTHY, 1976. "Wages and Price Inflation in a Labour Exporting Economy", *European Economic Review*, Vol. 8, No. 3, pp.

219-223, October.

GEARY, P.T., B.M. WALSH and J. COPELAND, 1975. "The Cost of Capital to Irish Industry", *The Economic and Social Review*, Vol. 6, No. 3, pp. 299-311.

GEARY, R.C., 1963/4. "Towards an Input-Output Decision Model for Ireland", *Journal of the Statistical and Social Inquiry Society of Ireland*, Vol. XXI, Part 2, pp. 1-49.

GLASS, J. COLIN, 1971/72. "Factor Substitution and Demand for Labour in the Northern Ireland Engineering Industry", *Journal of the Statistical and Social Inquiry Society of Ireland*, Vol. XXII, Part IV, pp. 156-185.

GODLEY, WYNNE and WILLIAM D. NORDHAUS, 1972. "Pricing in the Trade Cycle", *Economic Journal*, Vol. 82, No. 327, pp. 853-882, September.

GREGORY, R.G., 1971. "United States Imports and Internal Pressure of Demand: 1948-68", *American Economic Review*, Vol. 61, No. 1, pp. 28-47, March.

GRILICHES, Z., 1960. "Estimates of the Aggregate U.S. Farm Supply Function", *Journal of Farm Economics*, Vol. 42, pp. 282-293, August.

HAHN, FRANK, 1982. *Money and Inflation*, Oxford: Basil Blackwell.

HARRIS, JOHN R. and MICHAEL P. TODARO, 1970. "Migration, Unemployment and Development: A Two-Sector Analysis", *American Economic Review*, Vol. 60, pp. 126-142, March.

HARROD, R.F., 1973. "Letter to J.M. Keynes, 6 July 1938", in Donald Moggridge, (ed.), *The Collected Writings of John Maynard Keynes, Volume XIV*, pp. 297-299, London: Macmillan.

HECKMAN, J., 1974. "Shadow Prices, Market Wages, and Labour Supply", *Econometrica*, Vol. 42, No. 4, pp. 679-694, July.

HEIDHUES, THEODOR, 1976. "National Policy Decisions as an Adaptive Process", *European Review of Agricultural Economics*, Vol. 3, Nos. 2/3, pp. 349-389.

HELLIWELL, JOHN F., PAUL M. BOOTHE and ROBERT N. McRAE, 1982. "Stabilization, Allocation and the 1970's Oil Price Shocks", *Scandinavian Journal of Economics*, Vol. 84, No. 2, pp. 259-288.

HELLIWELL, J.F. and G. GLORIEUX, 1976. "Forward Looking Investment Behaviour", in J.F. Helliwell, (ed.), *Aggregate Investment: Selected Readings*, pp. 306-329, Harmondsworth, Middlesex: Penguin Books, Originally in *Review of Economic Studies*, Vol. 37, pp. 499-516, 1970.

HELLIWELL, JOHN F. and ROBERT N. McRAE, 1981. "Output, Potential Output, and Factor Demands in an Aggregate Open Economy Model with Energy and Capital Bundled Together", *Mimeo*, Department of

Economics, University of British Columbia.

HENDRY, DAVID F. and THOMAS VON UNGERN-STERNBERG, 1979. "Liquidity and Inflation Effects on Consumers' Expenditure", *Mimeo*, in A.S. Deaton, (ed.), *Essays in the Theory and Measurement of Consumers' Behaviour*, Cambridge: Cambridge University Press, forthcoming.

HENRY, E.W., 1976. *Irish Input-Output Structures, 1964 and 1968*, General Research Series No. 66, Dublin: The Economic and Social Research Institute.

HENRY, E.W., 1980. *Irish Input-Output Structures, 1976*, General Research Series No. 99, Dublin: The Economic and Social Research Institute.

HENRY, S.G.B. *et al.*, 1976. "Models of Inflation in the United Kingdom: An Evaluation", *National Institute Economic Review*, Vol. 10, pp. 60-71, August.

HICKMAN, BERT G. and ROBERT E. COEN, 1976. *An Annual Growth Model of the U.S. Economy*, Amsterdam: North-Holland.

HICKS, JOHN, 1965. *Capital and Growth*, Oxford: Oxford University Press.

HIGGINS, J., 1981. "Factor Demand and Factor Substitution in Selected Sectors of the Irish Food Industry", *The Economic and Social Review*, Vol. 12, No. 4, pp. 253-266.

HONOHAN, PATRICK, 1979. "Inflation and Consumption in Ireland", *The Economic and Social Review*, Vol. 10, No. 2, pp. 175-179, January.

HONOHAN, PATRICK, 1982a. "Ireland and the Small Open Economy", *Mimeo*, Paper to the Dublin Economic Workshop Conference, Killarney, October 17, 1981. (Abbreviated version) "Is Ireland a Small Open Economy?", *Administration*, Vol. 29, No. 4, pp. 356-375.

HONOHAN, PATRICK, 1982b. "A Bayesian Look at Consumption", *The Economic and Social Review*, Vol. 13, No. 4, pp. 233-249, July.

HONOHAN, PATRICK and JOHN DUNNE, 1982. "The Flow of Funds 1972-1977", *Mimeo, Journal of the Statistical and Social Inquiry Society of Ireland*, forthcoming.

HUGHES, J.G., 1981. "The Relationship Between Alternative Population and Migration Series: A Comment", *The Economic and Social Review*, Vol. 12, No. 2, pp. 141-144, January.

IRELAND, 1958. *Economic Development*, Dublin: Stationery Office.

IRELAND, 1970. *Input-Output Tables for 1964*, Dublin: Stationery Office.

IRELAND, 1978. *Input-Output Tables for 1969*, Dublin: Stationery Office.

IRELAND, 1979. *National Income and Expenditure 1979*, Dublin: Stationery Office.

IRELAND, 1981. *Report of the Committee on Cost and Competitiveness*, Dublin: Stationery Office.

IRVINE, IAN J., 1974. "Fiscal Policy in the Irish Economy", *The Economic* *and Social Review*, Vol. 6, No. 1, pp. 45-59.

JORGENSON, D.W., 1963. "Capital Theory and Investment Behaviour", *American Economic Review*, Vol. 53, pp. 247-259.

KALDOR, N., 1966. *Causes of the Slow Rate of Growth of the United Kingdom*, Cambridge: Cambridge University Press.

KALDOR, N., 1968. "Productivity and Growth in Manufacturing Industry: A Reply", *Economica*, Vol. 35, No. 140, pp. 385-391, November.

KALDOR, N., 1975. "Economic Growth and the Verdoorn Law – A Comment on Mr Rowthorn's Article", *Economic Journal*, Vol. 85, pp. 891-896, December.

KALT, JOSEPH P., 1978. "Technological Change and Factor Substitution in the United States: 1929-1967", *International Economic Review*, Vol. 19, No. 3, pp. 761-775.

KATSIAOUNI, O., 1979. *Manufacturing Output, Productivity Trends and Employment Planning in Ireland*, Dublin: Institute of Public Administration, April.

KATZ, J.M., 1968. "Verdoorn Effects, Returns to Scale and the Elasticity of Factor Substitution", *Oxford Economic Papers*, Vol. 20, pp. 342-352, November.

KATZ, J.M., 1969. *Production Functions, Foreign Investment and Growth*, Amsterdam: North-Holland.

KEENAN, J., 1978. "Unemployment, Emigration and the Labour Force", in B.R. Dowling and J. Durkan, (eds.), *Irish Economic Policy. A Review of Major Issues*, Dublin: The Economic and Social Research Institute, pp. 191-205.

KEENAN, J.G., 1981. "Irish Migration: All or Nothing Resolved?", *The Economic and Social Review*, Vol. 12, No. 3, pp. 169-186, April.

KELLEHER, ROBERT, 1977. "The Influence of Liquid Assets and the Sectoral Distribution of Income on Aggregate Consumers' Behaviour in Ireland", *The Economic and Social Review*, Vol. 8, No. 3, pp. 187-199.

KELLEHER, ROBERT and PETER SLOANE, 1976. "Import Demand Equations", *Technical Paper 13/RT/76*, Dublin: Central Bank of Ireland, December.

KENNEALLY, MARTIN F. and JEREMIAH V. McCARTHY, 1982. "A Preliminary Econometric Investigation of the Irish Housing Market 1969-1976", *The Economic and Social Review*, Vol. 14, No. 1, pp. 41-69, October.

KENNEDY, FINOLA, 1972. "Public Expenditure in Ireland on Housing in the Post-War Period", *The Economic and Social Review*, Vol. 3, No. 3, pp. 373-401, April.

KENNEDY, KIERAN A., 1971. *Productivity and Industrial Growth*, Oxford: Clarendon Press.

KENNEDY, KIERAN A. and BRENDAN R. DOWLING, 1970. "The Determinants of Personal Savings in Ireland: An Econometric Inquiry", *The Economic and Social Review*, Vol. 2, No. 1, pp. 19-51, October.

KENNEDY, KIERAN A. and BRENDAN R. DOWLING, 1975. *Economic Growth in Ireland: The Experience Since 1947*, Dublin: Gill and Macmillan.

KENNEDY, KIERAN A. and ANTHONY FOLEY, 1978. "Industrial Development", in B.R. Dowling and J. Durkan, (eds.), *Irish Economic Policy: A Review of Major Issues*, Dublin: The Economic and Social Research Institute, pp. 87-124.

KENNEDY, KIERAN A. and R.N. VAUGHAN, 1979. "Output, Employment and Wages in the Small Open Economy", *Memorandum Series No. 132*, Dublin: The Economic and Social Research Institute, April.

KHAN, MOSHIN S. and KNUD, Z. ROSS, 1977. "The Functional Form of the Aggregate Import Demand Equation", *Journal of International Economics*, Vol. 7, No. 2, pp. 149-160.

KILDUFF, A.P. and D.R. THOM, 1979. "The Demand for Durable Household Goods in Ireland 1953-1976", *Mimeo*, April.

KIRWAN, F.X., 1979. "Non-Wage Costs, Employment and Hours of Work in Irish Manufacturing Industry", *The Economic and Social Review*, Vol. 10, No. 3, pp. 231-254.

KIRWAN, F. and J. McGILVRAY, 1983. *Irish Economic Statistics*, Dublin: Institute of Public Administration.

KLEIN, L.R., 1980. "Economic Theoretic Restriction in Econometrics", *Mimeo*, Presented at an International Symposium on Criteria for Evaluating the Reliability of Macro-Models, Pisa, December.

KLEIN, L.R. and R.S. PRESTON, 1967. "The Measurement of Capacity Utilization", *American Economic Review*, Vol. 57, pp. 34-58, March.

KMENTA, J. and J.B. RAMSEY, 1981. *Large-Scale Macro-Econometric Models*, Amsterdam: North-Holland.

KOST, WILLIAM E., 1981. "The Agricultural Component in Macroeconomic Models", *Agricultural Economics Research*, Vol. 33, No. 3, pp. 1-10, July.

LACHMAN, LUDWIG M., 1973. *Macro-economic Theory and the Market Economy: An Essay on the Neglect of Micro-Foundations and its Consequences*, London: Institute of Economic Affairs.

LAIDLER, D.E.W. and J.N. PARKIN, 1975. "Inflation – A Survey", *Economic Journal*, Vol. 85, No. 340, pp. 741-809, December.

LANGLEY, PAUL C., 1974. "The Spatial Allocation of Migrants in England

and Wales: 1961-66", *Scottish Journal of Political Economy*, Vol. 21, No. 3, pp. 259-278, November.

LEIBENSTEIN, HARVEY, 1976. *Beyond Economic Man: A New Foundation for Microeconomics*, Cambridge, Mass.: Harvard University Press.

LIPSEY, R.G., 1960. "The Relation Between Unemployment and the Rate of Change of Money Wage Rates in the United Kingdom in 1862-1957: A Further Analysis", *Economica*, Vol. 27, No. 105, pp. 1-31, February.

LIPSEY, RICHARD G., 1978. "The Place of the Phillips Curve in Macroeconomic Models", in A.R. Bergstrom, *et al.*, (eds.), *Stability and Inflation: A Volume of Essays to Honour the Memory of A.W.H. Phillips*, Chichester and New York: John Wiley, pp. 49-75.

LIPSEY, R.G. and J.M. PARKING, 1970. "Incomes Policy: A Reappraisal", *Economica*, Vol. 37, No. 146, pp. 115-138, May.

LUCAS, R.E., 1976. "Econometric Policy Evaluation: A Critique", in K. Brunner and A.H. Meltzer, (eds.), *The Phillips Curve and Labour Markets*, Amsterdam: North-Holland, pp. 19-46.

LUCAS, ROBERT E., JR., 1981. *Studies in Business Cycle Theory*, Cambridge, Mass.: M.I.T. Press.

LUCAS, ROBERT E., JR. and THOMAS J. SARGENT, (eds.), 1981. *Rational Expectations and Econometric Practices*, London: George Allen and Unwin.

LYNCH, DAVID, 1983. "Modelling Irish Manufactured Exports", *Technical Paper I/RT/83*, Dublin: Central Bank of Ireland, March.

MAGEE, STEPHEN P., 1975. "Prices, Incomes, and Foreign Trade", in Peter B. Kenen, (ed.), *International Trade and Finance: Frontiers for Research*, Cambridge: Cambridge University Press, pp. 175-252.

MANDEL, ERNEST, 1970. *Marxist Economic Theory: Volume I*, New York: Monthly Review Press.

MASSON, P.R., D.E. ROSE and J.G. SELODY, 1980. "Building a Small Macro-Model for Simulation: Some Issues", *Technical Report No. 22*, Ottawa: Bank of Canada.

MATTHEWS, ALAN, 1977. "The Impact of Price and Technological Change on Irish Agricultural Output and Employment", *M. Sc. Thesis*, Ithaca: Cornell University, January.

McALEESE, DERMOT, 1970. *A Study of Demand Elasticities for Irish Imports*, General Research Series No. 53, Dublin: The Economic and Social Research Institute.

McALEESE, DERMOT, 1978. "Outward Looking Policies, Manufactured Exports and Economic Growth: The Irish Experience", in M.J. Artis and A.R. Nobay, (eds.), *Contemporary Economic Analysis*, London:

Croom-Helm, pp. 313-351.

McCARTHY, COLM, 1977a. "Estimates of a System of Demand Equations Using Alternative Commodity Classifications of Irish Data", *The Economic and Social Review*, Vol. 8, No. 3, pp. 8, 201-211, April.

McCARTHY, COLM, 1977b. "An Econometric Model of Non-Agricultural Stock Changes", in J. Durkan, *et al.*, *Quarterly Economic Commentary*, Dublin: The Economic and Social Research Institute, December.

McCARTHY, COLM, 1979a. "Economic Development and Economic Policy", in C. Fanning (ed.), *Economic Development Twenty Years On — Lessons and Prospects*, pp. 139-153, Cork: Commerce and Economics Society, University College, Cork, November, 1978. Also in *Administration*, Vol. 27, No. 2, pp. 201-210, Summer.

McCARTHY, COLM, 1979b. "The European Monetary System and Irish Macroeconomic Policy", *Central Bank Quarterly Bulletin*, pp. 109-122, Spring.

McCARTHY, W.E.J., J.F. O'BRIEN and V.G. DOWD, 1975. *Wage Inflation and Wage Leadership*, General Research Series No. 79, Dublin: The Economic and Social Research Institute.

McCOMBIE, J.S.L., 1980. "On the Quantitative Importance of Kaldor's Laws", *Bulletin of Economic Research*, Vol. 32, pp. 103-112.

McCOMBIE, J.S.L., 1981. "What Remains of Kaldor's Laws", *Economic Journal*, Vol. 91, pp. 206-216, March.

McCOMBIE, J.S.L., 1982. *Post-War Productivity and Output Growth in the Advanced Countries*, Ph.D. Thesis, Cambridge: Downing College.

McCORMACK, DARA, 1979. "Policy-making in a Small Open Economy: Some Aspects of Irish Experience", *Central Bank of Ireland Quarterly Bulletin*, No. 4, pp. 92-113, Winter.

McFALL LAMM, R., 1980. "The Role of Agriculture in the Macroeconomy: A Sectorál Analysis", *Applied Economics*, Vol. 12, pp. 19-35.

McGILVRAY, J., 1964/65. "The Stability of Coefficients in an Irish Inter-Industry Model", *Journal of the Statistical and Social Inquiry Society of Ireland*, Vol. XXI, Part 3, pp. 44-76.

McGILVRAY, JAMES, 1968. *Irish Economic Statistics*, Dublin: Institute of Public Administration.

McGINLEY, MICHAEL, 1976. "Pay Negotiation in the Public Service", *Administration*, Vol. 24, pp. 76-95, Spring.

McKINNON, RONALD I., 1976. "The Limited Role of Fiscal Policy in an Open Economy", *Banca Nazionale del Lavoro Quarterly Review*, No. 117, pp. 95-117, June.

McMAHON, PATRICK C. and DAVID J. SMYTH, 1974. "Quarterly Estimates of Capacity Utilization", *The Economic and Social Review*, Vol. 6, No. 1, pp. 81-105.

MINCER, J., 1966. "Labour Force Participation and Unemployment: A Review of Recent Evidence", in R.A. Gordon and M.S. Gordan, (eds.), *Prosperity and Unemployment*, New York: Wiley, pp. 73-112.

MODIGLIANI, FRANCO, 1970. "The Life Cycle Hypothesis of Saving and Intercountry Differences in the Savings Ratio", in W.A. Eltis, *et al.* (eds.), *Induction, Growth and Trade: Essays in Honour of Sir Roy Harrod*, Oxford: Clarendon Press, pp. 197-225.

MUKERJI, V., 1963. "Generalised SMAC Function with Constant Ratios of Elasticities of Substitution", *Review of Economics Studies*, Vol. 30, pp. 233-236.

MULVEY, C. and J. TREVITHICK, 1973. "Trade Unions and Wage Inflation", *The Economic and Social Review*, Vol. 4, No. 2, pp. 209-230, January.

MULVEY, C. and J. TREVITHICK, 1974. "Some Evidence on the Wage Leadership Hypothesis", *Scottish Journal of Political Economy*, Vol. 21, pp. 1-11, February.

MURPHY, A., 1979. "Non-agricultural Stock", *Mimeo*, Department of Finance.

MURRAY, C.H., 1979. "The European Monetary System: Implications for Ireland", *Central Bank Quarterly Bulletin*, pp. 96-108, Spring.

MURRAY, SEAN, 1980a. "Macroeconomic Policy in a Small Open Economy under Flexible Exchange Rates with Bond Financing of Government Deficits", *The Economic and Social Review*, Vol. 11, No. 3, pp. 217-235, April.

MURRAY, SEAN, 1980b. "Macroeconomic Policy in a Small Open Economy when Government Budget Deficits are Financed by Printing Money", *The Economic and Social Review*, Vol. 12, No. 1, pp. 1-16, October.

NADIRI, M.I., 1968. "The Effects of Relative Prices and Capacity on the Demand for Labour in the U.S. Manufacturing Sector", *Review of Economic Studies*, Vol. 35, pp. 273-288, July.

NELL, E.J., 1980. "Capital and the Firm in Neoclassical Theory", *Journal of Post-Keynesian Economics*, Vol. 2, No. 4, pp. 494-508, Summer.

NORDHAUS, WILLIAM D., 1970. "Recent Developments in Price Dynamics", *Discussion Paper No. 296*, Cowles Foundation for Research in Economics, Yale University, August.

NORDHAUS, WILLIAM D., 1972. "Recent Developments in Price Dynamics", in Otto Eckstein, (ed.), *The Econometrics of Price Determination: Conference*, Board of Governers, Washington, D.C.: Federal Reserve System, pp. 16-49.

NORDHAUS, WILLIAM D., 1974. "The Falling Share of Profits", *Brookings Papers on Economic Activity*, No. 1, pp. 169-217.

NORDHAUS, WILLIAM D., 1976. "Inflation Theory and Policy", *American Economic Review*, Vol. 66, No. 2, pp. 59-64, May.

NORTON, DESMOND, 1975. "Estimation of the Short-run Effects of Fiscal Policy in Ireland, 1960-1970", *The Economic and Social Review*, Vol. 6, No. 3, pp. 367-386.

O'BRIEN, JAMES F., 1981. *A Study of National Wage Agreements*, General Research Series No. 104, Dublin: The Economic and Social Research Institute, August.

O'CONNELL, THOMAS, 1977. "Demand and Supply Functions for Irish Exports of Manufactures", *The Economic and Social Review*, Vol. 8, No. 4, pp. 259-278.

O'CONNELL, THOMAS, 1982. "What Determines Irish Interest Rates?", *Irish Banking Review*, pp. 15-24, June.

O'CONNOR, R. and M. BRESLIN, 1968. *An Input-Output Analysis of the Agricultural Sector of the Irish Economy in 1964*, General Research Series No. 45, Dublin: The Economic and Social Research Institute.

O'CONNOR, R. and E.W. HENRY, 1975. *Input-Output Analysis and its Applications*, London: Charles Griffin and Co.

O'CONNOR, ROBERT and PHILIP KELLY, 1978. "Agriculture: Medium Term Review and Outlook", in B.R. Dowling and J. Durkan, (eds.), *Irish Economic Policy: A Review of Major Issues*, Dublin: The Economic and Social Research Institute, pp. 55-85.

O'CONNOR, ROBERT, MICEAL ROSS and MICHAEL BEHAN, 1977. *A Linear Programming Model for Irish Agriculture*, General Research Series No. 91, Dublin: The Economic and Social Research Institute.

OECD, 1981a. "A Medium-Term Simulation Model of the OECD Area", *Working Paper DES/WPI/EM (81) 1*, Paris: OECD.

OECD, 1981b. "Wage-Price Block", *Working Paper DES/WPI/EM (81) 5*, Paris: OECD.

OECD, 1981c. "The Demand Block: Specification and Empirical Results", *Working Paper DES/WPI/EM (81) 7*, Department of Economics and Statistics, Paris: OECD, February.

OECD, 1982a. "Overview of Key Behavioural Assumptions, Inter Block Relations, and System-Wide Identities", *Working Paper DES/WPI/EM (82) 1*, Paris: OECD.

OECD, 1982b. "Study of Producer Price Determination in Six OECD Countries", *Working Paper DES/WPI/EM (82) 5*, Paris: OECD.

O'FARRELL, P.N., 1975. *Regional Industrial Development Trends in Ireland 1960-1973*, Dublin: Industrial Development Authority.

O'HERLIHY, C., 1966. *A Statistical Study of Wages, Prices, and Employment in the Irish Manufacturing Sector*, General Research Series No.

26, Dublin: The Economic and Social Research Institute.

O'MAHONY, DAVID, 1964. *The Irish Economy: An Introductory Description*, Cork: Cork University Press, (2nd ed. 1967).

O'MAHONY, DAVID, 1964. *Industrial Relations in Ireland: The Background*, General Research Series No. 19, Dublin: The Economic and Social Research Institute.

O'MAHONY, DAVID, 1965. *Economic Aspects of Industrial Relations*, General Research Series No. 24, Dublin: The Economic and Social Research Institute, February.

O'REILLY, LIAM, 1981. "Estimating Quarterly National Accounts", *Technical Paper No. 12/RT/81*, Dublin: Central Bank of Ireland. *Journal of the Statistical and Social Inquiry Society of Ireland*, forthcoming.

O'REILLY, LIAM and BRIAN NOLAN, 1979. "The Measurement of Capacity Utilization in Manufacturing Industry in Ireland", *The Economic and Social Review*, Vol. 11, No. 1, pp. 47-65.

O'RIORDAN, W.K., 1974-75. "Consumer Response to Price and Income Changes", *Journal of the Statistical and Social Inquiry Society of Ireland*, Vol. XXIII, Part 2, pp. 65-89.

O'RIORDAN, WILLIAM K., 1981. "A Note on the Sectoral Employment Patterns", *The Economic and Social Review*, Vol. 12, No. 2, pp. 133-139, January.

ORMEROD, PAUL, 1979. *Economic Modelling: Current Issues in Macroeconomic Modelling in the UK and the US*, London: Heineman.

O'ROURKE, A. DESMOND, 1978. "Towards an Aggregate Production Function for Irish Agriculture", *The Economic and Social Review*, Vol. 9, No. 3, pp. 191-203.

PAGAN, ADRIAN, 1981. "Reflections on Australian Macromodelling", *Working Paper No. 048*, Australian National University.

PRACHOWNY, M., 1975. *Small Open Economies: Their Structure and Policy Environment*, London: Lexington Books.

REILLY, BARRY, 1982. "Agriculture, Forestry and Fisheries: Computer Data Bank of Time Series", *Mimeo*, Dublin: The Economic and Social Research Institute, January.

ROOP, JOSEPH M. and RANDOLPH H. ZEITNER, 1977. "Agricultural Activity and the General Economy: Some Macromodel Experiments", *American Journal of Agricultural Economics*, Vol. 59, No. 1, pp. 116-125, February.

ROWTHORN, R.E., 1975a. "What Remains of Kaldor's Laws?", *Economic Journal*, Vol. 85, pp. 10-19, March.

ROWTHORN, R.E., 1975b. "A Reply to Lord Kaldor's Comment", *Eco-*

nomic Journal, Vol. 85, pp. 897-901, December.

ROWTHORN, R.E., 1979. "A Note on Verdoorn's Law", *Economic Journal*, Vol. 89, pp. 131-133, March.

RUANE, FRANCES P., 1975. "A Statistical Analysis of Revisions to the Irish National Accounts", *The Economic and Social Review*, Vol. 6, No. 3, pp. 387-404, April.

RUANE, FRANCES P., 1982. "Corporate Income Tax, Investment Grants, and the Cost of Capital", *Journal of Public Economics*, Vol. 17, pp. 103-109.

SARGAN, J.D., 1964. "Wages and Prices in the United Kingdom: a Study in Econometric Methodology", in P.E. Hart, *et al.*, (eds.), *Econometric Analysis for National Economic Planning*, London: Butterworth, pp. 25-63.

SARGAN, J.D., 1971. "A Study of Wages and Prices in the U.K. 1949-1968", in H.G. Johnson and A.R. Nobay, (eds.), *The Current Inflation*, London: Macmillan, pp. 52-71.

SATO, R., 1967. "Two-Level Constant Elasticity of Substitution Production Function", *Review of Economic Studies*, Vol. 34, pp. 201-218, August.

SCHWARTZ, ANTOINE and JAN KOOYMAN, 1975. "Competition and the International Transmission of Inflation", *De Economist*, Vol. 123, No. 4, pp. 723-748.

SCOTT, S., 1980. *Energy Demand in Ireland, Projections and Policy Issues*, Policy Research Series No. 2, Dublin: The Economic and Social Research Institute, February.

SEXTON, J.J., 1981. "The Changing Labour Force", in ESRI, *The Irish Economy and Society in the 1980s: Papers presented at Twenty-First Anniversary Conference*, Dublin: The Economic and Social Research Institute, October, pp. 42-79.

SEXTON, J.J., 1982. "Sectoral Changes in the Labour Force over the Period 1961-1980 with Particular Reference to Public Sector and Services Employment", in P. Bacon, *et al.*, *Quarterly Economic Commentary*, Dublin: The Economic and Social Research Institute, August, pp. 36-45.

SEXTON, J.J. and B.M. WALSH, 1982. "A Study of Labour Force Flows 1961-80", in P. Bacon, *et al.*, *Quarterly Economic Commentary*, Dublin: The Economic and Social Research Institute, May, pp. 51-61.

SHEEHY, SEAMUS J., 1980. "The Impact of EEC Membership on Irish Agriculture", *Journal of the British Agricultural Economics Society*, Vol. XXXI, Part 3, pp. 297-309.

SLATTERY, D.G., 1977. "The Full-Employment Labour Supply in Ireland: 1954-1970", *The Economic and Social Review*, Vol. 8, No. 4, pp. 239-256.

SLOANE, PETER, 1974. "Import Demand Functions for Ireland", *Mimeo*, External Research Department, Dublin: Central Bank of Ireland, June.

SLOANE, PETER D., 1977. "Financing the Government Budget Deficit in a Small Open Economy: A Theoretical Analysis", *Technical Paper No. 12/RT/77*, Research Department, Dublin: Central Bank of Ireland, September.

SMITH, GRAHAM W., 1978. "Price Determination", in Michael Parkin and Michael T. Summer (eds.), *Inflation in the United Kingdom*, Manchester: Manchester University Press, pp. 93-111.

SMYTH, DAVID J. and PATRICK C. McMAHON, 1975. "Short-run Employment Functions for Irish Manufacturing", *The Economic and Social Review*, Vol. 6, No. 4, pp. 531-541.

SOLOW, R.M., 1973. "Law of Production and Laws of Algebra: The Humbug Production Function: A Comment", *Review of Economics and Statistics*, Vol. 55, p. 121.

STATISTICAL AND SOCIAL INQUIRY SOCIETY OF IRELAND, 1974/75. "A Symposium on Inflation", Dublin Meeting, *Journal of the Statistical and Social Inquiry Society of Ireland*, Vol. XXIII, Part 2, pp. 1-20.

SVEJNAR, JAN, 1982a. "On the Theory of a Participatory Firm", *Journal of Economic Theory*, Vol. 27, No. 2, pp. 313-330, August.

SVEJNAR, JAN, 1982b. "Employee Participation in Management, Bargaining Power, and Wages", *European Economic Review*, Vol. 18, pp. 291-303.

THIRLWALL, A.P., 1978. *Growth and Development: With Special Reference to Developing Economies*, London: Macmillan, 2nd ed.

THIRLWALL, A.P., 1980b. "Rowthorn's Interpretation of Verdoorn's Law", *Economic Journal*, Vol. 90, pp. 386-388, June.

TOBIN, JAMES, 1972. "The Wage-Price Mechanism: Overview of the Conference", in Otto Eckstein, (ed.), *The Econometrics of Price Determination: Conference*, Board of Governors, Washington, D.C.: Federal Reserve System, pp. 5-15.

TOWNEND, J.C., 1976. "The Personal Saving Ratio", *Bank of England Quarterly Bulletin*, March, pp. 53-73.

TUKEY, J.W. and M.B. WILK, 1970. "Data Analysis and Statistics: Techniques and Approaches", in Edward Tufte, (ed.), *The Quantitative Analysis of Social Problems*, Reading, Mass.: Addison Wesley, pp. 370-390.

TWEETON, L. and L. QUANCE, 1969. "Positivistic Measures of Aggregate Supply Elasticities: Some New Approaches", *American Journal of Agricultural Economics*, Vol. 51, pp. 342-352, May.

VAUGHAN, R.N., 1978. "Profits, Finance and Growth", in B.R. Dowling and J. Durkan (eds.), *Irish Economic Policy: A Review of Major Issues*, Dublin: The Economic and Social Research Institute, pp. 265-296.

VAUGHAN, R.N., 1980. *Measures of the Capital Stock in the Irish Manufacturing Sector, 1945-1973*, General Research Paper No. 103, Dublin: The Economic and Social Research Institute.

VERDOORN, P.J., 1949. "Fattori che Regolano lo Svilappo della Produttivita del Lavoro", *L'Industria*, Vol. 1, pp. 3-10.

VERDOORN, P.J., 1980. "Verdoorn's Law in Retrospect: A Comment", *Economic Journal*, Vol. 90, pp. 382-385, June.

VON UNGERN, THOMAS STERNBERG, 1981. "Inflation and Savings: International Evidence on Inflation-Induced Income Loss", *Economic Journal*, Vol. 91, No. 364, pp. 961-976, December.

WACHTER, MICHAEL L., 1972. "A Labour Supply Model for Secondary Workers", *Review of Economics and Statistics*, Vol. LIV, pp. 141-151, May.

WAELBROECK, JEAN, 1975. "A Survey of Short-Run Model Research Outside the United States", in G. Fromm and L.R. Klein, (eds.), *The Brookings Model: Perspective and Recent Developments*, Amsterdam: North-Holland, pp. 421-468.

WAELBROECK, JEAN and A. DRAMAIS, 1974. "DESMOS: A Model for the Coordination of Economic Policies in the EEC Countries", in A. Ando, *et al.* (eds.), *International Aspects of Stabilization Policies*, Conference Series No. 12, Boston: Federal Reserve Bank of Boston, pp. 285-347.

WALSH, B.M., 1966. "An Econometric Model of Ireland 1944-1962", Ph.D. Thesis, Graduate School, Boston College.

WALSH, B.M., 1969. "Influences on Mobility and Employment in Irish Family Farming", *Irish Journal of Agricultural Economics and Rural Sociology*, Vol. 2, No. 1, pp. 13-24.

WALSH, B.M., 1971. "Economic and Demographic Adjustment of the Irish Agricultural Labour Force, 1961-66", *Irish Journal of Agricultural Economics and Rural Sociology*, Vol. 3, No. 2, pp. 113-124.

WALSH, B.M., 1974. "Expectations, Information and Human Migration: Specifying an Econometric Model of Irish Migration to Britain", *Journal of Regional Science*, Vol. 14, No. 1, pp. 107-120.

WALSH, BRENDAN M., 1981. "Ireland in the European Monetary System: The Effects of a Change in Exchange Rate Regime", *Mimeo*, Presented to Colloquium on International Adjustment, The European Monetary System and Small European Economies, Florence: European University Institute, March.

WALSH, JOHN, 1982. "An Econometric Model of Production and Marketing of Calves", *Irish Journal of Agricultural Economics and Rural Sociology*, Vol. 9, pp. 51-75.

WARNER, DENNIS and MORDECHAI E. KREININ, 1980. "Determinants of International Trade Flows", *Review of Economics and Statistics*, Vol. 65, No. 1, pp. 96-104, February.

WHITAKER, KENNETH, 1982. "Economic Development – The Irish Experience", *Irish Times*, September 28, p. 18.

WHITAKER, KENNETH, 1973. "From Protection to Free Trade – The Irish Experience", *Administration*, Vol. 21, No. 4, pp. 405-423, Winter.

WINSTON, GORDON C., 1971. "Capital Utilization in Economic Development", *Economic Journal*, Vol. 81, No. 321, pp. 36-60, March.

WINSTON, GORDON C., 1974. "The Theory of Capital Utilization and Idleness", *Journal of Economic Literature*, Vol. 12, No. 4, pp. 1301-1320, December.

Appendix 2.1

THE ECONOMIC ACCOUNTING MATRIX

The economic accounting matrix or, as it is more frequently termed, the input-output table, provides a coherent framework within which to present the flows of goods and services produced, exchanged with the rest of the world, and used by all resident units in the course of a given accounting period (usually one year). It also shows the structure of production costs. To analyse flows taking place in the process of production one chooses units which bring out relationships of a technico-economic kind. A *branch* is defined as a grouping of units of homogeneous production, i.e., units characterised by a unique activity.

The basic input-output table is divided into three parts: first, a table of intermediate consumption which is square, with the producing branches along both rows and columns; second, a table of final uses where the rows correspond to the producer branches and the columns represent the categories of final uses (i.e., final consumption of households, collective consumption of government, gross fixed capital formation, changes in stocks and exports); and third, a table of primary inputs and resources, where in the upper part of the table the columns correspond to the producer branches and the rows correspond to the main components of value-added (i.e., compensation of employees, net operating surplus, consumption of fixed capital, net taxes linked to production). In the lower part of the table, the columns correspond to the products produced by each branch; the rows show the various transfers which make it possible to pass from actual output by branch to distributed output by product, and imports.

The Irish input-output tables are now produced by the Central Statistics Office according to the NACE-CLIO R44 European system of Integrated Economic Accounts (Eurostat, 1979). Official tables for this classification presently exist for 1969 and 1975. In Table A2.1 below we present a four-branch aggregation of the published 44-Branch table for 1975.

The EAM, and any model organised around it, implies balance equations between supply of, and demand for, the products of each of the producing branches. Demand for the output of each branch includes the demand for use as intermediate inputs by the branches themselves and an allocation among five categories of final demand. For each producing branch this

Table A2.1: *Four-branch aggregated input-output table for 1975, £m at current prices*

	A	*I*	*S*	*G*	*Total*	*Household consumption*	*Govt. consump.*	*Investment*	*Stock changes*	*Exports*
A	139012	860246	33	4097	1003388	97469	0	–18741	–24578	149257
I	223948	1511619	238432	145982	2119981	1538937	0	809475	–12079	1248260
S	59909	342920	385211	58176	846216	686996	0	47084	–561	95783
G	0	828	1452	1704	3984	83198	688100	0	0	4349
Total Intermediate Inputs	422869	2715613	625128	209959	3973569	2406600	688100	837818	–37218	1497649
	A	*I*	*S*	*G*						
Gross Wages and Salaries	42773	816597	594558	577684	2031612					
Employers' Social Contributions	2774	47178	30718	10518	91188					
Net Operating Surplus	489653	180497	195750	0	865900					
Net Value-Added at Factor Cost	535200	1044272	821026	588202	2988700					
Consumption of Fixed Capital	54338	87900	151562	24400	298200					
Gross Value-Added at Factor Cost	589538	1132172	952588	612602	3286900					
Net Taxes linked to Production	–4921	67367	–21045	4225	45626					
Gross Value-Added at Market Prices	584617	1199539	931543	616827	3332526					
Actual Output at Producers' Prices	1007486	3915152	1556671	826786	7306095					
Total Transfers	536	3201	43418	–47155	0					
Distributed Output at Producers' Prices	1008022	3918353	1600089	779631	7306095					
Imports at Producers' Prices	198536	1650955	35343	0	1884834					
Vat on Products	237	135266	40086	0	175589					
Total Resources at Producers' Prices	1206795	5704574	1675518	779631	9366518					

Legend
A: Agriculture, forestry and fishing
I: Industry
S: Market services
G: Non-market services

balance in value terms can be summarised as:

$$\begin{array}{lcl} \text{Branch gross output} & = & \text{Intermediate demands} + \text{Final demands} \\ X_i & = & \sum_{j=1}^{4} X_{ij} + \sum_{k=1}^{5} Y_{ik} \end{array}$$

where

X_i = gross output of branch i
X_{ij} = intermediate demand for output of branch i by branch j
Y_{ik} = final demand for output of branch i by final use k

The revenue derived from the sale of this gross output is completely distributed among the intermediate inputs and primary factors used by each branch. Therefore, the value of total gross output is correspondingly balanced by the value of inputs used by each branch, which is (reading down the columns) summarised as:

$$\begin{array}{lcl} \text{Branch gross outlay} & = & \text{Intermediate inputs} + \text{Primary factors} \\ X_j & = & \sum_{i=1}^{4} X_{ij} + \sum_{l} V_{lj} \end{array}$$

where

X_j = gross outlay on intermediate and primary inputs;
X_{ij} = intermediate inputs from industry i used by industry j; and
V_{lj} = primary inputs used by industry j.

The branch totals for gross outputs and gross outlays can be aggregated to give overall balances for the economy as:

$$\begin{array}{lcl} \text{Total gross output} & = & \text{Total gross outlay} \\ \sum_{i=1}^{4} X_i & = & \sum_{j=1}^{4} X_j \end{array}$$

This is the production accounting framework which summarises the inter-branch and final use flows in the economy in a particular period. It is the quantitative basis for aggregative analysis of the economy.

In the case of input-output *models* of the economy, the objective is to relate a given set of final demands for the output of each branch to the gross outputs of each branch and, by means of the inter-branch transactions matrix, to determine the allocation of output over branch production and primary, input activities. The book by O'Connor and Henry (1975) provides a good introduction to the uses and limitation of input-output models.

Appendix 2.2

DATA SOURCES AND NOTES

GENERAL REFERENCES

Empirical analysis of the economy requires data, and if regression techniques are used to investigate economic relationships, the data must be in the form of time-series of sufficient length and consistency to enable statistical estimation to be used. Since such analysis is invariably carried out by means of electronic computers, the most convenient form of data is "machine-readable", i.e., ready for direct insertion into computer data banks. No data are issued by the Central Statistics Office in Ireland in "machine-readable" form.[136] Hence, extensive data extraction and adjustment is usually required before Irish economic data can be used in time-series format, even for the post-1960 period.[137]

An invaluable source of "machine-readable" data is the computer data bank of annual time series prepared by the Department of Finance from various published sources and kindly made available to us (FitzGerald and Kirwan, 1981).[138] The coverage of this data bank is quite extensive and includes:

(i) the complete *National Income and Expenditure* data for the post-1960 period;

(ii) extensive additional data on government tax revenues and expenditures, extracted from published sources such as the *Annual Report of the Revenue Commissioners, Estimates for the Public Services*, the National Accounts Version of the Budget, *Trends in Employment and Unemployment, Economic Review and Outlook*, the *Finance Accounts* and the *OECD National Account*; and

(iii) trade data by broad SITC groupings from *Trade Statistics of Ireland*, adjusted to produce consistent series on a national accounts basis.[139]

In addition to providing a valuable computerised data bank of time series, the Department of Finance has adjusted the data in many ways, making it more useful for our kind of analysis, e.g.,

136. Certain data are, however, available indirectly via international organisations such as the OECD and the European Statistical Office in Luxembourg, on magnetic tape.

137. Kennedy and Dowling (1975) contains extensive discussion of data problems in the 1947 to 1960 period.

138. A data bank of quarterly and monthly time-series is also maintained by the Central Bank of Ireland (Central Bank of Ireland, 1982).

139. FitzGerald (1978) gives a detailed description of procedures followed to make adjustments.

(i) Government data published on a financial year basis prior to 1974, have been adjusted to a calendar year basis by simple interpolation; and

(ii) all constant price series have been expressed in 1975 prices.

The following additional sources of data have been used:

(i) *The Irish Statistical Bulletin*, as the main source of data for the agricultural sector. This has been documented separately in Reilly (1982).

(ii) The *Census of Population* and Sexton and Walsh (1982) have been used to derive data on population and employment. The important employment revisions described by Sexton (1981) and (1982) have been used to provide employment on the revised labour force survey basis for the entire 1961 to 1980 period.

(iii) Monetary and financial data have been derived from the *Quarterly Bulletin* of the Central Bank of Ireland.

SPECIFIC REFERENCES

In addition to the above general data references, we now describe the data used in this study sector by sector. For brevity 75 is used to indicate constant 1975 prices, '000 to indicate thousands of persons and all price indices (and deflators) are to base 1975 = 1.0. In order to save space, we merely give summary indications on the data definitions. Full details can be obtained directly from the authors and from FitzGerald and Kirwan (1981).

Supply: Industry Sector

(i) Output

OI	= Value-added in industry (£m, 75)
CURI	= Capacity utilisation in manufacturing industry: annualised version of O'Reilly and Nolan (1979)
OICAP	= Capacity output in industry (defined as OI/CURI)
PRI	= Labour productivity in industry (defined as OI/LI)

(ii) Factor Inputs

LI	= Employment in industry ('000)
LI*	= Trend employment in industry by scaled moving average method

IFI	= Gross fixed investment in industry (£m, 75)
KFI	= Capital stock in industry (£m, 75) generated as $KFI_t = IFI_t + (1-\delta)KFI_{t-1}$, with $KFI_{1952} = 0.0$ and $\delta = 0.05$
KFI*	= Trend capital stock in industry (£m, 75) by scaled moving average method
KFIU	= "Utilised" capital stock in industry (defined as CURI*KFI) (£m, 75)

(iii) Prices

POI	= Deflator of value-added in industry (OIV)
PIFI	= Deflator of gross fixed investment in industry (IFIV)
PQTIG	= Deflator of gross output of transportable goods industries
WI	= Annual average national accounts earnings in industry (£000)
UCCI	= Measure of user cost of capital in industry, defined as $UCCI = PIFI\,(0.02\,(1-\tau\theta-\Psi) + 0.05)/(1-\tau)$ where

0.02 = Assumed real rate of interest

τ = Rate of corporate income tax, adjusted for exporting as in Geary and McDonnell (1979) (GM)

θ = Initial depreciation allowances, weighted by structural and machinery content as in GM (1979)

Ψ = Capital grant rate, defined as the ratio of capital transfers to industry to IFI

(iv) Other

GDAOI	= Gross domestic absorption weighted by (1969) industrial output content (£m, 75)
XWM	= Index of volume of world trade in manufactures (1975 = 100): *Source* NIER: Reports (Table 21)

Supply: Agricultural Sector

(i) Output

OAFF	= Value-added in agriculture, forestry and fishing (AFF) (£m, 75)
QAG	= Gross output in agriculture (£m, 75)
QAGCAP	= Four year moving average of QAG (£m, 75)
PRA	= Labour productivity in AFF (defined as OAFF/LAFF)

(ii) Factor Inputs

LAH	=	Hired labour in agriculture ('000)
LAFF	=	Employment in AFF ('000)
LASE	=	Self-employed in AFF (defined as LAFF-LAH) ('000)
IFAFF	=	Gross fixed investment in buildings and machinery in AFF (£m, 75)
KFAFF	=	Capital stock of buildings and machinery in AFF (generated as for KFI above) (£m, 75)
MATA	=	Inputs of feed, seed and fertiliser (£m, 75)
MATNA	=	Other material inputs in agriculture (£m, 75)
MAT	=	Total material inputs in agriculture (defined as MATA and MATNA) (£m, 75)

(iii) Prices

POAFF	=	Deflator of value-added in AFF (OAFFV)
PQAG	=	Deflator of gross agricultural output (QAGV)
PIFAFF	=	Deflator of gross fixed investment in AFF (IFIV)
PMATA	=	Deflator of feed, seed and fertiliser inputs (MATAV)
PMATNA	=	Deflator of other material inputs (MATNA): *Source* for 1968-79 is unpublished CSO data. Prior to 1968 a weighted average of PQTIG and an energy price index of Scott (1980) was used.
PMAT	=	Deflator of total material inputs
WAH	=	Annual average national accounts earnings for hired labour in AFF (£000)
UCCA	=	User cost of capital in AFF (defined as PIFAFF (0.02 + 0.05))

(iv) Other

IIAV	=	Inventory (cattle) investment in agriculture (£m)
YAFF	=	AFF income (£m)
YSEAFF	=	AFF income from self-employment (£m)
RAW	=	Average annual income in AFF relative to average annual earnings in non-agriculture
RAAD	=	Defined as RAW/(1-UR/100), where UR is the global unemployment rate
WEATH 1	=	Average rainfall less evapotranspiration (*Source*: Meteorological Office)
WEATH 2	=	Deviation of WEATH 1 from mean of sample

WEATH 3 = Cumulative degree days over 6° C during growing season (*Source*: Meteorological Office)

Supply: Services Sector

(i) Output

OS = Value-added in services sector (£m, 75) (sum of transport and communication and other domestic)
PRS = Labour productivity in services (defined as OS/LS)

(ii) Factor Inputs

LS = Employment in services ('000)
IFS = Gross fixed investment in services (*Source: OECD National Accounts*)
KFS = Capital stock in services (generated as for KFI above) (£m, 75)

(iii) Prices

POS = Deflator of value-added in services (OSV)
PIFS = Deflator of gross fixed investment in services (IFSV)
WS = Annual average national accounts earnings in services (£000)
UCCS = User cost of capital in services (defined as PIFS (0.02 + 0.05))

(iv) Other

GFDOS = Gross final demand weighted by (1969) services output content (£m, 75)

Imports of Goods and Services

(i) Volumes

MGS = Total imports of goods and services (£m, 75)
MG = Imports of goods (£m, 75)
MS = Imports of services (£m, 75)
MMFP = Imports of materials for further production (£m, 75)
MGSO = MGS-MMFP (£m, 75)

(ii) Prices

PMGS = Deflator of Imports of goods and services
PMG = Imports of goods, unit value index
PMS = Deflator of imports of services

Labour Supply

(i) Population

NT	=	Total population ('000)
NLE14	=	Population aged under 15 years ('000)
N1564	=	Population aged between 15 and 64 ('000)
NGE65	=	Population aged over 64 years ('000)
N1564A	=	Working age population (N1564) not in full time education (defined as N1564–NLFED) ('000)

(ii) Migration

NMA	=	Net migration abroad ('000) (*Source*: Hughes, 1981 and Sexton and Walsh, 1982).

(iii) Labour Force

LF	=	Labour force ('000) (*Source*: Sexton and Walsh, 1982).
LFPR	=	Labour force participation rate (defined as LF/N1564A)
LR	=	Employment rate (defined as 100–UR)
NLFED	=	Working aged population in full-time education ('000)
EDPR	=	Working age education participation rate (defined as NLFED/N1564)
DUMED	=	"Free" education dummy (value zero up to 1967; values 0.2, 0.4, 0.6, 0.8 for 1968 to 1971; value unity since then)
NLFO	=	Working aged population neither employed nor in full-time education (defined as N1564–LF–NLFED)
L	=	Total employment (defined as LI+LS+LAFF+LPA) ('000)
U	=	Numbers unemployed (defined as LF–L) ('000)
UR	=	Unemployment rate (defined as 100.U/LF)

(iv) Other

WIRIR	=	Index of real non-agricultural earnings (defined as WNA/PCPER
WNA	=	Annual average non-agricultural earnings (defined as (WI.LI +WS.LS+WPA.LPA)/(LI+LS+LPA) (£000)
RUCP	=	Average unemployment transfers per unemployed person relative to WNA
RE	=	Index of rate of employment in Ireland relative to the UK
RW	=	Index of real non-agricultural wages in Ireland relative to the UK
LPA	=	Employment in public administration ('000)

Absorption

(i) Volumes

CPER	=	Personal consumption expenditure (£m, 75)
CG	=	Consumption by government (£m, 75)
CGO	=	Non public administration wage element of CG (£m, 75)
IH	=	Total housing investment (£m, 75)
IHP	=	Private housing investment (£m, 75)
IHG	=	Public housing investment (£m, 75)
IFI	=	Gross fixed investment in industry (£m, 75)
IFAFF	=	Gross fixed investment in agriculture, forestry and fishing (£m, 75)
IFS	=	Gross fixed investment in services (£m, 75)
IFG	=	Gross fixed investment by government (£m, 75)
III	=	Inventory investment by industry (£m, 75)
IIS	=	Inventory investment by services (£m, 75)
IIA	=	Inventory (cattle) investment by agriculture (£m, 75)
XGS	=	Exports of goods and services (£m, 75)

(ii) Prices

The price index mnemonic is obtained by placing a letter "P" before the corresponding volume (e.g., PCPER, is the deflator of personal consumption)

Income Distribution

(i) *Producer Prices*

POI	=	Deflator of value-added in industry
POAFF	=	Deflator of value-added in AFF
PQAG	=	Deflator of gross agricultural output
POS	=	Deflator of value-added in services

(ii) *Expenditure Prices*

These are defined in the domestic absorption section above.

TINR = Index of rate of indirect taxes net of subsidies (defined as TINR = 100 (TED+TAV+TIO+TCD- SUBC)/(CPERV)

(iii) *Other*

ULCI = Unit labour costs in industry (defined as WI/PRI)

(iv) *Wages*

WI	=	Annual average national accounts earnings in industry (£000 p.a.)
WS	=	Annual average national accounts earnings in services (£000 p.a.)
WPA	=	Annual average national accounts earnings in public administration (£000 p.a.)
WAH	=	Annual average national accounts earnings by hired labour in agriculture (£000 p.a.)

Fiscal Redistribution

(i) Indirect Taxation

TED	=	Revenue from excise duties on alcohol, tobacco, petrol, heavy oil and motor vehicles (£m)
TEDR	=	Weighted average rate of excise duty; (FitzGerald and Kirwan, 1981 (F-K give details)
TAV	=	Revenue from value-added taxation (£m)
TAVR	=	Weighted average VAT rate; (F-K give details)
TIO	=	Residual indirect tax revenue (£m)
TIOR	=	Imputed tax rate for residual category; (F-K give details)
TCD	=	Revenue from customs duties (£m)

(ii) Direct Taxation

TYPER	=	Revenue from direct income tax (£m)
TYPAL	=	Total personal allowances claimable; (Dowling, 1977 and F-K give details)
SOCFL	=	Revenue from flat-rate social insurance (£m)
SOCFLR	=	Weighted average flat-rate contribution; (F-K give details)
SOCYW	=	Revenue from pay-related social insurance (£m)
SOCYWR	=	Weighted average pay-related contribution rate; (F-K give details)
TYC	=	Company taxation revenue (£m)

(iii) Subsidies

SUBC	=	Subsidies on consumption of goods and services (£m)
SUBO	=	Other current subsidies (£m)

(iv) Personal Transfers

TRU	=	Unemployment assistance and benefit payments (£m)

TRUP = Weighted average rate of assistance and benefit (F-K give details)
TRUYW = Pay-related benefit payments (£m)
TRO = Other personal transfers (excluding debt interest) (£m)

(v) Debt Payments

TRDID = Debt interest payments on national loans (£m)
SECGNL = National loans outstanding (£m)
RSECGNL = Rate of interest (average) on national loans

(vi) Monetary

MON = Broad money supply (£m) (M3 in *Central Bank Quarterly Bulletin*)
LIQ = Liquid assets (defined as MON plus SECHGO) (£m)
SECHGO = Post Office savings, National Instalment Savings, Prize Bonds and Tax Reserve Certificates (£m)

Macroeconomic Summary Accounts

YP = Private income (£m)
YPER = Personal income (£m)
YPERD = Personal disposable income (£m)
YPERT = Personal taxable income; (F-K give details) (£m)
YC = Company profits (£m)
GDPFC = Gross domestic product at factor cost (£m, 75)
GNPM = Gross national product at market prices (£m, 75)

Appendix 2.3

PREVIOUS SECTORAL MACROECONOMETRIC STUDIES

It is useful to look briefly at some previous sectoral studies within the overall framework discussed in Chapter 2. This allows us to highlight those areas of the economic framework where relevant quantitative research findings are available for direct use and guidance in sectoral analysis, and conversely, to highlight the areas where less has been done.[140]

140. As mentioned earlier, previous studies of complete macroeconometric models of the Irish economy have been extensively surveyed by us elsewhere (Bradley and Fanning, 1983) and in this brief review we shall consider sector specific research classified within the three-block framework of Chapter 2.

The supply block is concerned with exploring the output decision process, the demand for factors of production (employment, investment), issues related to capacity and utilisation, the supply of labour, and imports. The major inputs to the sector are measures of aggregate demand and prices of factors. Some key outputs from the sector include the unemployment rate, capacity utilisation and investment and import demand. Existing Irish empirical work for this sector is somewhat limited in scope. For example, many of the issues which are raised in the supply block were not treated explicitly in the work of Kennedy and Dowling (1975), but were examined implicitly via the Verdoorn Law relationship between labour productivity and output, the gross investment-productivity ratio and the gross incremental capital-output ratio (GICOR). A few empirical studies of labour demand in Ireland exist (Smyth and McMahon, 1975; Kirwan, 1979).[141] Empirical work on investment (or capital demand) includes work by Geary, Walsh and Copeland (1975), Geary and McDonnell (1979), Ruane (1982), and Flynn and Honohan (1982) on the cost of capital; Vaughan (1980) on the capital stock, which has references to early work on the same subject; and Bradley (1979a) on a Neo-classical approach to investment demand. Studies of inter-related factor demands systems have not been very successful in Ireland, but recent work by Boyle and Sloane (1982), with highly disaggregated industrial data, deals with the issues of factor homogeneity and factor substitution. Import demand studies have been made by McAleese (1970) and FitzGerald (1979).

In any supply block different approaches to disaggregation are possible. At the most aggregate, the entire business sector could be treated as a single entity whose driving force is some measure of gross domestic product of business (determined in the demand block), and factor demand equations for capital and labour could be derived using some appropriate paradigm. Given the large size, and unique characteristics, of the Irish agricultural sector, a first attempt at disaggregation would involve the separation of agricultural activity for individual treatment. A further level of disaggregation would involve the splitting of the non-agricultural sector; into industry and services, thus providing the classical primary (agricultural), secondary (industrial) and tertiary (services) sectors of economic development. At this level it would be difficult to disaggregate further on the services side, for reasons discussed in Chapter 5.1. However, further disaggregation on the industrial side is possible, using the Census of Industrial Production data, which, however, are difficult to reconcile with NIPE accounts data.

141. A study by Glass (1971/72) deals with factor substitution and labour demand in the Northern Ireland engineering industry.

The domestic absorption and balance of payment block involves the modelling of selected items of expenditure: private consumption, private housing investment, inventory investment and finally, the determination of exports. Extensive Irish empirical work is available in these areas: Digby (1980) reviews consumption studies; O'Connell (1977) and Browne (1982) examine exports; McCarthy (1977a) and Murphy (1979) consider non-agricultural inventory investment; housing investment remains a somewhat under-explored field due mainly to data problems, but Kenneally and McCarthy (1982) is a recent contribution. Business fixed investment is determined in the supply block and combined in this block to form domestic absorption.

Turning to the income distribution block, the structure of the wage-price sector and its relationship to employment is one that remains the centre of continuing controversy. The recent *Report of the Committee on Costs and Competitiveness* (Ireland, 1981) presents the "conventional" view, and a response by a group of socialist economists is contained in *Jobs and Wages: The True Story of Competitiveness*, Callender *et al.* (1983). The task of this sector is to endogenise average annual earnings in the particular sectoral breakdown used in the supply block and to endogenise the main output and expenditure deflators. The seminal study by Geary (1976b) set the pattern for subsequent Irish empirical studies of wage-price issues. However, these issues remain an area of active empirical research, particularly in the aftermath of entry into the EMS in 1979.[142]

Within the income distribution block, the public authorities sector determines tax revenue (direct and indirect) and expenditures on transfers, subsidies and debt payments. The monetary authority, given the well-known limitations on the scope of monetary policy in a small open economy with fixed exchange rates and free capital mobility, is also considered as part of the consolidated income distribution sector. The structure of this sector obviously lies at the heart of any attempt to analyse the effect of, and scope for, fiscal and monetary actions. To the extent that such modelling is possible, the manner in which indirect taxes and consumer subsidies affect prices, and the manner in which direct taxes affect disposable income, and hence demand, have been well explored empirically (Bradley, *et al.*, 1981; FitzGerald and Keegan, 1982). However, on the capital side the only econometric work which addresses directly the influence of government capital

142. It is noteworthy that wage determination was not a matter considered in any detail by Kennedy and Dowling (1975) in their analysis of growth. However, use of export/investment-led growth models of the type considered by Kennedy and Dowling usually require a productivity driven wage rate if a "virtuous circle" growth process, once initiated, is to continue. This topic is considered in more detail in Chapter 4 and Appendix 4.2.

expenditure on private investment is that of Norton (1975). Recent work by Geary and McDonnell (1977) and Ruane (1982) has concentrated on fiscal influences on a measure of the cost of capital. But this work still awaits a comprehensive analysis of investment in Ireland before its empirical usefulness for policy analysis is clear.

Finally, the income distribution block also includes identities determining disposable income, total profits, undistributed profits, and other national accounts aggregates. Work on the macroeconomic behaviour of the Irish company sector is quite limited, but a study by Vaughan (1978) provides a first attempt at examining the role of company profits in company sector investment decisions.

Appendix 3.1

FACTOR DEMAND SYSTEMS: COBB-DOUGLAS AND CES CASES

In deriving the demand for the factors of production we first treat the simplest possible approach. We consider only two factor inputs: labour (L) and capital (K) and a long-run Cobb-Douglas production function which is viewed as a planning relation, i.e.,

$$O_t^* = A \exp(\gamma t)\, K^{*\alpha}\, L^{*\beta} \quad (A, \gamma, \alpha, \beta > 0) \tag{1}$$

where the "*" denotes long-run or expected values of a variable.

The first assumption concerning firm behaviour which we make is that the long-run factor inputs are chosen so as to minimise the cost of producing a given long-run output. The Lagrangean for such and optimisation problem is

$$L = C^*K^* + W^*L^* - \lambda \left[O^* - A \exp(\gamma t)\, K^{*\alpha}\, L^{*\beta}\right] \tag{2}$$

where C and W are the user costs of capital and labour, respectively. The two first order conditions for an optimum yield the following long-run factor proportions relationships:

$$\log\left(\frac{K^*}{L^*}\right) = \log\left(\frac{\alpha}{\beta}\right) + \log\left(\frac{W^*}{C^*}\right) \tag{3}$$

Solving this equation and the production function (1) yields the long-run factor demand equations:

$$K^* = \left[\left(\frac{\alpha}{\beta}\right)^{\beta} A^{-1}\right]^{1/(\alpha+\beta)} \left[\frac{W^*}{C^*}\right]^{\beta/(\alpha+\beta)} O^{*1/(\alpha+\beta)} \exp(-\gamma/(\alpha+\beta))t \tag{4a}$$

$$L^* = \left[\left(\frac{\alpha}{\beta}\right)^{-\alpha} A^{-1}\right]^{1/(\alpha+\beta)} \left[\frac{W^*}{C^*}\right]^{-\alpha/(\alpha+\beta)} O^{*1/(\alpha+\beta)} \exp(-\gamma/(\alpha+\beta))t \tag{4b}$$

which can be written in the form:

$$\log K^* = a_0 + a_1 \log RFP^* + a_2 \log O^* + a_3 t \tag{5a}$$

$$\log L^* = b_0 + b_1 \log RFP^* + b_2 \log O^* + b_3 t \tag{5b}$$

where RFP is the relative factor price (W^*/C^*) and where, although linear in the logarithms of the independent variables, there are non-linear constraints connecting the eight coefficients a_i, b_i ($i = 1,4$).

The factor demand system (4a, 4b) obviously depends on the exact form of the production function chosen. In the Cobb-Douglas case the resulting equations have the desirable property of linearity. A more general production function is the CES (constant elasticity of substitution):

$$O^* = \left[A \quad \delta\,(\exp(\lambda_L t)L^*)^{-\rho} + (1-\delta)\,(\exp(\lambda_K t)K^{*-\rho}\right]^{-\mu/\rho} \tag{6}$$

where A is a scale parameter, ρ is related to the constant elasticity of substitution σ by

$$\sigma = \frac{1}{1+\rho}$$

δ is a factor intensity parameter, μ is the returns to scale ($\mu = 1$ for constant returns to scale) and λ_L and λ_K are the rates of technical progress embodied in labour and capital, respectively.

Following an analogous process of cost minimisation, we obtain the following, highly non-linear factor demand equations:

$$\begin{aligned}\log K^* = &- \frac{1}{\mu}\log A + \left(\frac{\sigma}{1-\sigma}\right)\log(1-\delta) + \frac{1}{\mu}\log O^* - \lambda_K t \\ &+ \left(\frac{\sigma}{1-\sigma}\right)\log\left[\left(\frac{\delta}{1-\delta}\right)^{\sigma} RFP^{*(1-\sigma)}\exp\Big((\sigma-1)(\lambda_L-\lambda_K)t\Big) + 1\right]\end{aligned} \tag{7a}$$

$$\begin{aligned}\log L^* = &- \frac{1}{\mu}\log A + \left(\frac{\sigma}{1-\sigma}\right)\log\delta + \frac{1}{\mu}\log O^* - \lambda_L t \\ &+ \left(\frac{\sigma}{1-\sigma}\right)\log\left[\left(\frac{\delta}{1-\delta}\right)^{-\sigma} RFP^{*(\sigma-1)}\exp\Big((1-\sigma)\,(\lambda_L-\lambda_K)t\Big) + 1\right]\end{aligned} \tag{7b}$$

and a long-run factor proportions relation of form

$$\log\left(\frac{K^*}{L^*}\right) = \sigma\log\left(\frac{1-\delta}{\delta}\right) + \sigma\log RFP^* + (1-\sigma)\,(\lambda_L-\lambda_K)t \tag{8}$$

If Equations (3) and (8) are compared, it is seen that the more general non-neutral technical change, possible in the CES function, results in the bias of technical change (i.e., $\lambda_L - \lambda_K$) entering into the factor proportion equation. Hence, an assumption of neutral technical change ($\lambda_L = \lambda_K$) could result in biased estimates of the production function parameters. This aspect has been studied in a dual context (i.e., using cost functions rather than production functions) by Higgins (1981), Boyle (1981), and Boyle and Sloane (1982). In the latter reference, it was found that technical change was significantly labour saving in a wide range of Irish industries and that the imposition of neutral technical change led to serious bias in the subsequent elasticity estimates.

The above factor demand systems have been derived assuming exogenously given output and relative factor prices. If output levels are set by the firm itself, the appropriate criterion becomes one of profit maximisation where profit, π^*, is defined as

$$\pi^* = P^*O^* - [C^*K^* + W^*L^*] \tag{9}$$

Substitution of different production functions for O^* yields the corresponding factor demand functions. Assuming a Cobb-Douglas function (as in (1)) yields equations of form:

$$(1-\alpha-\beta) \log K^* = \log (A\alpha^{1-\beta}\beta^{\beta}) - \beta \log (\frac{W^*}{P^*}) - (1-\beta) \log (\frac{C^*}{P^*}) - \gamma t \tag{10a}$$

$$(1-\alpha-\beta) \log L^* = \log (A\alpha^{\alpha}\beta^{1-\alpha}) - (1-\alpha) \log (\frac{W^*}{P^*}) - \alpha \log (\frac{C^*}{P^*}) - \gamma t \tag{10b}$$

with a corresponding output equation

$$(1-\alpha-\beta) \log O^* = \log (A\alpha^{\alpha}\beta^{\beta}) - \beta \log (\frac{W^*}{P^*}) + \alpha \log (\frac{C^*}{P^*}) + \gamma t \tag{10c}$$

In the case of the Cobb-Douglas function the second order conditions for a profit maximum require that

$$0 < \alpha < 1, \ 0 < \beta < 1, \ \alpha + \beta < 1$$

From (10a) and (10b), if the returns to scale parameter $\mu = \alpha + \beta$, exceeds unity, the factor demand equations are upward sloping. If $\mu = 1$, the equations cannot be solved. Hence, decreasing returns to scale ($\mu < 1$) are necessary for a meaningful solution of the factor demand system in the profit maximisation case.

The differences between the cost minimisation (CM) and profit maximisation (PM) approaches have been summarised by Brechling (1975, p. 9):

(i) in CM no specific assumptions are needed about the competitive nature of the output market;

(ii) CM is quite compatible with homogeneous production functions with increasing returns to scale;

(iii) in CM the scale of production is determined by output. A change in relative factor prices leads only to factor substitution. In PM a change in one real factor price leads to a change in both the scale of production *and* some factor substitution; and

(iv) the CM approach has nothing to say about the output market. Hence, if output is actually endogenous, the resulting econometric estimates may be biased.

Finally, the factor demand systems have been derived in their long-run equilibrium form. In practice firms may not instantly adjust their actual inputs to variations in their long-run levels because of adjustment costs (such as labour hiring, training, layoffs, etc., and capital purchase and installation costs). The usual way of modifying the long-run factor demand relationships is to introduce simple empirical models of adjustment. For example, if we assume a partial adjustment process, we obtain

$$(K_t/K_{t-1}) = (K_t^*/K_{t-1})^{\lambda_1} \qquad (0 < \lambda_1 < 1) \tag{11a}$$

$$(L_t/L_{t-1}) = (L_t^*/L_{t-1})^{\lambda_2} \qquad (0 < \lambda_2 < 1) \tag{11b}$$

where λ_1 and λ_2 are the adjustment rates for capital and labour, respectively. Combining these adjustment mechanisms with the long-run equilibrium equations yields short-run (or disequilibrium) factor demands.

Hence, two approaches are possible:

(i) if proxy measures of the long-run variables K*, L*, O*, RFP* are available, then the equilibrium factor demands can be estimated separately from the short-run adjustment mechanisms; or

(ii) if proxy measures are not available, the disequilibrium form of the factor demands can be directly estimated and both the production function parameters and the adjustment parameters retrieved from the one set of equations.

A specific example of this problem is taken up in Chapter 4 for the industrial sector analysis.

Appendix 3.2

CAPACITY OUTPUT CONCEPTS

In Chapter 3 and Appendix 3.1 we have shown how long-run or equilibrium factor demand systems are derived, how a simple adjustment mechanism can be operationalised, and how this leads to short-run or disequilibrium factor demand equations. The key to this development was the interpretation of the production function as a long-run planning relationship. The corresponding short-run Cobb-Douglas production function is of form (assuming constant returns to scale):

$$O_t = A \exp(\gamma t)\,(k_t K_{t-1})^{\alpha}\,(l_t L_t)^{1-\alpha} \tag{1}$$

where k_t and l_t are indices of the intensity of use of K_{t-1} and L_t and where O_t is actual current output. Of course, k_t and l_t are not directly observable and we seek to relate them to observed phenomena. For simplicity we assume $O_t = O^*_t$, i.e., output is in equilibrium. This involves no loss in generality if O^*_t is proportional to O_t.

The hypothesis is made that the intensities of factor use are revealed by firms' investment and employment decisions and that the intensity of use of each factor is proportional to the degree of disequilibrium in each, i.e.,

$$k_t = K^*_t/K_{t-1},\; l_t = L^*_t/L_t \tag{2}$$

Hence, if we further assume a simple partial adjustment of factor inputs (with adjustment parameters λ_1 and λ_2), we obtain

$$k_t = (K_t/K_{t-1})^{1/\lambda_1},\; l_t = (L_t/L_{t-1})^{(1-\lambda_2)/\lambda_2} \tag{3}$$

which defines factor intensities in terms of factor inputs.

However, one usually thinks of factor utilisation measured in terms of output, and we now consider some such definitions due to Hickman and Coen (1976).

DEFINITION 1:
Capital Constrained Capacity Output (O^1)

This is the output which could be produced if the existing stock of capital were operated with the optimal input of labour for existing techniques and factor prices. Algebraically, this can be obtained by substituting actual capital stock (K_{t-1}) for desired stock (K^*_t) in the long-run capital demand function and solving for output:

$$O_t^1 = A(1-\alpha/\alpha)^{1-\alpha} e^{\gamma t} (\frac{C}{W})_t^{*1-\alpha} (K_{t-1}) \tag{4}$$

It can be shown that O_t^1 is the abscissa of the point of the long-run average cost curve for a firm with capital stock K_{t-1}. Also, the corresponding capacity utilisation index is

$$(\frac{O}{O^1})_t = (\frac{K_t}{K_{t-1}})^{1/\lambda_2} \tag{5}$$

DEFINITION 2:

Labour Constrained Capacity Output (O^2)

This is the output which could be produced if the existing employed labour were also used with the optimal input of capital for existing techniques and factor prices. Here,

$$O_t^2 = A(1-\alpha/\alpha)^{\alpha} e^{\gamma t} \left[(\frac{C}{W})_t^*\right]^{-\alpha} L_t \tag{6}$$

and the corresponding capacity utilisation index is

$$(\frac{O}{O^2})_t = (\frac{L_t}{L_{t-1}})^{(1-\lambda_1)/\lambda_1} \tag{7}$$

Consider the objective of full employment. Clearly, from Definition 1, the production of capital-constrained capacity output (O^1) will ensure full employment only if the optimal input of labour corresponding to the *existing* stock of capital happens to be greater than, or equal to, the active labour force (if greater than, one would, of course, have reached a prior constraint due to labour shortage).

Hickman and Coen also distinguish two measures of output at full employment.

DEFINITION 3:

Potential Ouput (O^3)

This is the output which could be produced with existing technology if the full employment supply of labour were combined with the existing capital stock *irrespective of cost considerations*. If we insert a measure of the full employment labour force (L^f) into the short-run production function (1) and measure the effective labour and capital inputs at their normal utilisation rates (η_L and η_K), then

$$O_t^3 = Ae^{\gamma t} (\eta_K K_{t-1})^{\alpha} (\eta_L L_t^f)^{1-\alpha} \tag{8}$$

DEFINITION 4:
Full-Employment Output (O^4)

This is the output which would have to be demanded in order to induce entrepreneurs to hire the full-employment labour supply at existing factor prices. Full-employment output, O^4, is obtained by solving the short-run labour demand equation for output and substituting the full-employment labour force, L_t^f, for actual employment, i.e.,

$$O_t^4 = A(1-\alpha/\alpha)^{-\alpha} \left[\left(\frac{C}{W}\right)_t^*\right]^{-\alpha} \exp(\gamma t)(L_t^f)^{1/\lambda_1} (L_{t-1})^{-(1-\lambda_1)/\lambda_1} \qquad (9)$$

All four definitions have been estimated by Hickman and Coen for the period 1924 to 1972 for the US economy. The divergences between the various definitions allow interesting observations about the relative speed with which capital and labour are adjusted to desired levels and the fact that the simultaneous achievement of full employment of labour and *optimal* employment of capital has persistently eluded the economy (Hickman and Coen, 1976, pp. 241-250).

The above approach to defining capacity/potential output may be summarised as follows. Long-run factor demands are modelled as a function of long-run expected output and expected relative factor prices. A simple model of disequilibrium is postulated to relate long-run and actual data values and measures of capacity utilisation drop out of the model by assuming that the level of factor utilisation is proportional to the degree of disequilibrium. While this approach is useful for the process of defining different concepts of "utilisation" and "potential" output, its direct empirical implementation begs many questions. In practical applications one usually falls back on simpler empirical measures of capacity utilisation, a specific example of which is given in Chapter 4 in the context of industry sector analysis.

Appendix 3.3

THE MALLEABILITY OF CAPITAL

The conceptual and technical problems involved in using a vintage capital approach have been mentioned in Chapter 3, Section IV. The following simple analysis allows some of these difficulties to be highlighted, the main problems being connected with the determination of the oldest "vintage" of capital stock to be maintained in use.

Consider the following simple model:

$$Q(t,v) = a(t,v)\, K(v)$$
$$Q(t,v) = b(t,v)\, L(t,v)$$

where

$Q(t,v)$ = output in period t from vintage v
$K(v)$ = equipment of vintage v
$L(t,v)$ = employment in period t associated with equipment of vintage v
$a(t,v)$ = output/capital ratio in period t for equipment of vintage v
$b(t,v)$ = output/labour ratio

Assuming that the productivity of vintages improves over time (embodied technical change) and that the average productivity of workers and equipment increases over time (disembodied technical change),

$$a(t,v) = \bar{a}\,(1+g)^{v}\,(1+r)^{t}$$
$$b(t,v) = \bar{b}\,(1+h)^{v}\,(1+s)^{t}$$

where

g = rate of embodied capital-augmenting technical change
h = rate of embodied labour-augmenting technical change
$r(s)$ = rate of disembodied capital (labour) augmenting technical change
$\bar{a}(\bar{b})$ = base year output/capital (labour) ratio

Hence,

$$Q(t,v) = \bar{a}\,(1+r)^{t}\,(1+g)^{v}\,K(v)$$
$$Q(t,v) = \bar{b}\,(1+s)^{t}\,(1+h)^{v}\,L(t,v)$$

Total output and employment in year t is obtained by aggregation over all vintages being used in year t:

$$Q(t) = \bar{a}\,(1+r)^{t} \sum_{v=m}^{t} (1+g)^{v}\,K(v)$$

$$L(t) = \left[\frac{\bar{a}\,(1+r)^{t}}{\bar{b}\,(1+s)^{t}}\right] \sum_{v=m}^{t} \left[\frac{(1+g)^{v}}{(1+h)^{v}}\right] K(v)$$

where "m" denotes the oldest vintage being used in year t.

Three cases can be distinguished:

(i) if the aggregation is carried out over all vintages ($m = -\infty$), Q(t) will provide a measure of potential output as a function of the capital stock;

(ii) if actual output is constrained by total demand (a Keynesian regime), "m" will be determined endogenously and all equipment of older vintage than the "m" thus determined will be left idle; and

(iii) if output prices and wages are exogenous and firms are not subject to any output constraint, "m" will be determined by the condition that current revenues must cover variable unit costs of the least efficient equipment. Assuming labour is the only current input,

$$P(t)\ Q(t,v) = \bar{b}\ (1+h)^{v}\ (1+s)^{t}\ L(t,v)\ W(t)$$

where P(t) and W(t) denote output price and nominal wages.

Hence,

$$\frac{W(t)}{P(t)} = Q(t,v)/[\bar{b}\ (1+h)^{v}\ (1+s)^{t}\ L(t,v)]$$

which is a relationship between real wage costs and labour productivity in year t, which can be solved for v, the oldest vintage used.

It should be clear from the above that the detailed implementation of the vintage approach gives rise to major empirical problems. The data demands are extremely heavy and aggregation problems are likely to be difficult. The empirical applications rest on very restrictive assumptions.

From a heuristic point of view, some implications of making different malleability assumptions for the derived factor demands can be examined. Consider a production function with a CES capital-energy bundle of the form

$$Q = A[\gamma(\delta K^{-\rho} + (1-\delta)E^{-\rho})^{-1/\rho}]^{\alpha}\ L^{1-\alpha} \exp(rt)$$

Overall, the production function is Cobb-Douglas with constant returns to scale and neutral disembodied technical progress. Capital and energy are considered separable and combined within a CES production function, also with constant returns to scale.

The Putty-Putty Version: The usual cost-minimising assumption yields a set of three simultaneous factor demand equations for long-run employment (L*), capital (K*) and energy demand (E*):

$$L^* = G[(\frac{PKE}{PL})]^{\alpha} Q^* \exp(-rt)$$

$$K^* = D[(\frac{PKE}{PK})^*]^{\sigma} [(\frac{PL}{PKE})^*]^{1-\alpha} Q^* \exp(-rt)$$

$$E^* = F[(\frac{PKE}{PE})^*]^{\sigma} [(\frac{PL}{PKE})^*]^{1-\alpha} Q^* \exp(-rt)$$

where the PKE, PK, PL, PE are appropriate prices. The derivation of short-run demands requires the usual adjustment mechanisms.

The Putty-Clay Version: Since in this case capital expenditure entails an irreversible commitment, investment decisions are forward-looking and based on expected developments in aggregate demand and relative factor prices (Helliwell and Glorieux, 1970). The factor demands are now worked out in hierarchical stages. Suppose that long-run expected output, Q*, is taken as a distributed lag over past values, i.e.,

$$Q_t^* = \sum_{i=0}^{n} \beta_i Q_{t-i}$$

and that expected relative factor prices are similarly determined:

$$(\frac{PL}{PKE})^* = \sum_{j=0}^{m} \beta_j^1 (\frac{PL}{PKE})_{t-j}$$

From this we obtain demands for the three factor inputs:

(i) Demand for capital: assuming a planning horizon long enough for all vintages to be adjustable, the desired capital-energy bundle (KE*) is determined by cost minimisation, i.e.,

$$KE^* = B \exp(-rt) [(\frac{PL}{PKE})^*]^{1-\alpha} Q^*$$

If the amount of capital in the bundle is separately determined by cost minimisation, the desired capital stock (K*) is as follows:

$$K^* = B^1 [(\frac{PK}{PKE})^*]^{\sigma} KE^*$$

Hence,

$$K^* = C \exp(-rt) [(\frac{PL}{PKE})^*]^{1-\alpha} [(\frac{PK}{PKE})^*]^{-\sigma} Q^*$$

where $$C = \left(\frac{\delta}{1-\delta}\right)^{\sigma} \left(\frac{\alpha}{1-\alpha}\right)^{1-\alpha} A^{-1}$$

The final equation for desired capital stock then becomes:

$$\log K^*_t = C^1 + \sigma \log \left(\frac{PKE}{PK}\right)^*_t + (1-\alpha) \log \left(\frac{PL}{PKE}\right)^*_t + \log Q^*_t$$

where the usual partial-adjustment relation could be used to transform K* to actual K.

(ii) Demand for energy: Assuming no substitution possibilities between K and E *ex post*, the demand for energy will have two components: a long-term component proportional to the initial capital stock; and a short-term component which reflects capital-energy substitution possibilities as the capital stock is changed by new investment, I_g. Assuming that the first component is proportional to energy demand in period t-1, with weight $(1-I_g/K_{t-1})$, and the second component is determined via cost minimisation,

$$\log E_t = D + \left(1 - \frac{I_g}{K_{t-1}}\right) \log E_{t-1} - \sigma \left(\frac{I_g}{K_{t-1}}\right) \log \left(\frac{PE}{PK}\right)_t$$

(iii) Demand for labour: The equilibrium labour input (L*) is assumed to depend on the *existing* capital stock (combined with energy), and the current level of output. Inverting the production function yields

$$\log L^*_t = G + a \log Q_t - \alpha\, a \log KE_t - \text{r.a.t.} \quad \left(a = \frac{1}{1-\alpha}\right)$$

where the usual partial adjustment mechanism would be used to obtain actual employment, L_t.

Hence, with the putty-clay approach, the firm's factor demand decisions are made in hierarchical order. The long-run investment decisions take full account of factor-price movements. Relative factor prices also affect energy demand, but only at the margin since we have excluded the possibility of changing the energy-capital ratios on installed equipment. The demand for labour only enters decisions in the very short run and relative factor prices play no role in the employment function unless it is assumed that price movements influence the adjustment of actual to equilibrium employment.

Appendix 4.1

EXPORT-LED GROWTH

The core of the export-led growth model is that it is the growth of autonomous demand which governs the long-run rate of growth of output and, in the case of open economies, export demand is regarded as the main component of autonomous demand. The rate of growth of exports governs the long-run rate of growth of output to which home investment and consumption adjust. Consider a conventional export demand equation

$$\log X_t = a_0 + \eta \log (P_{dt}/E_t P_{ft}) + \epsilon \log Z_t \tag{1}$$

where X is the quantity of exports, P_d is the domestic price of exports, P_f is the foreign price of goods competitive with exports, Z is the level of world income, E is the exchange rate, η is the price elasticity of demand for exports ($\eta < 0$) and ϵ is the world income elasticity of demand for exports ($\epsilon > 0$).

Suppose that domestic prices (P_d) are derived as a simple mark-up on unit labour costs:

$$P_{dt} = (W/R)_t \, (\tau)_t \tag{2}$$

where W is the level of money wages, R is the average product of labour, and τ is the (1 + %) mark-up on unit labour costs.

The key relation, which can lead to a virtuous circle of export-led growth, is the Verdoorn "law" relating the growth of labour productivity (r) to the growth of output (y), i.e.,

$$r_t = r_{at} + \lambda y_t \tag{3}$$

where r_a is the rate of autonomous productivity growth and λ is the Verdoorn coefficient.

It is the Verdoorn relationship which closes the model and makes the process cumulative: the higher the rate of growth of output (y) the faster the rate of growth of productivity; the faster the rate of growth of productivity, the lower the rate of increase in prices; the lower the rate of increase in prices, the faster the growth of exports and hence output. Combining the above three relations (and using lower case letters to represent rates of change) yields an expression for the rate of growth of exports:

$$x_t = \eta \, (w_t - r_{at} - \lambda y_t + \tau_t - p_{ft} - e_t) + \epsilon \, (z_t) \tag{4}$$

The balance of payments equilibrium on current account (measured in units of home currency) may be written:

$$p_{dt} X_t = p_{ft} M_t E_t \tag{5}$$

where M is the quantity of imports. In rates of change, the equilibrium condition is:

$$p_{dt} + x_t = p_{ft} + m_t + e_t \tag{6}$$

Suppose the demand for imports is a function of relative prices and domestic income (Y_t), i.e.,

$$\log M_t = \delta \log \left(\frac{P_{ft} E_t}{P_{dt}}\right) + \pi \log Y_t \tag{7}$$

where δ is the price elasticity of demand for imports ($\delta < 0$) and π is the income elasticity of demand for imports ($\pi > 0$). In rate of change form this becomes:

$$m_t = \delta \, (p_{ft} + e_t - p_{dt}) + \pi y_t \tag{8}$$

Then one can solve (4), (6) and (8) for the export-led growth rate consistent with balance of payments equilibrium (y_{bpv}) i.e.,

Table A4.1: *Growth rates consistent with balance of payments equilibrium, Ireland, selected periods, 1949-1979*

Period	*1949-61*	*1961-68*	*1968-79*
Export Growth Rate	3.7%	6.5%	9.3
Imports Income elasticity[a]	1.6	1.6	1.6
y_{bp}	2.3%	4.1%	6.2
Actual growth rate	1.9%	4.1%	4.7

[a]From Section 5.2, Table 5.2.1

$$y_{bpv} = \frac{(1 + \eta + \delta)\,[w_t - r_{at} + \tau_t - p_{ft} - e_t] + \epsilon\,(z_t)}{\pi + \lambda\,(1 + \eta + \delta)} \tag{9}$$

It is interesting to compare this growth rate with the simple rate of growth of domestic income which is consistent with balance of payments equilibrium (y_{bp}) (i.e., in the absence of a virtuous circle). Using the Equations (1), (2), (5) and (7), this rate is:

$$y_{bp} = \frac{(1 + \eta + \delta)\,(p_{dt} - p_{ft} - e_t) + \epsilon\,(z_t)}{\pi} \tag{10}$$

Hence, export-led growth incorporating the idea of a virtuous circle will raise the equilibrium growth rate above what it would otherwise be only if the Marshall-Lerner condition holds, i.e., $|\eta + \delta| > 1$. In the case of (9) above, this implies that the two (negative) price elasticities η and δ must sum to greater than unity.

Finally, a simplified form of (10) can be derived by assuming that there are no long-run changes in relative prices measured in a common currency, i.e.,

$$p_{dt} - p_{ft} - e_t = 0 \tag{11}$$

Hence,

$$y_{bp} = \frac{x_t}{\pi} \tag{12}$$

which Thirlwall states as the following "fundamental law of growth": "except where y_{bp} exceeds the maximum feasible capacity growth rate, the rate of growth of a country will approximate to the ratio of its rate of growth of exports and its income elasticity of demand for imports" (Thirlwall, 1980a, p. 255). Applying this formula to the Irish case yields the results given in Table A4.1.[143] The correspondence between y_{bp} and actual growth in the first two periods is seen to be quite close, in line with other international data quoted by Thirlwall (1980a, pp. 255-259, Tables 10.1 and 10.2). Thirlwall's interpretation of these data has, however, been criticised on the grounds of ambiguous causality (McCombie, 1982).

143. The deviation of 1.5 percentage points between y_{bp} and the actual growth rate in 1968-79 can only be explained in a more general model than the simple balance of payments constrained export-led growth model used here.

Appendix 4.2

VERDOORN'S LAW

A relationship which has been widely used in examining the growth of the industrial sector, and its role in stimulating further growth, is the so-called Verdoorn-Kaldor Law (Verdoorn, 1949 and 1980; Kaldor, 1966). Wide applications have been made to the Irish industrial sector (Kennedy, 1971; Katsiaouni, 1979) and it plays a central role in international studies of export-led growth models (Dixon and Thirlwall, 1975; Cornwall, 1977). We examine in this appendix the production function underpinnings of this relationship.

In his original paper Verdoorn (1949), using data for the volume of industrial production and labour productivity for a range of countries and for different time periods, concluded that there exists a stable relationship in the long run, between the change in productivity and the change in output. He held that such a relationship was plausible on *a priori* grounds, due to the division of labour and rationalisation which usually comes with growth in production. Letting $\dot{q}$ and $\dot{Q}$ represent the rates of growth of labour productivity and output, Verdoorn's relationship is:

$$\dot{q} = b_0 + b_1 \dot{Q} \qquad (1)$$

where b_1 measures the Verdoorn elasticity and b_0 measures autonomous changes in productivity. Statistically significant results have been found by numerous researchers using cross-section and time-series data. In addition, since by definition,

$$\dot{Q} = \dot{q} + \dot{E}$$

a relationship between employment (E) and output follows as a direct consequence:

$$\dot{E} = -b_0 + (1 - b_1)\dot{Q}$$

Verdoorn's Theory

The Verdoorn elasticity, b_t, is defined as follows:

$$b_t = [\ (\dot{Q}/L) \,/\, (Q/L)\ ] \,/\, [\dot{Q}/Q] = 1 - \frac{\dot{L}/L}{\dot{Q}/Q} \qquad (2)$$

where b_t is the elasticity of labour productivity with respect to output, Q, and L is employed labour. It is conventional to regard the constancy of the Verdoorn elasticity as a statistical finding unsubstantiated by much theory. Although, of course, rationalised in many ways *ex post*, nevertheless it is interesting that Verdoorn's original derivation of the relation sprang from a very stylised theoretical Neo-classical framework. In his later work on the relationship (Verdoorn, 1980) the technology is assumed to be Cobb-Douglas with disembodied neutral technical progress:

$$Q_t = e^{\gamma t} L_t^{\alpha} K_t^{\beta}$$

Investment is assumed to equal savings, with a constant savings rate, s, i.e.,

$$\dot{K}_t = I_t = S_t = sQ_t$$

and labour demand and supply is represented by a single equation for effective employment, i.e.,

$$L_t = L_o \exp(\pi t)$$

where the growth rate, π, is assumed constant. Substituting into (2) yields

$$b_t = 1 - \frac{\pi(1-\beta)}{(\pi\alpha+\gamma)A_t}$$

$$\text{where } A_t = 1 + \beta\left[\frac{s(1-\beta) - k_o(\pi\alpha+\gamma)}{s(1-\beta)\left[\exp((\pi\alpha+\gamma)t) - 1\right] + k_o(\pi\alpha+\gamma)}\right]$$

and k_o is the initial capital-output ratio.

Since $\lim_{t \to \infty} A_t = 1$, then

$$\lim b_t = b_\infty = \frac{\pi(\alpha+\beta-1)+\gamma}{\pi\alpha+\gamma}$$

Hence, the constancy of b_t over time can be expected to hold only in the steady state. Verdoorn concludes that the b_ts derived from periods of disequilibrium growth yield unreliable values if used for extrapolation under conditions that differ appreciably from the period of observation. Such a view is borne out by the structural changes which occur in estimates of the Verdoorn relationship.

Using cross-section data for 43 of the CIP industries, Kennedy and Foley (1978) presented the following regression results:

$$\text{1953-63: } \dot{q}_m = \underset{(1.5)}{-0.72} + \underset{(7.2)}{0.57}\,\dot{Q}_m \qquad R^2 = 0.75 \qquad \text{(t-ratios in parenthesis)}$$

$$\text{1963-73: } \dot{q}_m = \underset{(2.6)}{-2.04} + \underset{(4.6)}{0.56}\,\dot{Q}_m \qquad R^2 = 0.58$$

Hence, there is a much stronger autonomous tendency for productivity to rise during the latter period compared with the former. A possible explanation in terms of the growth of capital inputs was advanced. A measure of the growth of combined labour and capital input was derived using weights related to the share of wages and gross-profits in value added. If f_m represents total factor productivity thus measured, one obtains the following modified regressions:

$$\text{1953-63: } \dot{f}_m = \underset{(0.6)}{-0.25} + \underset{(8.6)}{0.61}\,\dot{Q}_m \qquad R^2 = 0.80$$

$$\text{1963-73: } \dot{f}_m = \underset{(0.7)}{-0.40} + \underset{(8.2)}{0.67}\,\dot{Q}_m \qquad R^2 = 0.78$$

Hence, the acceleration of labour productivity growth relative to output growth was strongly influenced by the accelerated growth in capital intensity, a phenomenon which is not explained within the Verdoorn framework.

Despite, or because of, these difficulties which have given rise to much debate,[144] there is a number of reasons why the Verdoorn relationship continues to be of great interest, and particularly so in the context of medium-term analysis of Irish growth. These are,

(i) it has been widely studied and applied to Irish data (Kennedy, 1971; Kennedy and Foley, 1977; and Katsiaouni, 1979);
(ii) it has been, and continues to be, used in employment planning and projection in Ireland (Kennedy and Foley, 1977; Katsiaouni, 1979);
(iii) it plays a crucial role in the export-led growth literature (Beckerman, 1962; Kaldor, 1966; Dixon and Thirlwall, 1975; Kennedy and Dowling, 1975; Cornwall, 1977);
(iv) it has Neo-classical underpinnings[145] which are of interest to examine in the light of previous material on factor demands and the recent instabilities in estimates.

The third point was taken up in Chapter 4.I and Appendix 4.1 where the role

144. Rowthorn (1975a, 1975b, 1979); Kaldor (1975); Cornwall (1977); Verdoorn (1980); Thirlwall (1980b); McCombie (1980, 1981, 1982).

145. Verdoorn (1949, 1980); Katz (1968, 1969).

of the Verdoorn relationship in export-led growth models was highlighted. The last point is now briefly examined.

VERDOORN RELATIONSHIP AND FACTOR DEMAND SYSTEMS

Verdoorn used a stylised Neo-classical model to give a theoretical justification to his empirical relationship where the production technology was assumed to be Cobb-Douglas. An alternative and interesting perspective on this emerges from the theory of joint factor demand systems of Chapter 3, in which we derived long-run factor demand relations for a model where output and prices were assumed exogenous and where a cost minimisation objective was pursued. Still assuming a Cobb-Douglas production function with non-constant returns to scale,

$$Q_t^* = Ae^{\gamma t} K_t^{*\alpha} L_t^{*\beta} \tag{3}$$

we obtained factor demand equations[146] which can be rewritten in labour and capital productivity form as:

$$\log\left(\frac{Q}{L}\right)_t^* = c_0 + \left(\frac{\alpha}{\alpha+\beta}\right)\log\left(W^*/C^*\right)_t + \left(\frac{\alpha+\beta-1}{\alpha+\beta}\right)\log Q_t^* + \left(\frac{\gamma}{\alpha+\beta}\right)t \tag{4}$$

$$\log\left(\frac{Q}{K}\right)_t^* = d_0 - \left(\frac{\beta}{\alpha+\beta}\right)\log\left(W^*/C^*\right)_t + \left(\frac{\alpha+\beta-1}{\alpha+\beta}\right)\log Q_t^* + \left(\frac{\gamma}{\alpha+\beta}\right)t \tag{5}$$

Taking logarithmic derivatives yields:

$$\dot{p}_L^* = \left(\frac{\gamma}{\alpha+\beta}\right) + \left(\frac{\alpha}{\alpha+\beta}\right) R\dot{F}P_t^* + \left(\frac{\alpha+\beta-1}{\alpha+\beta}\right)\dot{Q}_t^* \tag{6}$$

$$\dot{p}_K^* = \left(\frac{\gamma}{\alpha+\beta}\right) - \left(\frac{\beta}{\alpha+\beta}\right) R\dot{F}P_t^* + \left(\frac{\alpha+\beta-1}{\alpha+\beta}\right)\dot{Q}_t^* \tag{7}$$

where p_L and p_K are the productivities of labour and capital, respectively, and RFP is the price of labour services relative to capital services. The assumption that the underlying production technology is of a Cobb-Douglas type is highly restrictive and, while it brings relative factor prices into the relationships for growth of factor productivity, it still assumes an elasticity of substitution of unity. To remove this restriction we must extend the underlying production function to a more general form.

146. Appendix 3.1 contains the necessary derivations.

In the case of a CES technology the labour and capital productivity relations analogous to (4) and (5) are:

$$\log\left(\frac{Q}{L}\right)^* = \text{constant} + \left(\frac{\mu-1}{\mu}\right)\log Q^* + \lambda_L t \tag{8}$$
$$- \left(\frac{\sigma}{1-\sigma}\right)\log\left[\left(\frac{\delta}{1-\delta}\right)^{-\sigma} \text{RFP}^{*-(1-\sigma)} \exp\left[(1-6)\,(\lambda_L-\lambda_K)t\right] + 1\right]$$

$$\log\left(\frac{Q}{K}\right)^* = \text{constant} + \left(\frac{\mu-1}{\mu}\right)\log Q^* + \lambda_k t \tag{9}$$
$$- \left(\frac{\sigma}{1-\sigma}\right)\log\left[\left(\frac{\delta}{1-\delta}\right)^{\sigma} \text{RFP}^{*(1-\sigma)} \exp\left[(\sigma-1)(\lambda_L-\lambda_K)t\right] + 1\right]$$

where the derivations have been given in Appendix 3.1. Clearly, the simple Verdoorn relationship follows from Equation (8) only in the case of fixed relative factor prices (RFP*) and unbiased technical change ($\lambda_L - \lambda_K = 0$). However, the "correct" Verdoorn relationship is highly non-linear in relative factor prices.

The above structural Verdoorn-type productivity relationships were based on a model where output (Q*) is exogenous and cost minimisation is the firm's criterion. In the case of profit maximisation a slightly different form can be derived as follows. Equating the marginal product of labour $\left(\frac{\delta Q}{\delta L}\right)$ to the real wage (W/P) (i.e., the first order condition for profit maximisation) yields an expression of the form:

$$\log\left(\frac{Q}{L}\right) = \text{constant} + \sigma\log\left(\frac{W}{P}\right) + (1-\sigma)\left(\frac{\mu-1}{\mu}\right)\log Q + \lambda_L t \tag{10}$$

with an equivalent expression for capital productivity. Hence, the "true" Verdoorn coefficient,

$$b = (1-\sigma)\left(\frac{\mu-1}{\mu}\right) \tag{11}$$

is composed of the elasticity of substitution, σ, and the returns to scale parameters, μ. If $\sigma = 0$ (i.e., a Leontief technology), b is determined by the returns to scale parameter alone. If we had data on real wage rates and real output per worker, we could obtain estimates of the elasticity of factor substitution, the "true" Verdoorn coefficient, and the rate of labour-embodied technical progress. Katz (1968) proceeds to apply this model to data from Argentinian industry and concludes that one has strong grounds for believing that the way in which Verdoorn's coefficient has been generally estimated (by a log regression of changes in output *per capita* on changes in output) introduces a systematic bias in the results, the bias being due to the omission of various other explanatory variables. He also concludes that, for reasonable production function parameters, the value of the Verdoorn coefficient obtained from the "incomplete" regression will be biased upwards.

It is interesting to examine the meaning of the true Verdoorn coefficient when considered in a cross-section context. The coefficient is a function of two production function parameters: the elasticity of substitution between capital and labour, σ, and the returns to scale parameter, μ, i.e.,

$$b = (1-\sigma)\left(\frac{\mu-1}{\mu}\right)$$

For illustrative purposes, assume $\mu > 0$ and $0 < \sigma < 1$. Hence, for any given μ, b is a linearly decreasing function of σ. This is due to the fact that the $\left(\frac{W}{P}\right)$ term in (10) brings into the model the incidence of a marginally higher capital-labour price ratio as an explanatory variable of part of the observed increases in the average productivity of labour. The strength of this component depends on the size of σ, the elasticity of substitution. Only in the extreme case where $\sigma = 0$ will the total change in output *per capita* be thought to derive from the observed change in output. If, however, $\sigma > 0$, then the observed changes in labour productivity will derive partially from the marginal adjustments in the capital-labour ratio, proportionally reducing the importance of the expansion of output as an explanation. The importance for growth policy is clear, since the marginal adjustment of the K/L ratio (in response to factor prices) clearly constitutes an alternative avenue for productivity growth, *even when output is stagnant*. In addition, if σ varies between industries, then a ranking of industries by the size of the Verdoorn coefficient need not necessarily coincide with a ranking by returns to scale.

To conclude, the above analysis may shed some light on the results of Kennedy and Foley (1978). In a period of stable relative factor prices, Equation (6) is effectively reduced to the simple Verdoorn relationship, (1), and the constant b_0, in (1) subsumes the technical progress $(\gamma/\alpha+\beta)$ and relative factor price $\left(\frac{\alpha}{\alpha+\beta}\right)$ terms. If, in addition to constant relative factor prices, technology was of a constant returns to scale nature, then the growth of labour productivity is tautologically identified with the disembodied technical progress term (γ). If, on the other hand, large shifts in relative factor prices were to occur, say against labour (i.e., RFP in Equation (6) were to rise), then capital for labour substitution would occur with the result that labour productivity would rise and capital productivity fall.[147] In such a

147. Technical progress was assumed to be disembodied. Alternative assumptions could be made and could alter this statement.

situation, estimation of the simple Verdoorn relationship (1) will lead to biased coefficients due to omitted variables. In the context of structural macro-analysis a summary relationship such as that of Verdoorn's emerges naturally from the interaction of the entire system.

Appendix 4.3

SURVEY OF AGRICULTURAL SECTOR MODELLING

Agriculture sector modelling studies can be conveniently grouped into the following five broad categories:

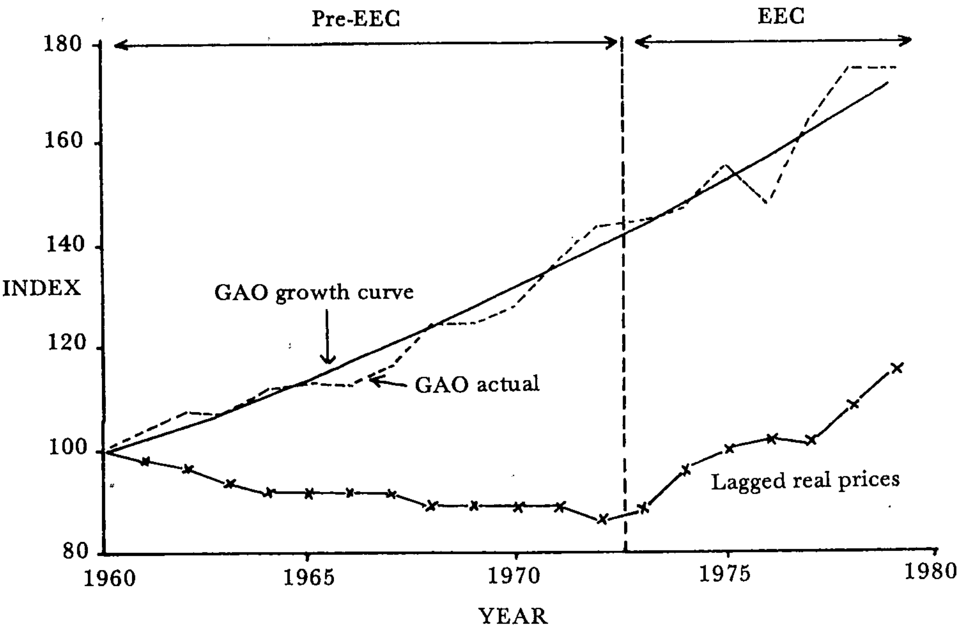
(i) Descriptive studies
(ii) Microeconomic studies of single commodities or groups of commodities
(iii) Macroeconomic studies at a sectoral level
(iv) Macroeconomic studies within the context of an economy-wide macro model
(v) Planning models.

Many useful descriptive studies have been published. The work of O'Connor and Kelly (1978) surveys developments in the agricultural sector over the period 1953 to 1976. Three periods are isolated: 1953 to 1960, a period of slow growth; 1960 to 1970, a period dominated by the first two Programmes for Economic Expansion and the AIFTAA in 1966; and 1970 to 1976, a period of rapid growth covering the entry of Ireland into the EEC, with all its consequential adjustments. Attwood (1978) examined the period 1970 to 1977, in particular the three factors determining Irish agricultural prices, i.e., general EEC price increases, harmonisation of Irish prices over a transition period and changes in the Green £.

Sheehy (1980) examined the impact of EEC membership on Irish agriculture. In particular, he concluded that the upheaval in agricultural prices and incomes which occurred in the period 1970 to 1979 appears to have caused no acceleration in overall growth. A graph, reproduced below, is adduced as evidence for this conclusion.

Finally, Attwood (1982) surveys current trends and problems and comments on the growing specialisation, decline in efficiency, indebtedness and substitution of purchased for farm-produced inputs, which has left agriculture more vulnerable to developments in the domestic and external economies.

Figure A4.1: *Growth of Agricultural Output and Prices, 1960-1979*



While a good overall view of developments in agriculture can be obtained from descriptive studies, a detailed examination of the production of individual commodities is required to balance the impressions obtained. Among the many such studies for Ireland are the model of cattle population and disposals of Casey (1979/71a); the study of crop production (wheat, feeding, barley, oats, potatoes, malting barley, sugar beet) also by Casey (1970/71b); supply response in the Irish creamery herd, by Buttimer and MacAirt (1971) and Cuddy (1982); the demand for fertiliser, by Boylan, Cuddy and Ó Muircheartaigh (1980a) and Boyle and Sherington (1980); and the micro-economics of demographic adjustments in the agricultural labour force, by Walsh (1971). A more integrated model of the Irish cattle sector has been constructed by Walsh (1982), where the production and marketing stages are studied and the regional dimension of the cattle industry is examined. A previous study by Baker, O'Connor and Dunne (1973) fitted supply equations for cattle numbers and examined the lags in responses to price changes. A comprehensive survey of commodity elasticity estimates is presented in Matthews (1977). His finding of generally high cross-elasticities implied that, although farmers were quite responsive to price changes *between* commodities, the aggregate supply elasticity may be quite small (1977, pp. 31-32).

By macroeconomic studies at a sectoral level we mean studies which examine the determinants of aggregate agricultural output or product. Matthews (1977) estimates an aggregate supply equation using the basic model of Tweeten and Quance (1969), i.e., aggregate output is made a function of lagged relative output-input prices, the stock of productive farm assets, and a productivity index. A simpler model due to Griliches (1960) was also examined, i.e.,

$$QAG_t = a_0 + a_1 \left(\frac{PQAG}{PINP}\right)_t + a_2\, QAG_{t-1}$$

where QAG is aggregate output, PQAG is the price received for output and PINP is the price of inputs. The usual partial-adjustment argument is used to justify the lagged dependent variable, and Matthews further adds a weather index and a time trend to represent technological change. A short-run elasticity of 0.17 (0.45 in the long run) was found, results which are broadly in line with other international estimates.

O'Rourke (1978) estimates an aggregate Cobb-Douglas production function for agriculture. His agricultural output measure is gross output excluding the value of change in livestock numbers. Nine inputs were distinguished (fertilisers, feed, labour, machinery, land, cattle, repairs, land taxes and a miscellaneous category). Annual factor shares were calculated and, using a simple linear adjustment equation of the form

$$\hat{b}_{it} - \hat{b}_{it-1} = \lambda_i (b_i - \hat{b}_{it-1})$$

where b_i is the constant (but unobserved) equilibrium factor share and b_{it} is the factor share actually observed at time t, the Cobb-Douglas production function was estimated. Various criticisms of O'Rourke's approach can be made. For example, the Cobb-Douglas technology may be very restrictive given the multi-factor approach used (refer Boyle, 1981 and Chapter 3 above). The method of valuing land is suspect (i.e., income accruing to landowners). Using the method of factor shares for parameter estimation is a very strong assumption. The factor share device is not a test of aggregate production functions or marginal productivity. It merely shows how one goes about interpreting given time series if one starts by *assuming* that they were generated by a production function and that the competitive marginal product relations apply (Solow, 1973).

Boyle (1981) examines the degree of resource substitution existing in agriculture and the nature of technical change in the period 1953-1977. He used the more general translog production function and assumes constant returns to scale. The actual estimation uses the dual cost function, imposing adding up, linear homogeneity and symmetry constraints. He disaggregates factor inputs into five elements; machinery and equipment, labour, feed-stuffs, fertilisers, and seeds. As with O'Rourke (1978), Boyle assigns the wage rate for hired labour to the entire agricultural labour force. Among his conclusions are that the specification of technologies within agriculture was found to differ significantly over two subperiods, 1953-1970 and 1953-1977. Over the longer period, 1953-1977, production did not conform to a well-behaved technology as one's own elasticity of substitution (machinery) was positive. He attributes this, in part, to the static specification of the model used. For the subperiod 1953-1970, it was found that labour and machinery, and labour and materials, were highly substitutable. With respect to technical change, it was found to be labour saving and machinery and materials using over the period 1953 to 1977.

The above macro studies concern only the agricultural sector. Since the agricultural sector in Ireland is so large and plays such an important role in trade, it is interesting to consider macroeconomic studies of agriculture which have been carried out in the context of a complete integrated macroeconometric model. The first such attempt was due to Walsh (1966). Walsh recognised that an aggregate agricultural production function could not be interpreted too clearly in terms of the technological requirements of various efficient levels of output, but rather attempts to show simple historical relationships between outputs and inputs. Imposing constant returns to scale on the Cobb-Douglas production function

$$QAG = A \exp (\gamma t) LA^{1-\alpha} R^{\alpha}$$

(where QAG is output, LA is employment, and R measures farm inputs), one obtains

$$\log \left(\frac{QAG}{LA}\right) = \log A + \gamma t + \alpha \log \left(\frac{R}{EAG}\right)$$

An agricultural production decision function was then specified, where it was assumed that output will remain fairly constant from year to year unless changes occur in the current level of stocks on farms. The equation estimated was of form

$$QAG = f_1 \left(XAG_t, \frac{SAG}{QAG}\right)$$

where XAG is the volume of agricultural exports and SAG is the volume of stock changes. This equation was used to determine output while the former one above was used to determine labour input, LA.

Farm inputs, (R), were determined by a simple partial adjustment to desired output, i.e.,

$$R_t = f_2 (QAG_{t-1}, \ R_{t-1})$$

Agricultural exports were determined as a function of GNP in the United Kingdom, i.e.,

$$XAG_t = f_3 (GNPVK_t)$$

Finally, the agricultural price level was determined as a function of excess demand, i.e.,

$$PAG_t = f\,(QAG^D - QAG^S)_{t-1}$$

where this excess was proxied by

$$\frac{\Delta SAG}{QAG}$$

i.e., the stock change/output ratio. Walsh was unable to solve his complete model, due to numerical problems. Hence, a complete investigation of the interrelationship between the agricultural and non-agricultural sectors was not carried out. Fanning (1979) attempted to estimate a competitive profit maximisation model of Irish agriculture. However, the results indicated implausible estimates for factor elasticities and returns to scale parameters. Hence, only agricultural output and agricultural exports were endogenised. Agricultural output (QAG) is a function of a weather index and profitability (measured by relative output-input prices).

No macromodel of the Irish economy has been constructed for the specific task of examining the relationship of the agricultural and non-agricultural sectors. An increasing international recognition of the importance of such studies has arisen due to

- (i) the increasing sophistication of the agents in agriculture;
- (ii) the increasing role of governments and international organisations in regulating agriculture;
- (iii) the increasing "industrialisation" of agriculture.

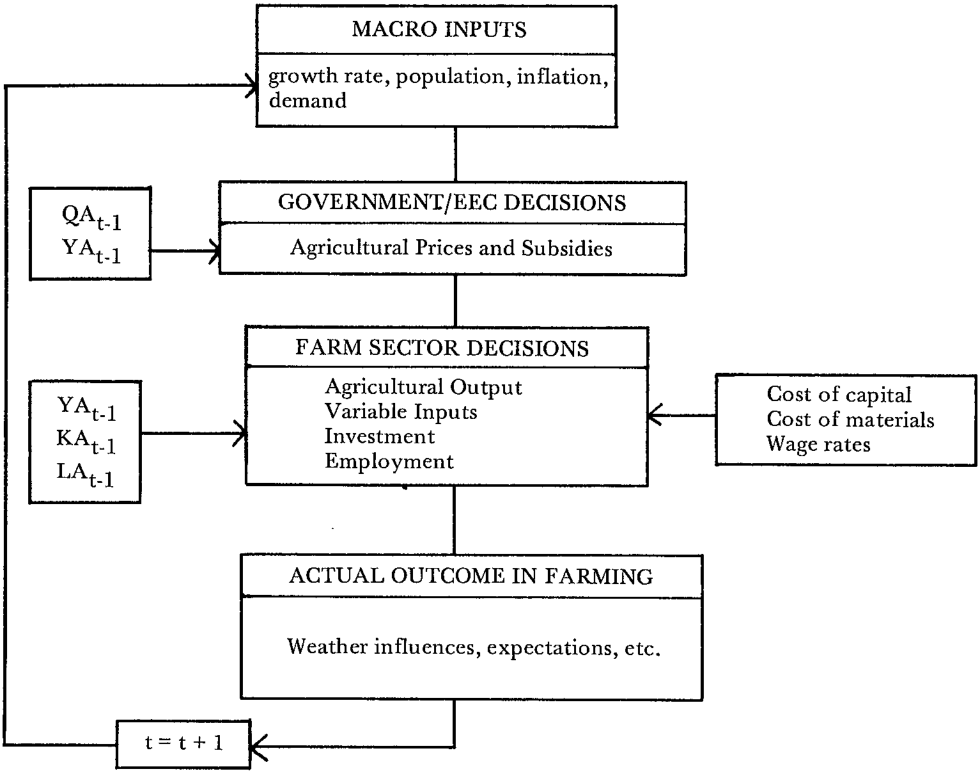
Two such recent papers are singled out as having particularly influenced our approach to agricultural sector modelling. McFall Lamm (1980) constructs such a stylised agricultural-non-agricultural model of the US, consisting of an aggregate linear production function, a labour supply equation, an investment supply equation, and closing identities. A model exploring the relationship between the government sector and the agricultural sector has been constructed by Heidhues (1976). Specifically, Heidhues investigates the effects of short-term (one-year) government decision making on agricultural prices and subsidies, within the overall framework of the CAP, where government decisions are made in a largely unknown environment and in reaction to limited information about the agricultural sector. The government collects and processes general economic information and estimates demand for agricultural products. It then decides on target levels for agricultural production, income, and the acceptable level of outmigration from agriculture. It fixes prices and subsidies and the reaction of the agricultural sector is characterised by an econometric model of farm production and factor use. Heidhues' model is based on concepts of short-run competitive market equilibrium, but takes into account the limited mobility of fixed resources and labour. The process is illustrated in Figure A4.2 in a schematic diagram. The first stage (Macro Inputs) represents an input from the entire macroeconomy and includes an estimate of the demand for agricultural output. The second stage (Policy Decisions) represents the setting of targets and the selection of values of instruments[148] (i.e., prices and subsidies). The third stage (Farming Decisions) represents the production decisions made by the agriculture sector, in response to government decisions (stage two), exogenous information and previous agricultural results. This third stage is represented by an econometric model of the agricultural sector. The final stage (Actual Farming Outcome) represents the combination of the production decisions with the other exogenously caused production fluctuations, such as weather, where *ex-ante* decisions result in *ex-post* output, income, etc. The entire sequence then repeats in the next planning period.

Heidhues' model consists in a production function (Cobb-Douglas) and four factor input functions for labour, capital, land and variable inputs. Given the structure of farm decision making, a recursive system of estimation is used, where labour and capital adjustments are governed by a high degree of caution and characterised by long time lags with respect to changes in the agricultural environment.

Finally, two studies of Irish agriculture can be classified as planning models. The first, by O'Connor and Breslin (1968) constructs an input-output table for 1964 consisting of eleven purely farming sectors and four

148. Within the CAP, the freedom of any national government may be circumscribed in price setting.

Figure A4.2: *Agricultural Sector Planning Framework*



Legend:
QA = Agricultural Output
KA = Agricultural Capital Stock
LA = Agricultural Employment
YA = Agricultural Income

Source: Heidhues (1976).

agricultural industry sectors. The purpose of the study was to quantify the interrelationships between the various components of agriculture and certain industries which are directly or indirectly dependent on farming. The second paper, by O'Connor, Ross and Behan (1977) constructs a linear programming model of Irish agriculture, at a detailed level of commodity disaggregation. A model is constructed for determining the combination of farming activities which will maximise income arising in agriculture in any year subject to the estimated technology and constraints. The model was calibrated to reproduce the 1968 actual outturn, and gave good results for a later year, 1972.

Appendix 5.1

IMPORT DATA AND CATEGORIES

Three separate types of data are required in any study of imports. First, data on the value of imports are obviously required, and these are available by a wide range of categories. Two main categories can be distinguished:

(i) Data by economic category, e.g.,

Consumption goods;
Producers' capital goods
Materials for further production.

(ii) Data by SITC category, the main groupings of which are shown below:

SITC Sections	*Description*
0	Food and live animals chiefly for food
1	Beverages and tobacco
2	Crude materials, inedible, except fuels
3	Mineral fuels, lubricants and related materials
4	Animal and vegetable oils, fats and waxes
5	Chemicals and related products
6	Manufactured goods classified chiefly by materials
7	Machinery and transport equipment
8	Miscellaneous manufactured articles
9	Commodities and transactions not classified elsewhere

Second, data on price deflators are required in order to derive imports in constant prices. Since imports are valued in trade statistics c.i.f. (i.e., at the quay side, exclusive of any customs and excise duty), the appropriate deflators must exclude such duties. Such deflators are available as import unit value indices only for the four-way SITC classification shown below:

SITC Sections	*Description of Unit Value Index*
0 + 1	Food, drink and tobacco
2 + 4	Raw materials
3	Fuels
5 + 9	Manufactured goods

Import unit values for, say, the three-way "economic" classification are not available.

Third, data on relative prices for domestic production and imported goods are required where now the import price index used should include any customs and excise duties charged. Wholesale price indices were published for the three-way "economic" classification up to 1978 but suffered from the limitation that the basic weights used in constructing these indices referred to 1950. In addition, they contained certain discontinuities due to the replacement of turnover and wholesale taxes by value-added tax. Since 1978, only wholesale price indices for elements of total domestic production are available.

To summarise, if one chooses the four-way SITC breakdown, one has appropriate deflators but no appropriate relative prices. On the other hand, if one chooses the "economic" three-way breakdown, one has no suitable deflators but suitable (if somewhat suspect) relative prices. A comprehensive disaggregated study using the SITC breakdown was carried out by FitzGerald (1979), and forms the basis of the import demand equations in the Department of Finance/Central Bank macromodel (FitzGerald and Keegan, 1982). An earlier study by McAleese (1970) used the "economic" three-way breakdown, where the missing deflators were "manufactured" using wholesale prices and available unit value indices.

Appendix 5.2

LABOUR FORCE PARTICIPATION

A supply of labour function has two elements to it: the labour force participation decision and the supply of hours decision. Although these decisions are not necessarily independent, empirical studies of overall labour supply have generally concentrated on either the population activity rate or the hours decision.[149] The most extensive theoretical development has been on the supply of hours decision. A major influence on this work has the theory of the general allocation of time over the life cycle proposed by Becker (1965). The hours decision is, therefore, modelled within quite a tight choice – theoretic framework of individual and household decision-making. In contrast, the empirical studies of labour force participation, which usually are concerned with the net flows rather than the gross flows into and out of the labour force, are based on a looser and more eclectic theoretical framework.[150] The theoretical basis for examining the aggregate supply of labour, in the sense of number of persons participating in the labour force, is that of a basic supply function such as

$$LF^d = LF^d(Z_1) = \alpha_0 \left(\frac{W}{P}\right)^{\alpha_1} (Z_1)^{\alpha_2} \tag{1}$$

where LF^d is the labour force, with particular demographic (age, sex) characteristics, $(\frac{W}{P})$ the real price for supplying labour (in terms of, for example, the anticipated annual earnings for a standard person-year) and is the slope variable in price-quantity space, and Z_1 is the set of other factors influencing LF^d. Included in the latter, which are the shift variables in price-quantity space, is of course the appropriate demographic pool from which the segment of the labour force is drawn. In the case of total labour force, LF, this is the total population of working age not in full education, N1564A. The decision of persons to participate in the labour force is generally estimated as a labour force participation rate equation, (LF/N1564A) for the aggregate activity rate. This rate is then interpreted as the probability that a person with certain demographic characteristics will be active in the labour force, i.e.,

149. Integrated approaches have been proposed by Boskin (1973) and Heckman (1974). Boskin set out a two-stage procedure which determined the probability of a potential worker being in the labour force and, given that participation decision, the expected hours of work. Heckman, in modelling the expected hours of work of married women, estimated two functions – for the offered/market wage and the asking wage – and used these jointly to determine the probability of a woman working and the hours of work.

150. A survey of the early US studies of this type is provided by Mincer (1966) and the behavioural rationale of the variables included in the cross-section and time-series studies is stated.

either in employment or seeking employment/unemployed, or conversely not in the labour force. The demographic characteristics separately identified may include, for example, age, sex, location, some primary or secondary labour force classification, occupation and industry.

The remaining general variables in Z_1 are then suggested by economic theory of individual choice and, in recent developments, by extension to allow for such decisions being made in the context of family or household involving interdependent decision making and, in that context also, non-market activity encompassing a wide range of activities, some of which are time saving and others of which are time intensive.

A major aspect of these studies has been to examine the effects on participation and hours worked, of changes in incomes from labour and non-labour sources; in other words, to identify income and substitution effects. These are particularly important in attempting to distinguish fluctuations in labour supply due to secular and cyclical factors. Analysis of the influence of demand conditions and variations in employment earnings opportunities has focused on two competing hypotheses each reflecting one or other of the effects:

(i) Added worker hypothesis (income effect dominant) – additional household members, especially secondary workers (wives, older children), seek employment to compensate for a transitory decline in family or primary-worker income due to unemployment or reduced hours.

(ii) Discouraged worker hypothesis (substitution effect dominant) – workers leave or do not enter the labour force because unemployment is such that potential wages or probability of employment is reduced.

The discouraged worker effect can be viewed as part of an optimisation process particularly by secondary workers who have more flexibility than primary workers in timing their labour force entry and exit decisions. But it also points to the possibility that there may be hidden unemployment – workers who would be in the labour force seeking employment if they did not feel that the prospects from job search were so low as to be pointless. There has been considerable discussion about the empirical analysis of the net result of these two effects and also the interpretation of conflicting evidence from cross-section and time series studies.[151]

151. Mincer (1966) and Bowen and Finegan (1969, pp. 505-515) discuss these issues. The later developments, for example Cain and Watts (1973), in this area have generally been in the context of studying the effects of taxation, income maintenance and negative taxation schemes.

In this paper we do not study the supply of hours decision, but deal only with the number of persons employed in the labour force. Furthermore, the available data limit us to examining the effect and the determinants of net changes in labour force participation, and the gross flows, which may be substantial are not considered. Our treatment of labour supply is, therefore, concerned only with the net number of persons recorded as active in the labour force and the approach we follow is that associated with the empirical studies of the labour force participation rate, LFPR. The basic approach can be illustrated by reference to the study of the aggregate US labour force by Coen (1973).

Aggregate labour supply depends on the willingness of individuals to enter the labour force and the number of hours work per year they desire. Under full employment conditions, these decisions are essentially a choice between income and leisure, given the level of the real wage. However, during business fluctuations, both the labour supply and hours worked may be influenced by conditions in the labour market in the sense that, for example, participation tends to decline as unemployment rises (the discouraged worker hypothesis) and average hours may diverge from desired hours due to fluctuations in demand. The following relationship is then assumed to determine the full employment level of labour force participation:

$$\log\left(\frac{LF^f}{N1564A}\right) = \alpha_0 + \alpha_1 \log\left(\frac{W}{PC}\right) + \alpha_2 t \tag{2}$$

where LF^f is the potential labour force at "full employment". Hence, the participation rate is a function of the real wage (perhaps net of taxes) and a time trend which acts as a proxy for long-run demographic and social changes. The difference between the actual (LFPR) and full employment ($LFPR^f$) participation rates depends on conditions in the job market as they affect the perceived probability of obtaining work. The unemployment rate (UR) and deviations of the average hours worked per employee (LFH/L) from its full employment level (LFH^f/L^f) serve as job market indicators, so that

$$\log\left(\frac{LF}{N1564A} / \frac{LF^f}{N1564A}\right) = \alpha_3 \log(UR) + \alpha_4 \log\left(\frac{LFH}{L} / \frac{LFH^f}{L^f}\right) \tag{3}$$

where α_3 and α_4 measure the strength of the discouraged worker and added worker hypotheses. If full employment working hours per worker are determined by the real wage, then

$$\log(LFH^f/L^f) = \beta_0 + \beta_1 \left(\frac{W}{PC}\right) + \beta_2 t \tag{4}$$

By substituting for the full employment labour force using Equation (2) and full employment hours per worker from Equation (4), the estimating equation is

$$\log\left(\frac{LF}{N1564A}\right) = \gamma_0 + \gamma_1 \log(UR) + \gamma_2 \log\left(\frac{W}{PC}\right) + \gamma_3 \log\left(\frac{LFH}{L}\right) + \gamma_4 t \quad (5)$$

Coen found the expected negative sign on the unemployment rate and a negative sign on hours worked. Either the time trend or real wages included separately yielded negative signs, but included together they resulted in severe multicollinearity. Coen's interpretation is as follows. In the earlier stages of a downturn in economic activity it is common for employers to reduce average hours of work before beginning to make sharp reductions in the number of employees. The participation rate equation indicates that workers respond to the decline in income resulting from shorter hours by having other family members enter the labour force, an added worker effect. However, if the downturn becomes severe, and leads to high unemployment, some job seekers view this as a poor indication of their employment and earnings prospects and withdraw from the workforce, becoming discouraged workers. Furthermore, the negative trend is simply picking up the trend in average hours and, since the long-term movement of average hours and the real wage are closely (negatively) related, the (positive) influence of the real wage on full employment labour supply is limited largely to its effect on average hours per employee.

This is the basic format for estimating labour force participation functions and, by building on a relationship of this type, the comprehensiveness of the model can be extended, for instance by allowing for a money illusion effect.[152] The question at issue then is whether labour force participants respond to the money wage or the real wage in the short run. Fair (1971), in his study using US quarterly data for the primary and secondary labour forces, obtained mixed results. The real wage effect for the most important group of secondary workers was positive, while for primary workers it was small but negative. Also the rapid increase in the labour force participation of women in the age group 20-34, in the last half of the 1960s, could be explained by rising real wage rate and a falling unemployment rate. No long-run money or price illusion was found, and any short-run effects were not very pronounced.

152. Studies along these lines have been done by Fair (1971) and Wachter (1972).

Appendix 5.3

NET MIGRATION ABROAD

As discussed in Chapter 5.III, migration is regarded as due primarily to the relative differential in expected returns from migration with allowance made for the variability of return.[153] The expected lifetime net advantage from migration is taken to be due to income differentials and job opportunity differentials as a measure of the variability of returns. In this context, if inter-regional income differentials are constant, job opportunity differentials are of primary importance in the timing of migration decisions and the direction of migration is determined by net expected returns to migration. Thus wage differentials are a necessary but not a sufficient condition for migration (Langley, 1974, p. 260). A distance variable to take some element of the costs of migration into account, and a migrant stock variable to include information, income assistance, and other influences from relatives and friends are also included (Langley, 1974, pp. 263-267). The four behavioural elements of the migration model are, therefore, expected return, job opportunity as a measure of earnings variability, distance, and a relatives/friends factor. It is also necessary to control for scale effect, the relative sizes of the population pools exposed to migration, by including an appropriate population variable. The relevant population base is identified by the matching with the migration groups whose behaviour should be homogeneous with respect to the determining variables (Langley, 1974, p. 261). The gross migration model can then be stated as follows[154] with gross out-migration as the dependent variable,

$$M^d_{ijt} = M^d_{ijt}\,(Y^*_{it}, Y^*_{jt}; U^*_{it}, U^*_{jt}; C_{ijt}; MS_{j/i,t}; NM_{i,t-1}) \tag{1}$$

where t is the time subscript, and * denotes expected values for variables superscripted,

153. The specification of this type of migration model is set out, for instance, in Langley (1974) and Walsh (1974).

154. This is the general form, with a typical selection of variables, and the scale variable is included on the right hand side. Langley, Walsh, and many others sometimes define the dependent variable as an out-migration rate, i.e., the number of gross migrants from i to j as a ratio of the potential migrant population at j in t−1. This, as we shall see, is the source of some difficulties when it comes to net migration.

M^d_{ij} is gross out migration from region i to region j by homogeneous demographic (age, sex), group d;
Y_i, Y_j are expected earnings from employment in regions i and j, respectively;
U_i, U_j are measures of uncertainty about earnings such as the probability of employment, e.g., expectations (in weeks) of remaining unemployed, in regions i and j, respectively;
C_{ij} is a measure of distance/cost of migration from i to j;
$MS_{j/i}$ is migrant stock from i living in j, corrected for distance; and
NM_i is the potential population in region i exposed to out migration to region j.

Following Langley (1974, p. 268), the expected signs on the partial derivatives with respect to the behavioural variables, for male working age migrants, are

(1) $\partial M_{ij}/\partial Y_i \gtrless 0$ (4) $\partial M_{ij}/\partial U_j < 0$
(2) $\partial M_{ij}/\partial Y_j > 0$ (5) $\partial M_{ij}/\partial C_{ij} < 0$
(3) $\partial M_{ij}/\partial U_i \gtrless 0$ (6) $\partial M_{ij}/\partial MS_{(j/i)t} > 0$

Emigration from and immigration into a national labour market are, as stated already, subsets of these gross flows, and can be derived by summation over the appropriate regions such that for gross emigration ($M_{DF,t}$),

$$M_{DF,t} = \sum_{i=1}^{m} \sum_{j=m+1}^{n} M^d_{ijt} \tag{2a}$$

and for gross immigration ($M_{FD,t}$),

$$M_{FD,t} = \sum_{i=m+1}^{n} \sum_{j=1}^{m} M^d_{ijt} \tag{2b}$$

where i, j = 1 . . . m are regions internal to the national labour market boundary, denoted by the index set D for domestic; and i, j = m+1 . . . n are regions external to the national labour market boundary, denoted by index set F for foreign. This brings out the essentially cross-section, or spatial reallocation of persons and the nature of emigration and immigration within the gross migration flows, which is illustrated in Figure 1. The origins (i) and (j) are grouped according to internal (D) and external (F) to the national labour market, i.e., i, j = 1,2,3,4,5 are domestic and i, j = 6,7,8,9 are foreign. Summation of the gross flows in the North-East quadrant – migration from

Fig. A5.1. *Gross migration flows and classification into emigration and immigration*

From (i) \ To (j)		D 1	D 2	D 3	D 4	D 5	F 6	F 7	F 8	F 9
D	1						x	x	x	x
D	2						x	x	x	x
D	3						x	x	x	x
D	4						x	x	x	x
D	5						x	x	x	x
F	6	x	x	x	x	x				
F	7	x	x	x	x	x				
F	8	x	x	x	x	x				
F	9	x	x	x	x	x				

domestic regions to foreign regions – is gross emigration; summation of the gross flows in the south-west quadrant – migration from foreign regions to domestic regions – is gross immigration. Therefore, from Equation (1) and definitions (2a) and (2b), we can stage gross emigration and gross immigration functions, respectively, as

$$M_{DF,t} = M_{DF}\,(Y^*_{D,t}, Y^*_{F,t}; U^*_{D,t}, U^*_{F,t}; C_{DF,t}; MS_{D/F,t}; NM_{D,t-1}) \qquad (3a)$$

and

$$M_{FD,t} = M_{FD}\,(Y^*_{D,t}, Y^*_{F,t}; U^*_{D,t}, U_{F,t}; C_{FD,t}; MS_{F/D,t}; NM_{F,t-1}) \qquad (3b)$$

Hence, net migration abroad is defined by

$$NMA_t = M_{DF,t} - M_{FD,t} = M_{DF}\,(Z^E_{D,t}; Z^E_{F,t}; NM_{D,t-1}) - M_{FD}\,(Z^I_{D,t}; Z^I_{F,t}; NM_{F,t-1}) \qquad (4)$$

where Z_D and Z_F are used for temporary convenience to summarise the variables other than potential migrant population, i.e., the Y*, U*, C and MS variables, and the superscripts E and I indicate the emigration and immigration functions, respectively. The estimation of these functions, and thus derivation of net migration abroad, poses no particular specification difficulties provided that gross migration flow data are available. However, a time series of such data is not available[155] and the limitation of aggregate data to overall net migration flows sets constraints on the empirical modelling of migration from and to the domestic labour market. With only net flow migration data, the consistent aggregation of Equations (3a) and (3b) to give Equation (4) and the estimation of the latter, would require non-linear estimation techniques if the functional form specification of (3a) and (3b) is non-linear. This limits the functional form of (3a) and (3b) to a linear one, and an acceptance of the behavioural implications of that form.[156] Thus, the underlying structural equations are

$$M_{DF,t} = \alpha_0 + \alpha_1 Z^E_{D,t} + \alpha_2 Z^E_{F,t} + \alpha_3 NM_{D,t-1} \tag{5a}$$

$$M_{DF,t} = \beta_0 + \beta_1 Z^I_{D,t} + \beta_2 Z^I_{F,t} + \beta_3 NM_{F,t-1} \tag{5b}$$

so that on the basis of the definition of net migration in Equation (4), the estimating equations are of form

$$NMA_t = (\alpha_0 - \beta_0) + \alpha_1 Z^E_{D,t} - \beta_1 Z^I_{D,t} + \alpha_2 Z^E_{F,t} - \beta_2 Z^I_{F,t} + \alpha_3 NM_{D,t-1} + \beta_3 NM_{F,t-1} \tag{6}$$

If it is assumed, as is generally done (Walsh, 1974, p. 108) that the same domestic and foreign variables enter into the Z sets in the two migration functions, i.e.,

$$Z^E_{D,t} = Z^I_{D,t} = Z_{D,t} \text{ and } Z^E_{F,t} = Z^E_{F,t} = Z_{F,t}$$

then

155. The gross flow data on passenger movements does not permit the identification of gross emigrant and gross immigrant flows or the origin and destination of these.

156. This constraint would not have been severe during a period of large-scale emigration and little immigration so that net migration abroad and emigration could be taken as practically synonomous, i.e., M_{FD} drops out of Equation (4). That, however, is not the case during the sample period for this study as the net migration flow has been subject to reversal, i.e., in the period of interest it started as a relatively high net emigration flow, which then declined and the net flow became net immigration, which finally reversed again in 1980.

$$\mathrm{NMA}_t = (\alpha_0 - \beta_0) + (\alpha_1 - \beta_1)\, Z_{D,t} + (\alpha_2 - \beta_2)\, Z_{F,t} + \alpha_3\, \mathrm{NM}_{D,t-1} - \beta_3\, \mathrm{NM}_{F,t-1} \tag{7}$$

A fairly large number of net migration abroad functions have been estimated for Ireland.[157] These have broadly been of the following type:

$$\frac{\mathrm{NMA}_t}{\mathrm{NM}_{D,t-1}} = \gamma_0 + \gamma_1 Z_{D,t} + \gamma_2 Z_{F,t} \tag{8}$$

Depending on the assumptions made about the formation of expectations concerning variables in the Z sets, a lagged dependent variable may be included on the right hand side (Walsh, 1974, p. 110). Contrasting Equation (8) with Equations (5a) and (5b) points to some features of (8) that need to be examined.

An important feature of the formulation in Equations (5a) and (5b) is the inclusion of the respective populations from which out migration may occur as separate regressors. Since the actual number of migrants is dependent on the potential number of migrants, it is necessary to control for this factor. A frequent method of doing so is to make the dependent variable a ratio of the number of migrants to the number in the potential migrant population stock. Even if one were estimating structural gross migration functions of the type (5a) and (5b), such a procedure would introduce a bias as each of the estimated coefficients would implicitly include the respective structural coefficients divided by the migrant population variable appropriate to each equation, and the estimated constant would further include the respective population coefficient (α_3 or β_3) by subtraction. Thus, for example, $\gamma_1 = [(\alpha_1 - \beta_1)/\mathrm{NM}_{D,t-1}]$. The implicit assumption being made when this is done is that the scale effect is constant. However unsatisfactory this may be, it is compounded in Equation (8) by the omission of $\mathrm{NM}_{F,t-1}$ entirely. The estimated constant, therefore, also includes the structural coefficient of the foreign potential migrant population variable, β_3. Thus, formulations such as Equation (8) ignore the fact that the respective populations exposed to out migration are different. Yet only one, $\mathrm{NM}_{D,t-1}$, is included although immigrants come from the population $\mathrm{NM}_{F,t-1}$ which is omitted entirely. Net advantage includes non-economic as well as economic factors. The effect of this on migration varies with the demographic characteristics of the potential migrant population due to uncertainty, incomplete information,

157. O'Herlihy (1966), Walsh (1974), Geary and McCarthy (1976), Slattery (1977), Bradley *et al.* (1978), Keenan (1979), Fanning (1979), and Bradley *et al.* (1981). Keenan (1981) re-estimated a selection of these with a common data sample.

and the demographic characteristics themselves. The need to allow for types of migrants and differing propensities to migrate from their population sources is supported by data on net migration by age groups for intercensal periods from 1961-1979. For the period 1961-1971 there was large net emigration from the 15-29 age group plus a lesser amount from the 45-64 age group; there was substantially less net immigration among the 0-14, 30-44 and 65 and over age groups; the net result was substantial overall net emigration. For 1971-1979 net emigration was concentrated in the 20-29 age group; large net immigration was concentrated in the 0-19 and 30-65 and over age groups; the net result was very substantial overall net immigration. Omitting the relevant population variables results in specification bias due to omitted variables and aggregation errors.

There are three further issues to be resolved in the estimation of Equation (8): the manner of operationalising the relation of the foreign and domestic variables — the respective elements of Z_D and Z_F — to each other; the specific variables to be included in Z_D and Z_F; and the operationalisation of an expectations formation process.[158] First, in Equation (8) the Z_D and Z_F variables are entered independently as levels. On the further assumption that $\gamma_1 = -\gamma_2$ the level of net migration abroad is a function of the differences in the domestic and foreign explanatory variables, giving

$$\frac{NMA_t}{NM_{D,t-1}} = \gamma_0 + (\gamma_1 - \gamma_2)\,[Z_{D,t} - Z_{F,t}] \qquad (9)$$

Walsh points out that a problem with entering these variables as differences is that it implies that the same absolute change in a variable has the same impact on migration flows irrespective of the level of the variable.[159] The variables are then entered as ratios although, as Walsh says, it may not seem plausible to have expectations formed in terms of the ratio of two income streams (Walsh, 1974, p. 109). Entering the variables as ratios implies that, for example, if both the foreign and domestic variables were growing at the same rate, migration would not change although the absolute difference between them would have increased. But, in terms of human capital rationale for the model, there should be a change in migration because the gains from doing so have increased.

The second issue concerns the particular variables entering into Z_D and Z_F. These have been confined to variables for Ireland *vis-à-vis* the United Kingdom. This has been done for the pragmatic reason that, as the infor-

158. The alternatives involved have been addressed by Walsh (1974, pp. 108-111).

159. A way around this, as Walsh suggests, is to estimate the equation in terms of the logarithms of the variables but such a formulation, as has been shown, is not derivable from the structural net migration relationship and unless the appropriate non-linear estimation approach is also used.

mation from the 1966 Census of Population cited by Walsh (1974, pp. 108, 111) indicates, the largest part of Irish migration is to Britain, a very high proportion is economically active, and the vast majority of migrants from Britain to Ireland are returning migrants. The particular variables included have been real earnings and unemployment rates. With this narrowing down of the destinations and foreign origins to the UK, variables such as the cost/distance variables are treated as constant and omitted as separate regressors. Data for the information/migrant stock variable, $MS_{(j/i)t}$, are not available and on the basis of two assumptions an estimating equation, which is a variation of (6), is derived. This variable, which is the stock of migrants from i living in j at period t, represents the only group with an incentive to distribute (informal) job specific information under competitive conditions as well as other influences, to encourage persons from region i to choose region j (Langley, 1974, pp. 265-266). It is first assumed that the same stock of migrants variable can be used in both the structural foreign migration equation, i.e., $MS_{D/F,t} = MS_{F/D,t} = MS_t$, on the grounds that the majority of migrants from Britain to Ireland are returning Irish emigrants (Walsh, 1974, p. 111) so the net migration abroad equation is

$$\begin{aligned} NMA_t = {} & (\alpha_0 - \beta_0) + (\alpha_1' - \beta_1')\, Z'_{D,t} + (\alpha_2' - \beta_2')\, Z'_{F,t} \\ & + (\alpha_1'' - \beta_1'' + \alpha_2'' - \beta_2'')\, MS_t + \alpha_3\, NM_{D,t-1} - \beta_3\, NM_{F,t-1} \qquad (10) \end{aligned}$$

where the change from Equation (6) is that the migrant stock variable and appropriate coefficients have been extracted, as indicated by the prime superscripts, from the Z sets of variables and accompanying coefficients. Annual data for MS_t are not, however, available and, after taking first differences of (10), it is further assumed that ΔMS_t can be equated with NMA_{t-1},[160] so that

$$\begin{aligned} \Delta NMA_t = {} & (\alpha_1' - \beta_1')\, \Delta Z'_{D,t} + (\alpha_2' - \beta_2')\, \Delta Z'_{F,t} + (\alpha_1'' - \beta_1'' + \alpha_2'' - \beta_2'' + 1) NMA_{t-1} \\ & + \alpha_3\, \Delta NM_{D,t-1} - \beta_3\, \Delta NM_{F,t-1} \qquad (11) \end{aligned}$$

160. This as Walsh states (1974, p. 111) is the case if all migration, in both directions, is comprised of residents i. Langley (1974, pp. 264-267) discusses difficulties in operationalising and interpreting the migrant stock variable.

This is the form of the estimating equation.[161] However, once again the appropriate migrant population variables ($NM_{D,t}$ and $NM_{F,t}$) are omitted. The third issue involves the specification of an expectation formation process[162] which, as in the case of modelling information flows, poses particular difficulties which we need not go into here.

The preceding examination of the specification and estimation of net migration functions together with the unsatisfactory experience in estimating such relations[163] suggest the need to reconsider such a task in the light of the needs of an economy-wide macroeconometric study. In particular, if the choice is, as it seems, to be between omitting the necessary population variable, or using a poor proxy, it may be better to make an alternative, direct simple approach, which is set out in Chapter 5.III.

161. Walsh (1974, p. 108) states that the gross migration flows, converted to rates by division by the population exposed to migration, can be interpreted as probabilities, i.e., the probability of a person from i moving to j. This, however, still requires data on both the appropriate populations, $NM_{D,t}$ and $NM_{F,t}$. In his estimating equations Walsh (1974, p. 112) used the rate of net emigration from Ireland per 100 estimated population aged 15-64 as the dependent variable. This, as pointed out already, is only valid if it can be taken that net emigration is for practical purposes synonymous with gross migration.

162. Walsh (1974, p. 110) examines three standard techniques for modelling expectations – static, extrapolative, and adaptive.

163. Keenan (1981) found great instability and poor out-of-sample predictive power when he replicated some previous models using alternative series of net migration estimates.

Appendix 6.1

RECENT APPROACHES TO THE CONSUMPTION FUNCTION

Three recent international papers on consumption have greatly influenced applied work in Ireland.[164] A technique common to all three papers is the error correction mechanism (ECM), which is used as follows. If one postulates that in long-run equilibrium real consumption is proportional to real disposable income, then

$$C_t = K\,YD^r_t \tag{1}$$

where K is the long-run average (= marginal) propensity to consume out of disposable income, and may be parametric in other explanatory variables (e.g., unemployment). Hence,

$$\log C_t = \log K + \log YD^r_t \tag{2}$$

However, when the economy is not in equilibrium we do not have such an explicit relationship between consumption and income. Assuming initially a very general disequilibrium relationship, we can write

$$\sum_{i=0}^{n} \alpha_i \log C_{t-1} = \log K + \sum_{j=0}^{m} \beta_j \log YD^r_{t-j} \tag{3}$$

However, we require this relationship to reduce to the equilibrium relationship if dynamic equilibrium is assumed. This requires

$$\sum_i (\alpha_i + \beta_i) = 1 \tag{4}$$

In the simpler case where n = m = 1, this yields

$$\log C_t - \log C_{t-1} = \log K + \beta_1 (\log YD^r_t - \log YD^r_{t-1}) + (\beta_1 + \beta_2) \\ (\log YD^r_{t-1} - \log C_{t-1}) \tag{5}$$

164. Davidson *et al.* (1978); Hendry and von Ungern-Sternberg (1979); and von Ungern-Sternberg (1981).

and if $\dot{C} = \dot{YD}^r = g$, where g is the constant equilibrium growth rate, then

$$\frac{C_t}{YD^r_t} = \exp\,[\log K + g\,(\beta_1 - 1)]/(\beta_1 + \beta_2) \tag{6}$$

i.e., the consumption-income ratio is constant along a given equilibrium path, but depends on the equilibrium growth rate, g. Hence, the basic form of the ECM consumption function is

$$\log\left(\frac{C_t}{C_{t-1}}\right) = a_0 + a_1 \log\left(\frac{YD^r_t}{YD^r_{t-1}}\right) + a_2 \log\left(\frac{YD^r_{t-1}}{C_{t-1}}\right) \tag{7}$$

which can be modified to include such additional factors as inflation (PC_t/PC_{t-1}), unemployment rate (UR), and the dependence ratio (NDEP/NT).[165]

Probably the most commonly cited explanation for the negative effect of a rise in inflation on consumption is through the erosion in the value of real liquid assets. An interesting and easily tested hypothesis is provided by von Ungern-Sternberg (1981). According to this view, a fall in the real value of net monetary assets held by the personal sector and issued by the business and public sectors leads to a transfer of real resources from the personal to these other sectors. Consumers consider this fall as negative income and adjust their disposable income accordingly. The definition of personal sector disposable income used in the national accounts is an overestimate since it does not include such a correction. The above theory can be tested within the ECM framework as follows. As a proxy for the perceived rate of inflation, a moving average of the actual rates of inflation is used, i.e.,

$$\dot{P}^e_t = \tfrac{1}{2}(P_t - P_{t-2})/P_{t-2} \tag{8}$$

The negative income of period t is then defined as the stock of monetary assets held at the end of the preceding period multiplied by the expected rate of inflation, i.e.,

$$Neg_t = \dot{P}^e_t\, LIQ^r_{t-1} \tag{9}$$

165. Estimates for such models for the six largest OECD countries are given in OECD (1981c). However, applications to Irish data have been limited by the lack of sub-annual data.

Hence, perceived income, Y^*_t, equals disposable income, YD^r, minus negative income Neg_t, i.e.,

$$YD^{r*}_t = YD^r_t - \dot{P}^e_t \ LIQ^r_{t-1} \tag{10}$$

the ECM model now becomes

$$\log\left(\frac{C_t}{C_{t-1}}\right) = a_0 + a_1 \log\left(\frac{YD^{r*}_t}{YD^{r*}_{t-1}}\right) + a_2 \log\left(\frac{C_{t-1}}{YD^{r*}_{t-1}}\right) \tag{11}$$

where $YD^{r*} = YD^r_t - \delta \dot{P}^e_t \ LIQ^r_{t-1}$

and the hypothesis to be tested is $\delta = 1$.

If the more familiar simple permanent income model is used, where

$$C_t = a_0 + a_1 \ YD^{r,P}_t \tag{12}$$

the von Ungern-Sternberg model can be written in the form:

$$C_t = b_0 + b_1 \ (YD^r_t - \dot{P}^e_t \ LIQ^r_{t-1}) + b_2 \ C_{t-1} \tag{13}$$

Appendix 7.1

ADMINISTERED PRICE DETERMINATION — LONG-RUN AND SHORT-RUN MODELS

We present some examples of price equations that emerge from long-run pricing models based on explicit underlying technology assumptions and behavioural postulates.

Consider first the criterion of profit maximisation,[166]

$$\text{maximise } \pi = PQ - WL - CK \tag{1}$$

where π is profit, PQ is total revenue, W, C, and P are the prices of labour (L), capital (K) and output (Q). For expositional simplicity we assume a Cobb-Douglas technology with neutral disembodied technical progress, i.e.,

$$Q = Ae^{\gamma t} K^{\alpha} L^{\beta} \tag{2}$$

The product market is assumed to operate under conditions of imperfect competition with a demand equation log-linear in price (P) and income (Y), i.e.,

$$Q = BP^{-\delta_1} Y^{\delta_2} \tag{3}$$

Application of the usual first-order conditions for profit maximum, and substituting the factor demand equations resulting into the production function and demand equation yields

$$P = (B^{h-1} A)^k \exp(-hkt) \left(\frac{\alpha}{C}\right)^{-\alpha k} \left(\frac{\beta}{W}\right)^{-\beta k} Y^{-\delta_2 (h-1)k} \left(1 - \frac{1}{\delta_1}\right)^{-hk} \tag{4}$$

where $h = \alpha + \beta$ is the degree of homogeneity of the production function and

$$k = [\delta_1 + (1 - \delta_1) h]^{-1}$$

166. This section is based on Nordhaus (1972, pp. 28-30; and 1970, pp. 23-30).

In the case of constant returns to scale (h = 1), Equation (4) simplifies to

$$P = F \exp(-\gamma t)\, C^{\alpha} W^{1-\alpha} \tag{5}$$

where $F = (1 - \frac{1}{\delta_1})^{-1} \alpha^{-\alpha} (1-\alpha)^{(1-\alpha)}$.

In the competitive market case (characterised in this stylised model by an infinite elasticity of demand, $\delta_1 = \infty$) the optimal price is equal to the average (and marginal) costs. Under a situation of imperfect competition, the ratio of the optimal price to marginal cost equals

$$(1 - \frac{1}{\delta_1})$$

Nordhaus (1972, p. 29) points to three important aspects of the "optimal" price:

(i) the logarithm of price is a linear function of the logarithms of the factor prices so that the exponents α and $(1-\alpha)$ in Equation (5), are the elasticities of product price with respect to factor prices;
(ii) the cost of capital, C, is an important component of the optimal price; and
(iii) productivity only enters the optimal price equation through the smooth autonomous rate of technical progress, γ, and not in a variable short-run sense.

In Table A7.1 we give the form of the optimal price equation for alternative assumptions about the underlying technology and for a three factor production function.[167]

In the cost minimisation approach no specific assumptions need to be made about the competitive nature of the output market. However, if a firm pursues a cost minimising strategy the issue of price settings remains open as such an approach does not permit the explicit derivation of an optimal pricing rule. The usual procedure is to assume that prices are based on a mark up of some measure of expected long-run or "normal" unit costs derived from factor demand systems. Assuming once again a Cobb-Douglas technology, the long-run factor demand equations have been given in Appendix 3.1. The total cost of producing the desired level of output Q is

167. This is taken from Nordhaus (1972, p. 29, Table 1) and the reader is referred to this for further details. Derivations based on demand functions of the type in (3) as well as alternative demand functions are given in Nordhaus (1970, pp. 24-33).

Table A7.1: *Profit maximising optimal price equations*

Production function	*Price equation*
Fixed proportions	
1. Constant returns to scale	
$Q = \min.[\frac{K}{\alpha_1}, \frac{L}{\alpha_2}, \frac{M}{\alpha_3}] e^{ht}$	$P = B(\frac{b_1}{b_1-1})(\alpha_1 C + \alpha_2 W + \alpha_3 V)e^{-ht}$
2. Nonconstant returns to scale	
$Q = \min.[\frac{K}{\alpha_1}, \frac{L}{\alpha_2}, \frac{M}{\alpha_3}]^m e^{ht}, m \neq 1$	$P = B(\frac{b_1}{b_1-1})^{\theta m} [\alpha_1 C + \alpha_2 W + \alpha_3 V]^{m\theta} Y^{\theta b_2(1-m)} e^{-h\theta t}$
Cobb-Douglas	
3. Constant returns to scale	
$Q = AK^{\alpha_1} L^{\alpha_2} M^{\alpha_3} e^{ht}, \alpha_1 + \alpha_2 + \alpha_3 = 1$	$P = B(\frac{b_1}{1-b_1}) C^{\alpha_1} W^{\alpha_2} V^{\alpha_3} e^{-ht}$
4. Nonconstant returns to scale	
$Q = AK^{\alpha_1} L^{\alpha_2} M^{\alpha_3} e^{ht}, \alpha_1 + \alpha_2 + \alpha_3 \neq 1$	$P = B(\frac{b_1}{1-b_1})^{m\theta} [C^{\alpha_1} W^{\alpha_2} V^{\alpha_3}]^{\theta} Y^{b_2} (1-m)^{\theta} e^{-h\theta t}$
Constant elasticity of substitution	
5. Constant returns to scale	
$Q = e^{ht} [\delta_1 K^{-\rho} + \delta_2 L^{-\rho} + \delta_3 M^{-\rho}]^{-1/\rho}$	$P = B(\frac{b_1}{1-b_1}) e^{-ht} [\delta_1{}^{\sigma} C^{\sigma\rho} + \delta_2{}^{\sigma} W^{\sigma\rho} + \delta_3 V^{\sigma\rho}]^{1/\sigma\rho}$
6. Nonconstant returns to scale	
$Q = e^{ht} [\delta_1 K^{-\rho} + \delta_2 L^{-\rho} + \delta_3 M^{-\rho}]^{-m/\rho}, = \frac{1}{(1+\rho)}$	$P = B(\frac{b_1}{1-b_1})^{m\theta} [\delta_1{}^{\sigma} C^{\sigma\rho} + \delta_2{}^{\sigma} W^{\sigma\rho} + \delta_3{}^{\sigma} V^{\sigma\rho}]^{m\theta/\sigma\rho} Y^{b_2(1-m)-\theta} e^{-h\theta t}$

Source: Nordhaus (1972, p. 2a, Table 1).

Note: The degree of homogeneity of the production function is $m.\theta = [b_1 + (1-b_1)m]^{-1}$ and C is constant. All parameters, except ρ, are non-negative.
K, L, M are inputs of capital, labour and materials.
C, W, V are factor prices.

$$TC = w.L + c.K \tag{6}$$

and after substitution for optimal L and K and dividing by Q, we obtain the average cost formula:

$$AC = A_0 C^{\alpha} W^{1-\alpha} \exp(-\gamma t) \qquad (A_0 \text{ constant}) \tag{7}$$

The desired price is now assumed to be a mark up on average cost

$$p = (1 + \theta)\, AC \tag{8}$$

or, if the mark up is assumed to be parametric in demand pressure (proxied by the capacity utilisation rate in industry, CURI), we can write

$$p = (1 + \theta)\, CURI^{\delta}\, AC \tag{9}$$

Other influences on the rate of mark up include foreign prices and business financial constraints (OECD, March 1982b, pp. 13-17). Different production functions lead to alternative versions of (9) and to a set of cost-minimisation based price setting equations equivalent to those for profit maximisation shown in Table A7.1.

A variation on the long-run mark up model has been given by Nordhaus (1974, p. 195) where the derivation of average cost is based on "normal" historical costs rather than the underlying production function. Using the subscript "n" to denote normal or cyclically corrected values, the definition of average total normal historical cost is

$$AC = W\frac{L_n}{Q_n} + \frac{CK}{1-\tau} + tr + \frac{D}{Q_n}$$

where C is the current cost of capital, τ the effective tax rate on capital income, tr the indirect business tax rate, and D is economic depreciation. This version is closely linked to more heuristic short-run models of mark up pricing to be outlined below. Finally, it may be remarked that the above long-run (or equilibrium) price setting models can be related to short-run (disequilibrium) price setting by means of appropriate adjustment mechanisms (e.g., partial or adaptive adjustment). The need for these adjustments arises because it is unlikely that firms can adjust prices instantaneously due to such factors as uncertainty, market interdependencies, and costs of adjustments.[168]

The above models of long-run optimal price setting were based on an

168. These are discussed by Nordhaus (1972, pp. 31-34).

assumed underlying production technology and showed how the assumed production technology affected the specific functional form of the equations. In the case of cost-minimising behaviour, which does not permit an explicit derivation as in the case of profit-maximisation behaviour, the production function constraint influences price setting through the definition of average cost based on the long-run demand for factor inputs. However, these models of long-run optimal price setting were derived on the assumption that firms are not prevented from pursuing such a course. The only constraints on pricing behaviour were such as to introduce adjustment lags of actual to desired price. The second broad approach to price setting is based on the view that short-run price setting decisions may not, or cannot, be consistent with the long-run models above. This also gives rise to a family of price setting rule which vary according to the elements of cost included (Nordhaus, 1974, pp. 183-189).

Table A7.2 lists the family of short-run mark up price equations based on the non-technology approach. The relationship of a target-return price determination (Equations 5 and 6) to the profit maximising price model is discussed by Nordhaus (1972, pp. 30-31). He concludes that optimal pricing only coincides with target return pricing under competitive conditions. Yet the latter is specifically designed for pricing in non-competitive markets. Under the assumed demand and production conditions, therefore, target return pricing is not a good rule of thumb except under competitive conditions. A better approach is that in Equation 5 or a linearised version of Equation 4.

Table A7.2: *Alternative specification of mark up price equations*

	Description	*Equation*
1.	Price marked up on normal unit labour cost	$P_1 = (1 + \theta_1) \frac{WL}{Q}$
2.	Price marked up on normal unit labour cost plus indirect taxes	$P_2 = (1 + \theta_2) [\frac{WL}{Q} + z]$
3.	Price marked up on normal unit labour cost plus indirect taxes plus normal depreciation	$P_3 = (1 + \theta_3) [\frac{WL}{Q} + z + \frac{D}{Q}]$
4.	Price marked up on normal unit labour cost plus indirect taxes plus normal depreciation plus normal interest	$P_4 = (1 + \theta_4) [\frac{WL}{Q} + z + \frac{D}{Q} + \frac{I}{Q}]$
5.	Target-return pricing (I): price equals costs, plus a normal before-tax return on capital	$P_5 = \frac{WL}{Q} + z + \frac{D}{Q} + r\frac{K}{Q}$
6.	Target-return pricing (II): price equals costs plus normal after-tax return on capital	$P_6 = \frac{WL}{Q} + z + \frac{D}{Q} + (1-\tau)r\frac{K}{Q}$

Notation:

P_i = Predicted price in specification i, i = 1, 6
Q = normal gross output
W = normal compensation per manhour
L = normal labour inputs
z = indirect business taxes per unit of real output
D = economic depreciation
I = net interest
K = replacement cost of net stock of capital, current prices
θ = mark up
r = average before-tax rate of return on capital
τ = effective corporate tax rate

Source: Nordhaus (1974, p. 89, Table 6).

Appendix 7.2

WAGE DETERMINATION-DISEQUILIBRIUM COMPETITIVE MODEL

We assume a long-run CES production function of the form

$$Q = \gamma \, [(1-\delta)L^{-\rho} + \delta K^{-\rho}]^{-\mu/\rho}$$

where non-constant returns to scale (μ) are imposed and we drop the "*" denoting long-run values of variables. The product and factor input markets are assumed to operate under conditions of imperfect competition with demand equations of form

$$Q = a_0 P^{-\beta_0}$$

$$L = a_1 W^{-\beta_1}$$

$$K = a_2 C^{-\beta_2} \qquad (1)$$

where P, W and C are the prices of output, labour and capital, respectively. The profit equation can be written

$$\pi = PQ - WL - CK$$

$$= b_0 Q^{\eta_0} - b_1 L^{\eta_1} - b_2 K^{\eta_2} \qquad (2)$$

where the ηs are simple functions of the βs.

Assuming a profit maximisation criterion, the derived demand for labour is

$$L_d^{(1+\rho)} = c_0 W^{-1} \, . \, Q^{(1+\rho/\mu)} \, . \, P \qquad (3)$$

But since output (Q) is the product of employment (L) times the average productivity of labour (q), then

$$L_d = c_0^{1/k} \, . \, (W)^{-1} \, . \, (q)^{(1+\rho/\mu)/k} \, . \, P^{1/k} \qquad (4)$$

where $k = \rho - \rho/\mu$.

Assuming labour supply is a function simply of the real (consumption) wage (W/P_c),

$$L_s = d_0 (W/P_c)^{d1} \tag{5}$$

Equating long-run equilibrium labour supply and demand yields

$$\log W = e_0 + e_1 \log P_c + e_2 \log P + e_3 \log q \tag{6}$$

Hence, the long-run factors of wage-rate determination are the consumption price index (from the supply side), the product price (from the demand side) and the average productivity of labour.[169]

The above long-run equilibrium relation for W can either be used in an adjustment (disequilibrium) mechanism or, alternatively, explicitly short-run factors can be added to the long-run equation, such as the rate of capacity utilisation (CUR_I), or the differential wage rate in the high productivity sector (W^{HP}) relative to the given sector etc., yielding

$$\log W = e_0 + e_1 \log P_c + e_2 \log P + e_3 \log q + e_4 \log CUR_I + e_5 \log \left(\frac{W^{HP}}{W}\right) \tag{7}$$

169. Economou and Panareton (1976, pp. 121-122) advance reasons for including the *level* of employment in the long-run equation, based on arguments relating to the fact that the expansion of the manufacturing sector in developing countries is based on imported technology, which entails increases in employment and wage rates, and shifts in product supply.

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Printed in the Republic of Ireland by
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