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Costs and Prices in Transportable Goods Industries

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CONTENTS

1.	Introduction	1
2.	The scope of the study	1
3.	The pricing equation	3
4.	Regression equations: Model I	5
5.	Regression equations: Model II	11
6.	Time lags: Model I	14
7.	Time lags: Model II	18
8.	Utilisation of Capacity	21
9.	Utilisation and Prices: the results	27
10.	Conclusions and applications	30

Appendices

A	Statistical problems	32
B	Comparing of actual and estimated prices	36
C	Data and sources	37

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1. INTRODUCTION

The main purpose of this paper is to examine the relationships between output prices in the transportable goods industries and the main elements of production costs, wages and material costs, in Ireland during the period between 1955 and 1967. (See Figure I.). The broadly parallel march of costs and prices is a familiar feature of most developed economies during the last two decades and a considerable amount of work has been done on the details of the relationships, the nature of the lag between wage changes and price changes, the effects of productivity changes on wage costs, etc.[1]

The particular stimulus which gave rise to the research was the slow reaction of Irish prices to the 10th wage round in 1966. Between the last quarter of 1965 and the last quarter of 1966 average weekly earnings in transportable goods industries rose by 12%. Over the same period wholesale prices rose by 5% and the consumer price index rose by only 4%. In their comments on the Report by the Department of Finance "Review of 1966 and Outlook for 1967", the National Industrial Economic Council[2] conclude that the rise in consumer prices:

> "... is less than might have been expected, given that average weekly earnings in industry in the latter half of 1966 appear to have been running at a rate about 12% higher and output per man hour in manufacturing industry about 2 to 3% higher ...".

This, in turn, caused some difficulty in forecasting the movement of prices in 1967. The report went on to say:

> "The full effects on prices of the events of 1966 may not yet have worked their way through the economy so that some further price increases may be inevitable in 1967".[3]

[1]Cf. Dicks-Mireaux, L. A., "The Interrelationship between Cost and Price Changes 1946–1959", Oxford Economic Papers, October 1961.
Neild, R. R., "Pricing and Employment in the Trade Cycle", National Institute of Economic and Social Research, Occasional Papers XXI, and "The Problem of Rising Prices", O.E.E.C., (1961).

[2]Report No. 20, p. 11. Dated 31 March 1967.

[3]*Op. cit.*, p. 22. The reference is to changes in money incomes, indirect taxes and import prices.

2. THE SCOPE OF THE STUDY

The emphasis of the paper is therefore on three things: firstly, it attempts to forecast changes in output prices, secondly, it attempts to establish the time-form of the lagged relationship between input prices and output prices in Irish transportable goods industries since 1955; thirdly, it examines the possibility that the lags may themselves be variables, and in particular that they may be systematically related to the level of industrial activity.

The theoretical model underlying this approach can best be viewed as a modified form of full-cost pricing. Manufacturers are assumed to calculate prices by adding a percentage margin to their variable costs, the margin reflecting their estimate of an adequate target return on capital. While prices may reflect this full-cost principle, on average over fairly long periods of time, manufacturers may, however, be willing to accept prices lower than full-cost prices when demand is slack and may seek prices higher than full-cost prices when demand is particularly buoyant.

When costs and prices are changing through time this sort of behaviour can give rise to two alternative statistical hypotheses. Variations in the level of ac-

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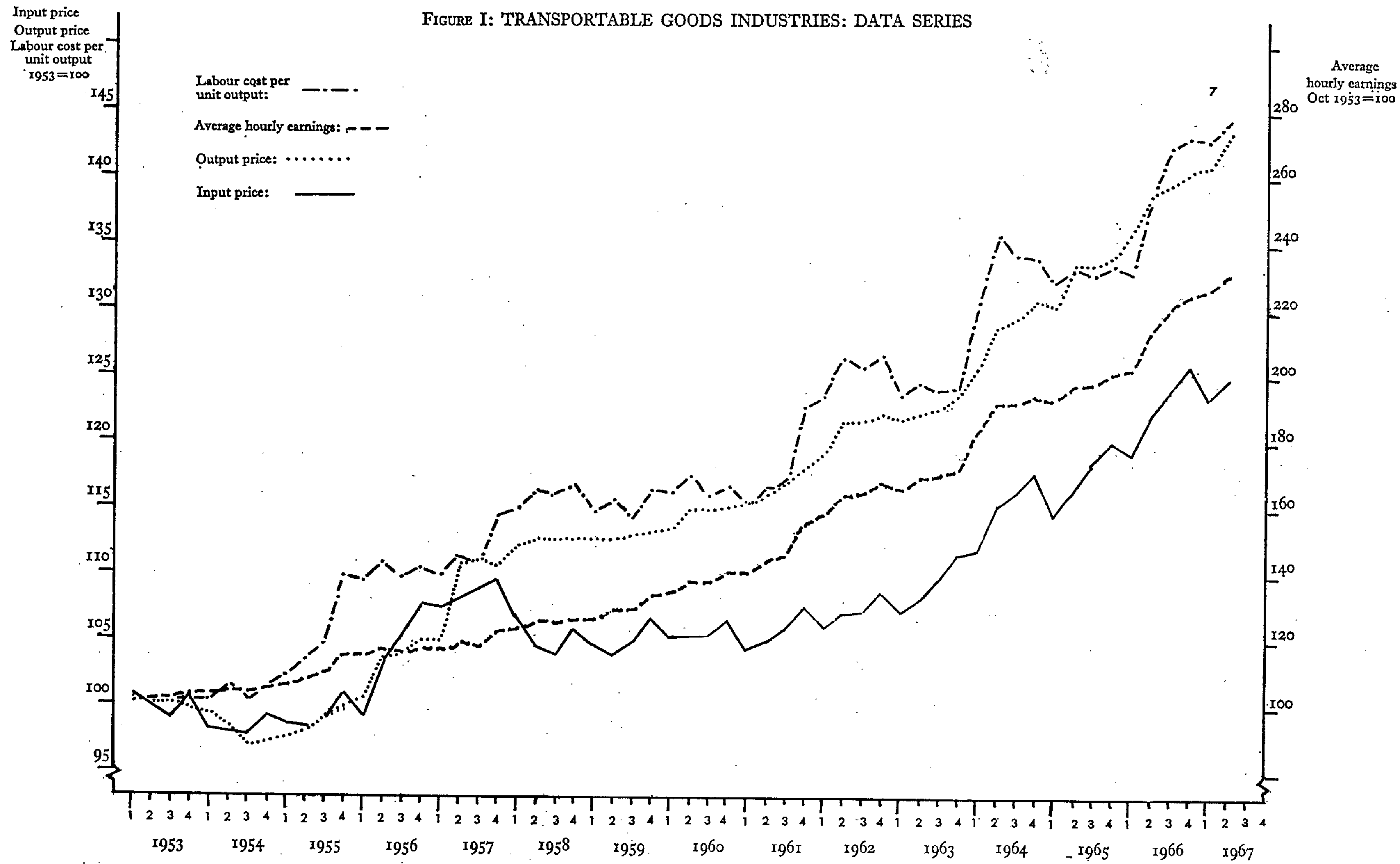
FIGURE I: TRANSPORTABLE GOODS INDUSTRIES: DATA SERIES



tivity may cause divergences between prices calculated on a full-cost basis and actual prices which would be reflected by variations in the margin which entrepreneurs add to their variable costs; the hypothesis can be tested by examining the relationship between activity and margins. Alternatively variations in activity may cause variations in the rapidity with which cost changes are passed on into prices; the hypothesis can be tested by examining the relationship between activity and the average length of time lag between cost changes and price changes. Clearly these are two forms of one general hypothesis—the modified full-cost hypothesis—and in this paper both formulations will be examined.

The modified full-cost model set out above could be made formally equivalent to a marginalist pricing model. It is well recognised that marginal cost pricing and output behaviour could be interpreted in terms of behaviour designed to cover variable costs plus a margin to give a return on capital, a margin which, however, varied to reflect the state of market demand.[1] The hypothesis as it is presented here might best be said to be neutral with respect to the controversy between full-cost and marginalist supporters. The hypothesis requires that margins vary with activity, and hence with the state of market demand; moreover it requires that the relationship between margins and activity is stable through time; but it does not require that the variations in the margin should reflect a full-blown marginal cost approach to profit maximisation. The implication is that the formulations of the full-cost approach which involve a constant margin are inefficient models of pricing behaviour; it does not necessarily follow that marginalist models are more efficient.

[1]The model used here is a single equation one in which output price is expressed as a function of (among other variables) average hourly earnings. It could be argued that since price increases lead to increases in earnings, there should be a second equation in the model expressing earnings as a function of price. This would be particularly necessary if the interaction between earnings and prices was thought to be simultaneous. If the interaction is not simultaneous then the model is recursive in character and ordinary least squares estimation can be relied on to yield unbiassed and consistent estimates. The existence of time lags in the relationships between earnings and prices would result in a model which is likely to approximate to a recursive system.

Investigations carried out for Irish data by O'Herlihy in "A Statistical Study of Wages, Prices and Employment in the Irish Manufacturing Sector", Economic Research Institute, Publication No. 29, and for U.K. data by Dicks-Mireaux in "The Interrelationship between Cost and Price Changes, 1946–1959", Oxford Economic Papers, October 1961, indicate only minor bias in the ordinary least squares results. On the basis of this evidence it was decided that a single equation model was sufficient.

3. THE PRICING EQUATION

To examine the long-term form of the relationship between input costs and output prices it has been assumed that pricing behaviour in transportable goods industries can be represented by an equation of the form:

$$P = a_0 + a_1 C. \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1).$$

where
P is the price per unit of final output and
C is prime cost per unit of output.

Prime cost per unit of output, C, is composed of labour costs per unit of output, and materials cost per unit of output. Materials cost per unit of output is the product of materials cost per unit of input, M, and the number of units of input required to make one unit of output, b. It is unlikely that the co-efficient b is very sensitive to technological change and over the period covered by the investigation it has been assumed to be constant.

Labour cost per unit of output is similarly the product of labour costs per unit of input, i.e. average hourly earnings, W, and the number of units of labour input required to produce one unit of output, a. It cannot be assumed, however, that the co-efficient a is constant through time for the co-efficient is subject to both short-term fluctuations and a long-term trend. This can perhaps be more readily appreciated if attention is directed towards the reciprocal of "a" which is, of course, output per man hour, or labour productivity (π).

It is possible to get around this problem by calculating labour cost per unit of output directly from a and W. Labour cost per unit of output is equal to the product, aW, and adequate data are available for a, from output per man-hour and W, average hourly earnings. The resulting series could be used in the price equation which would then become

$$P = a_0 + a_1 \, (aW + bM) \ldots\ldots\ldots\ldots\ldots (2).$$

There are, however, two objections to this procedure.

First, examination of the productivity series reveals that the short-term variations of labour productivity about its trend are systematically related to the utilisation of capacity. This is a phenomenon which has recently been observed in other economies, including the United Kingdom and the United States. All that need be pointed out here is that the relationship creates significant difficulties for this present investigation. For it is one of the aims of this work to examine the direct effect of utilisation of capacity upon price formation, and it would confuse the issue if a proxy for utilisation, i.e. labour productivity, were included in the price equation.

Second, and perhaps more important, short-term variations in productivity are unlikely to have much direct effect on the pricing behaviour of entrepreneurs. Certainly the quantity of labour element in the typical costing department's computation of prime costs will change through time; but it is likely to change slowly and the *trend* of productivity is probably a more accurate indicator of labour requirements than are quarterly movements in productivity.

For these reasons the pricing equation is adjusted to the form

$$P = a_0 + a_1 \quad (a_T W + bM) \ldots\ldots\ldots\ldots\ldots (3)$$

where a_T is the trend of labour requirement per unit of output and $\frac{1}{a_T} (= \pi_T)$ is the trend of labour productivity. Since a_T can be calculated it is possible to estimate a_1, the mark-up of prime costs which when added to a_0 gives price from the available data and hence it is possible to estimate b indirectly.

It should be noted that the coefficient a_1 applies to the product $a_T W$. The implication is that the entrepreneur reacts similarly to changes in labour costs per unit of input whether they are the result of changes in hourly earnings or changes in productivity. Some investigators[1] have attempted to separate earnings and productivity effects by treating productivity as a separate element in the pricing equation. Such a procedure could be expressed by a pricing equation of the form

$$P = a_0 + a_1 (aW + bM + c\pi_T) \ldots\ldots\ldots (4)$$

where π_T is an index of the trend of output per man hour. The value of this procedure is that it allows for the possibility that the entrepreneur's reactions to changes in labour costs which stem from increased productivity may differ from his reaction to changes which stem from changes in hourly earnings. On the other hand, the procedure has some statistical disadvantages. Since the coefficient "a" is no longer the inverse of labour productivity it cannot be calculated separately from a_1 and hence it is not possible to separate out a_1, the mark-up of prime costs, from a_1b or a_1c.

[1]Cf. OHerlihy, E. St. J., "A Statistical Study of Wages, Price and Employment in the Irish Manufacturing Sector", Economic Research Institute, Paper 29.

Dicks-Mireaux, L. A., "The Interrelationship between Cost and Price Changes, 1946–1959", Oxford Economic Papers (1961).

Because the advantages and disadvantages of the two formulations of the pricing equation are complementary it has been thought desirable to estimate results on the basis of both. Most attention is directed to the formulation set out in equation (3) above and in what follows this is described as Model I. Where possible, however, estimates have been made for comparative purposes on the basis of the formulation set out in equation (4). This is hereafter described as Model II.

As they are outlined above, Models I and II are expressed in terms of simultaneous reactions in output prices to changes in input prices. However in seeking to explain the level of output prices in the transportable goods industries in terms of the costs of labour and material inputs, it is essential to bear in mind that the index of output price is a highly aggregative concept. It relates to a flow of goods emanating from a particular sector of the economy and does not include the movement of goods within this sector.

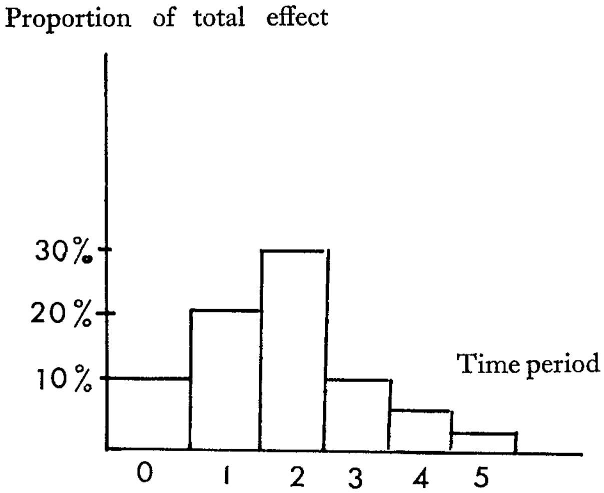
It may be helpful to regard the output of the transportable goods industries as a flow of produce coming off a conveyor belt. At the start of the process input materials are entered and at each stage additions are made in the form of further material inputs or of labour expended, until the finished product passes off the conveyor belt. Only at this point does its price enter the output price index.

In this context, a change in the price of the original material input will not be felt immediately on output price. The new price level will take some time to pass through the system. The same will be true to a lesser extent of materials which enter the process at subsequent stages. In general, therefore, there will tend to be a time lag between material price changes and output price changes because of this pipeline effect. The fact that some materials enter the system at later stages means that the full effect of the change will not occur all at once, even allowing for the lag. Some of the "new price" materials will be combined with "old price" materials, so that the change in output price will be gradual, thus giving rise to a distributed time lag.

The same will also be true of a change in the price of labour, though here the time lag will probably be of shorter duration. Since the final stages of production are more likely to be concerned with finishing off the product rather than adding material inputs, a large part of a labour cost change will be manifest in output price almost immediately. There will, however, still be a time lag before the full effect of the change is realised because changes in the price of the unfinished product due to the labour cost change will be subject to the pipeline effect.

The existence of stocks of materials, and the reluctance of manufacturers to continually vary prices are further reasons why a time lag between input cost changes and output price changes will prevail.

One of the objects of this paper is to attempt to establish the nature and duration of these distributed time lags, i.e. to determine the length of time which elapses before the full effect of a change in the price of inputs is manifest in output price, and to determine the lag after which the greatest proportion of full effect occurs. This is called the modal point of the distributed lag. The situation may be represented graphically as shown opposite.



Time period O represents the current time period. Time period I is interpreted as "one time period later", and so on. On this interpretation it will be seen that after six time periods almost all of the total effect has worked through, so that the duration of the lag is (approximately) six time periods. It will also be noted that the greatest proportion of the total effect occurs after a lag of two time periods. Thus the modal point of the distributed lag occurs after two time periods.

In addition to the influences acting on output prices considered above, it is possible that the level of activity (i.e. degree of utilisation of capacity) in the transportable goods industries may influence the level of output prices or the time taken for output prices to react to changes in import costs. This possibility is examined later in this study.

4. REGRESSION EQUATIONS: MODEL I

This section describes the methods used to establish the price equation which best explains the fluctuations in output price over the eleven year period from 1955 to 1965, inclusive.[1] The criterion for selecting the "best" equation was the standard error of estimate, calculated as

$$\frac{\sqrt{\sum_{t=1}^{n}(P_t - \hat{P}_t)^2}}{(n-k)}$$

where P is actual output price
$\hat{P}$ is estimated (using the regression equation) output price
n is the number of observations
k is the number of coefficients in the equation.

The standard error of estimate is expressed in units of the variable to be explained[2] and gives a measure of the amount of variation unaccounted for by the regression equation. Hence the equation with the smallest standard error of estimate is, in this sense, "best". Since the addition of any variable will tend to reduce the squared sum of differences between actual and estimated prices, it is necessary to use the difference (n-k) in the denominator, rather than n, the number of observations. This means that the reduction in the numerator above, due to the addition of another variable, must be sufficient to overcome the corresponding reduction in the denominator before the standard error of estimate as a whole is reduced.

The first step was to establish the location of the modal points of the distributed lags for earnings and input prices. To this end a series of regressions was carried out using combinations of current and lagged values of the explanatory variables. It seemed reasonable to expect that the modal points would occur with a lag of less than a year so that values lagged by more than four quarters were not introduced.[3] Subsequent findings bore out this assumption. When two explanatory variables (labour cost per unit output and input price) were considered in this fashion it was necessary to estimate a total of 450 regressions. To consider three explanatory variables (earnings, input price and labour productivity) would require a total of 6750 regressions. Even with computer facilities this latter presented a prohibitive task in terms of computer programme preparation and computer time. As a consequence, it was necessary to carry out the estimation of modal points on the model I price equation and later to extend the findings to the model II price equation.

Table I shows the standard error of estimate for each of the first 225 regressions. The row and column

[1]Later figures were not used so that the results obtained could be used to "forecast" later years and these could then be compared with the actual data.

[2]The units are index numbers from the series, Wholesale Price Index for the Total Output of Industry, where 1953=100.

[3]In a similar exercise on British manufacturing prices, Neild. *op. cit.*, does not introduce lags of more than two quarters.

TABLE I: REGRESSION RESULTS: MODEL I (WITHOUT LAGGED DEPENDENT VARIABLES)

	(1) M	(2) M_{-1}	(3) M_{-2}	(4) M_{-3}	(5) M_{-4}	(6) MM_{-1}	(7) $M_{-1}M_{-2}$	(8) $M_{-2}M_{-3}$	(9) $M_{-3}M_{-4}$	(10) MM_{-1} M_{-2}	(11) $M_{-1}M_{-2}$ M_{-3}	(12) $M_{-2}M_{-3}$ M_{-4}	(13) MM_{-1} $M_{-2}M_{-3}$	(14) $M_{-1}M_{-2}$ $M_{-3}M_{-4}$	(15) MM_{-1} $M_{-2}M_{-3}$ M_{-4}
(1) $\left(\frac{W}{\pi}\right)$	2·297	2·122	1·933	1·826	1·736	2·095	1·940	1·848	1·752	1·964	1·874	1·738	1·900	1·762	1·787
(2) $\left(\frac{W}{\pi}\right)_{-1}$	2·212	2·152	2·006	1·893	1·857	2·180	2·014	1·918	1·867	2·016	1·944	1·883	1·939	1·909	1·890
(3) $\left(\frac{W}{\pi}\right)_{-2}$	2·290	2·260	2·232	2·158	2·120	2·287	2·255	2·187	2·141	2·264	2·171	2·155	2·172	2·131	2·119
(4) $\left(\frac{W}{\pi}\right)_{-3}$	2·431	2·379	2·385	2·427	2·416	2·410	2·393	2·412	2·434	2·417	2·403	2·367	2·424	2·350	2·361
(5) $\left(\frac{W}{\pi}\right)_{-4}$	2·571	2·479	2·461	2·549	2·645	2·511	2·478	2·494	2·582	2·509	2·506	2·518	2·537	2·528	2·557
(6) $\left(\frac{W}{\pi}\right)\left(\frac{W}{\pi}\right)_{-1}$	2·122	2·015	1·845	1·728	1·654	2·016	1·844	1·752	1·669	1·869	1·776	1·674	1·800	1·698	1·718
(7) $\left(\frac{W}{\pi}\right)_{-1}\left(\frac{W}{\pi}\right)_{-2}$	2·124	2·081	1·981	1·877	1·835	2·109	2·000	1·903	1·851	2·007	1·927	1·870	1·927	1·893	1·879
(8) $\left(\frac{W}{\pi}\right)_{-2}\left(\frac{W}{\pi}\right)_{-3}$	2·247	2·212	2·199	2·160	2·125	2·241	2·219	2·187	2·148	2·237	2·175	2·153	2·184	2·134	2·132
(9) $\left(\frac{W}{\pi}\right)_{-3}\left(\frac{W}{\pi}\right)_{-4}$	2·403	2·339	2·339	2·397	2·417	2·371	2·352	2·370	2·423	2·381	2·374	2·362	2·403	2·357	2·378
(10) $\left(\frac{W}{\pi}\right)\left(\frac{W}{\pi}\right)_{-1}\left(\frac{W}{\pi}\right)_{-2}$	1·869	1·770	1·680	1·581	1·483	1·756	1·698	1·603	1·504	1·719	1·623	1·508	1·645	1·523	1·546
(11) $\left(\frac{W}{\pi}\right)_{-1}\left(\frac{W}{\pi}\right)_{-2}\left(\frac{W}{\pi}\right)_{-3}$	1·896	1·844	1·750	1·722	1·689	1·865	1·761	1·741	1·707	1·782	1·765	1·702	1·783	1·727	1·737
(12) $\left(\frac{W}{\pi}\right)_{-2}\left(\frac{W}{\pi}\right)_{-3}\left(\frac{W}{\pi}\right)_{-4}$	2·034	1·989	1·958	1·923	1·958	2·016	1·984	1·948	1·949	2·010	1·959	1·972	1·981	1·981	2·000
(13) $\left(\frac{W}{\pi}\right)\left(\frac{W}{\pi}\right)_{-1}\left(\frac{W}{\pi}\right)_{-2}\left(\frac{W}{\pi}\right)_{-3}$ ..	1·672	1·577	1·487	1·455	1·372	1·534	1·499	1·472	1·393	1·505	1·494	1·369	1·505	1·390	1·405
(14) $\left(\frac{W}{\pi}\right)_{-1}\left(\frac{W}{\pi}\right)_{-2}\left(\frac{W}{\pi}\right)_{-3}\left(\frac{W}{\pi}\right)_{-4}$ ..	1·699	1·646	1·547	1·520	1·550	1·652	1·541	1·539	1·540	1·564	1·552	1·554	1·575	1·570	1·592
(15) $\left(\frac{W}{\pi}\right)\left(\frac{W}{\pi}\right)_{-1}\left(\frac{W}{\pi}\right)_{-2}\left(\frac{W}{\pi}\right)_{-3}\left(\frac{W}{\pi}\right)_{-4}$	1·468	1·381	1·282	1·250	1·239	1·295	1·277	1·266	1·246	1·260	1·279	1·245	1·268	1·262	1·259

TABLE II: REGRESSION RESULTS MODEL I (WITH LAGGED DEPENDENT VARIABLES)

	(1) M	(2) M_{-1}	(3) M_{-2}	(4) M_{-3}	(5) M_{-4}	(6) MM_{-1}	(7) $M_{-1}M_{-2}$	(8) $M_{-2}M_{-3}$	(9) $M_{-3}M_{-4}$	(10) $MM_{-1}M_{-2}$	(11) $M_{-1}M_{-2}M_{-3}$	(12) $M_{-2}M_{-3}M_{-4}$	(13) $MM_{-1}M_{-2}M_{-3}$	(14) $M_{-1}M_{-2}M_{-3}M_{-4}$	(15) $MM_{-1}M_{-2}M_{-3}M_{-4}$
(1) $\left(\frac{W}{\pi}\right)$	0·813	0·846	0·845	0·871	0·885	0·816	0·854	0·853	0·882	0·807	0·864	0·864	0·817	0·875	0·827
(2) $\left(\frac{W}{\pi}\right)_{-1}$	0·884	0·943	0·953	0·977	0·989	0·867	0·956	0·956	0·980	0·865	0·965	0·968	0·873	0·978	0·886
(3) $\left(\frac{W}{\pi}\right)_{-2}$	0·900	0·972	0·994	1·020	1·025	0·874	0·983	0·981	1·011	0·877	0·985	0·990	0·878	0·996	0·890
(4) $\left(\frac{W}{\pi}\right)_{-3}$	0·896	0·972	0·995	1·022	1·025	0·865	0·983	0·980	1·009	0·865	0·985	0·989	0·869	0·995	0·881
(5) $\left(\frac{W}{\pi}\right)_{-4}$	0·898	0·973	0·995	1·022	1·025	0·866	0·984	0·981	1·011	0·867	0·986	0·991	0·873	0·997	0·886
(6) $\left(\frac{W}{\pi}\right)\left(\frac{W}{\pi}\right)_{-1}$	0·811	0·844	0·847	0·877	0·892	0·816	0·853	0·852	0·888	0·811	0·862	0·863	0·820	0·874	0·830
(7) $\left(\frac{W}{\pi}\right)_{-1}\left(\frac{W}{\pi}\right)_{-2}$	0·879	0·940	0·946	0·974	0·988	0·860	0·953	0·946	0·973	0·848	0·959	0·958	0·852	0·971	0·865
(8) $\left(\frac{W}{\pi}\right)_{-2}\left(\frac{W}{\pi}\right)_{-3}$	0·907	0·983	1·004	1·030	1·036	0·876	0·995	0·994	1·021	0·876	0·999	1·004	0·882	1·010	0·894
(9) $\left(\frac{W}{\pi}\right)_{-3}\left(\frac{W}{\pi}\right)_{-4}$	0·909	0·985	1·008	1·035	1·038	0·875	0·996	0·992	1·017	0·876	0·998	0·999	0·881	1·007	0·894
(10) $\left(\frac{W}{\pi}\right)\left(\frac{W}{\pi}\right)_{-1}\left(\frac{W}{\pi}\right)_{-2}$	0·822	0·855	0·858	0·888	0·902	0·828	0·865	0·864	0·900	0·822	0·875	0·876	0·830	0·886	0·842
(11) $\left(\frac{W}{\pi}\right)_{-1}\left(\frac{W}{\pi}\right)_{-2}\left(\frac{W}{\pi}\right)_{-3}$	0·890	0·949	0·953	0·983	0·997	0·873	0·961	0·950	0·984	0·861	0·964	0·963	0·865	0·978	0·879
(12) $\left(\frac{W}{\pi}\right)_{-2}\left(\frac{W}{\pi}\right)_{-3}\left(\frac{W}{\pi}\right)_{-4}$	0·920	0·993	1·012	1·038	1·045	0·888	1·006	1·005	1·022	0·889	1·011	1·012	0·895	1·020	0·908
(13) $\left(\frac{W}{\pi}\right)\left(\frac{W}{\pi}\right)_{-1}\left(\frac{W}{\pi}\right)_{-2}\left(\frac{W}{\pi}\right)_{-4}$ ..	0·832	0·859	0·859	0·893	0·906	0·840	0·868	0·863	0·906	0·834	0·876	0·873	0·841	0·886	0·853
(14) $\left(\frac{W}{\pi}\right)_{-1}\left(\frac{W}{\pi}\right)_{-2}\left(\frac{W}{\pi}\right)_{-3}\left(\frac{W}{\pi}\right)_{-4}$ ..	0·901	0·953	0·952	0·982	1·000	0·886	0·964	0·953	0·976	0·874	0·968	0·964	0·879	0·979	0·893
(15) $\left(\frac{W}{\pi}\right)\left(\frac{W}{\pi}\right)_{-1}\left(\frac{W}{\pi}\right)_{-2}\left(\frac{W}{\pi}\right)_{-3}\left(\frac{W}{\pi}\right)_{-4}$	0·835	0·852	0·843	0·876	0·895	0·847	0·856	0·851	0·886	0·839	0·865	0·864	0·848	0·878	0·861

headings show respectively the combinations of labour cost and input price variables which comprise the explanatory variables. The subscripts refer to the lag and are measured in quarters of a year. Thus, for example, M_{-3} indicates the input price variable lagged by three quarters.

From the table a pattern is identified which gives an indication of the probable position of the modal lags, since combinations which include the modal lag time periods should have the smallest standard errors of estimate. The modal lag seems well established for labour cost. When the labour cost variable is introduced singly or in groups, the smallest standard errors of estimate tend to occur when current labour cost is included. Furthermore the errors tend to increase when more recent values of the labour cost variables are replaced by earlier values. The addition of lagged values to the current value causes the errors to decrease. This is consistent with the assumption of a distributed lag relationship.

The situation with regard to input price is less clear. Examination of the results shows that the errors tend to fall as the lag is lengthened, though in some cases[4] they increase again when the lag is longer than two or three quarters. This would seem to indicate that the modal point occurs some time after the current quarter, but before the third quarter. This can only be a tentative conclusion at this point and some further investigation is obviously required. Once again, the existence of a distributed lag relationship seems verified.

For the table as a whole, the smallest error occurs when all variables are included and it might therefore be inferred that the addition of further lagged terms would continue to reduce the error. Table II allows for this by introducing output prices in the previous quarter as an additional explanatory variable. This is equivalent to assuming that the distributed lag structures have a particular shape over time, namely that after some particular quarter the lag coefficients decrease in geometric progression[5]. The geometric progression starts after the last labour cost and input price variables included in the equation so that the distributed lags are now assumed to have a geometric "tail".

As might be expected, the errors in Table II are smaller than the corresponding errors in Table I.

Examination of these results shows again, that the modal point of the labour cost lag is probably centred on the current quarter. When current labour cost is included the addition of labour cost lagged by one quarter adds little, on balance, to the explanation of output prices. This was further investigated by repeating the regressions using the average output price over the previous two years $\frac{1}{8}\sum_{i=1} P_{-i}$ in place of output price in the previous quarter. The substitution, while still approximating to the geometric tail format, has the advantage of reducing the necessarily close correlation between the variable to be explained (i.e. current output price) and the explanatory variable, output price in the previous quarter.[6] By this method it was found that the addition of labour cost lagged one quarter clearly increased the error. Hence the "best" equation as regards labour cost is taken to be that which includes only current labour cost.

For input price, it now appears that the current input price level cannot be omitted as an explanatory variable. Appropriate comparisons show that those combinations which include current input price yield the smallest errors. With current input price already included, the addition of M_{-1} and M_{-2} in general tends to reduce the errors further, but when M_{-3} and M_{-4} are added the errors are increased. In some cases, however, the addition of M_{-2} increases, or fails to decrease, the errors.[7] Once again, the repetition of the regressions with $\frac{1}{8}\sum_{i=1} P_{-i}$ in place of P_{-1} indicated that the combination M, M_{-1}, M_{-2} was best.

The equation selected as best, was therefore, that which included $\frac{W}{\pi}$, M, M_{-1}, M_{-2} and P_{-1} as explanatory variables. The regression results for this equation were,

$$\hat{P} = -0.122 + \underset{(3.11)}{0.147}\frac{W}{\pi} + \underset{(2.56)}{0.305}M - \underset{(2.30)}{0.318}M_{-1}$$
$$\underset{(1.56)}{+0.184}M_{-2} + \underset{(1.35)}{0.793}P_{-1} + \underset{(13.35)}{0.009}Q_1 + \underset{(1.65)}{0.011}Q_2 \quad (2.49)\ldots(5)$$
$$+\underset{(1.04)}{0.004}Q_3$$

$$\bar{R}^2 = .996$$
$$d = 2.32$$

Figures in brackets are t- statistics, i.e. the ratio of the estimated coefficient to its standard error. "d" is the Durbin-Watson "d" statistic, and $\bar{R}^2$ is the coefficient of determination adjusted for degrees of freedom.[8]

[4]This can be seen by comparing Rows 4, 5, 9, 12 and 14.

[5]This assumption is considered in greater detail in Appendix A.

[6]This substitution was used by Klein *et al.*, "An Econometric Model of the United Kingdom". It is considered in more detail in Appendix A.

[7]This is seen by comparing rows 6 and 10.

[8]The coefficient of determination shows the percentage of the total variation in output price which is explained by the equation. Since the unadjusted coefficient cannot be decreased by the introduction of a further explanatory variable, it is better to use the adjusted coefficient which may be decreased by the additional variable. See e.g. Christ, C. F., "Econometric Models and Methods", J. Wiley and Sons (1966), p. 509.

FIGURE II: REGRESSION EQUATION: MODEL I

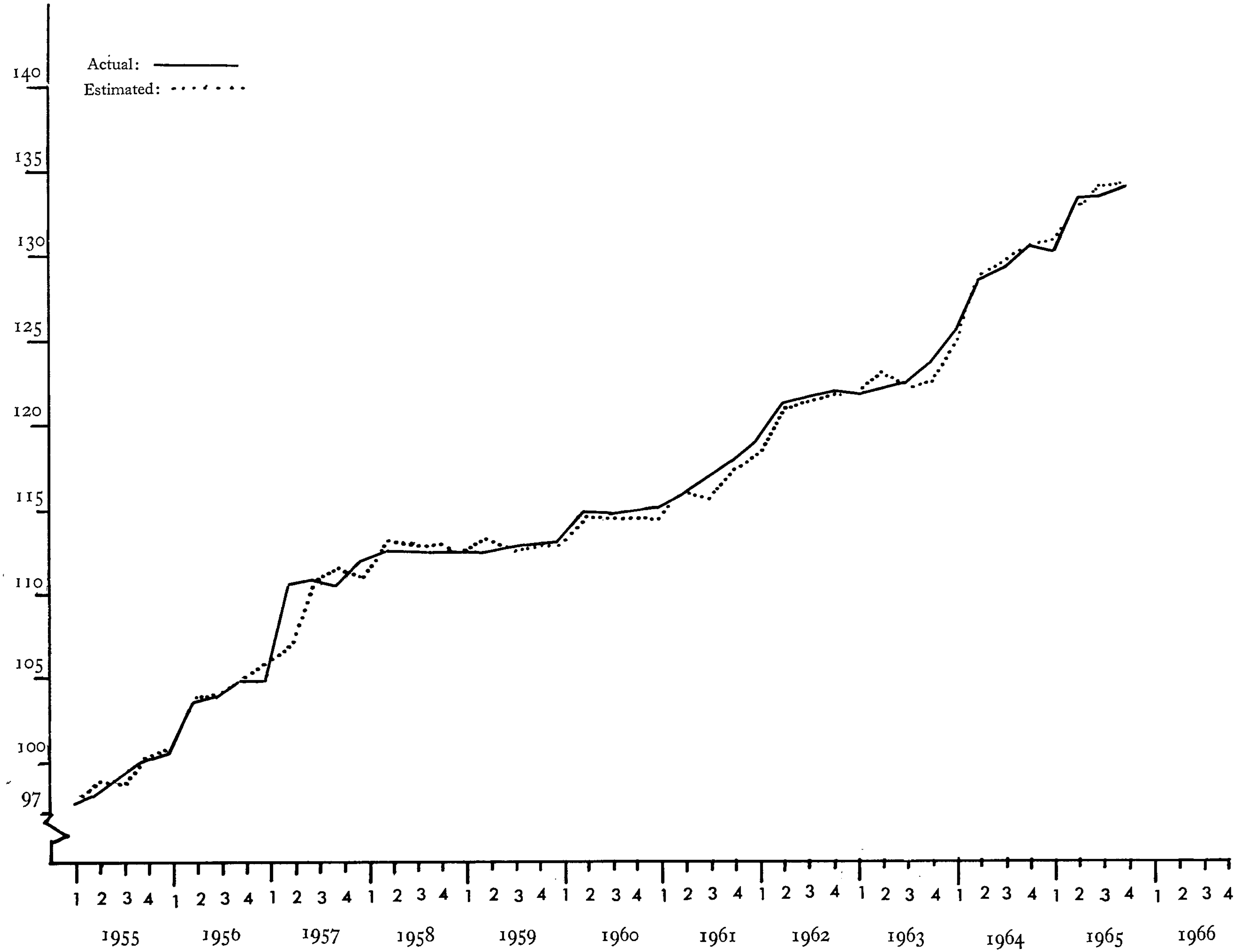


FIGURE III: FORECASTS: MODEL I

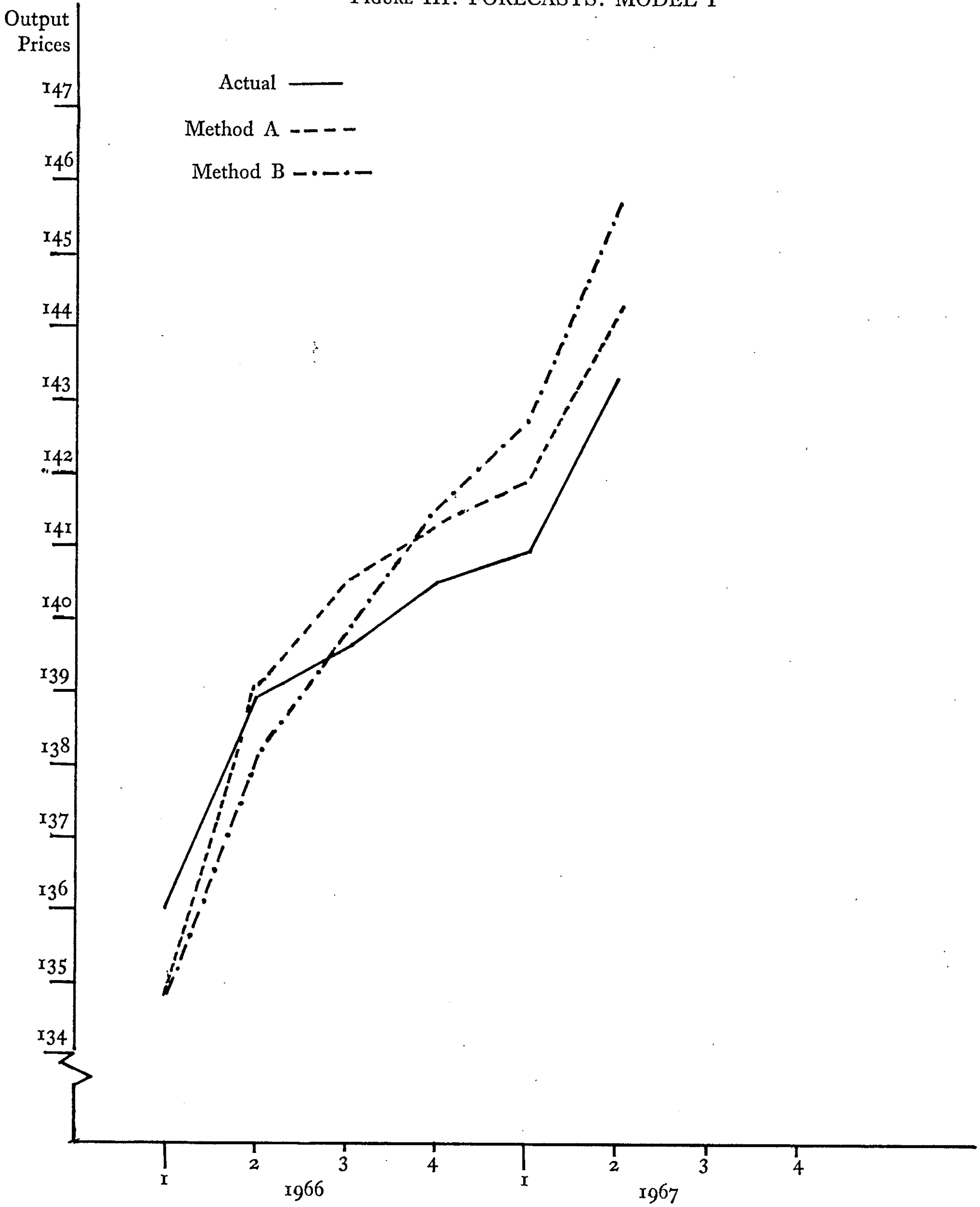


Figure II compares the actual and estimated price levels over the period 1955-1965 using Model I. Attempts to analyse the distributed lag structures on the basis of this equation proved unsatisfactory and further consideration of the lags is postponed until Section 5 below.

Attention is now turned to forecasting future levels of output price, using the estimated equation (5) above. Since no attempt has been made to explain the levels of labour cost and input price, these must be assumed known in any given quarter before an estimate of output price can be obtained. However, the level of output price in the preceding quarter can be treated in two ways. First, it may be taken as known in any given quarter since it relates to the previous quarter (see A below). Alternatively, it may be assumed that only output price in the last quarter of the regression period is known and the *estimates* of output price used in each subsequent forecast (see B below). Using this latter method, inaccuracies will be cumulative.

Both methods were used to forecast output price levels for 1966 and the first two quarters of 1967. The results are shown in Table III and Figure III.

There is little to choose between the two sets of forecasts in the early periods, though as might be expected, the discrepancy increases slightly later on. A better test than comparing orders of magnitude, is to examine the accuracy with which turning points are forecast. As can be seen in Figure III both methods forecast the upswing of prices during the first two quarters of 1966, with the subsequent levelling off, followed by the sharp upturn in the second quarter of 1967, so that all of the turning points are forecast correctly both in direction and in timing. This "best" equation supplies therefore a useful means for short-term forecasting of output price levels, once labour cost and input price levels are known, or accurately predicted.

TABLE III: ACTUAL AND ESTIMATED OUTPUT PRICE OF TRANSPORTABLE GOODS INDUSTRIES: MODEL I

		Actual output price index	A		B	
			Estimated output price index	Estimated as percentage of actual	Estimated output price index	Estimated as percentage of actual
1966	I	136·0	134·8	99·1	134·8	99·1
	II	138·9	139·0	100·1	138·1	99·4
	III	139·6	140·5	100·6	139·8	100·1
	IV	140·5	141·3	100·6	141·5	100·7
1967	I	140·9	141·9	100·7	142·7	101·3
	II	143·3	144·2	100·6	145·6	101·6

5. REGRESSION EQUATIONS: MODEL II

This section reports the statistical results found by using the Model II price equation. In Model I it was assumed that entrepreneurs' reactions to changes in labour costs were not affected by the source of the change, i.e., their reaction was the same whether the change in labour cost was due to a change in earnings or to a change in productivity. Model II allows for the possibility that they may react differently to earnings and productivity changes, by including separate earnings and productivity variables, thus permitting separate estimates of the total effects. It is to be expected that the estimated total effect of a change in earnings will have a positive sign, indicating that an upward change in earnings will lead to an upward change in output prices, and vice versa. For the estimated productivity effect, a negative sign is to be expected since changes here will tend to induce a reverse change in price.

Model I also assumed that the structure of the distributed lag for labour cost was not influenced by the source of the change. It would perhaps be more realistic to expect that a change in labour productivity would take longer than a change in earnings before its effect was manifest in output price, if only because such a change is more difficult for entrepreneurs to evaluate.

The procedure employed for finding the "best" equation was the same as that used for Model I. The explanatory variables were average hourly earnings (W), input price (M) and a labour productivity trend (π).

To reduce the number of regressions to manageable proportions, the Model I "best" equation was taken as the starting point. Thus current average hourly earnings and input price for the current and two preceding quarters were included. The regression results of the "best" equation were:

$$
\begin{aligned}
P = {} & 0{\cdot}058 + 0{\cdot}119W + 0{\cdot}285M - 0{\cdot}322M_{-1} \\
& (0{\cdot}83) \quad (2{\cdot}40) \quad (2{\cdot}07) \quad (1{\cdot}58) \\
& + 0{\cdot}244M_{-2} - 0{\cdot}149\pi_{-4} + 0{\cdot}757P_{-1} + 0{\cdot}008Q_1 \\
& (1{\cdot}71) \quad (1{\cdot}76) \quad (10{\cdot}84) \quad (1{\cdot}45) \quad \ldots(6) \\
& + 0{\cdot}010Q_2 + 0{\cdot}004Q_3 \\
& (2{\cdot}01) \quad (1{\cdot}02) \\
& \bar{R}^2 = {\cdot}996 \\
& d = 2{\cdot}31
\end{aligned}
$$

FIGURE IV: REGRESSION EQUATION: MODEL II

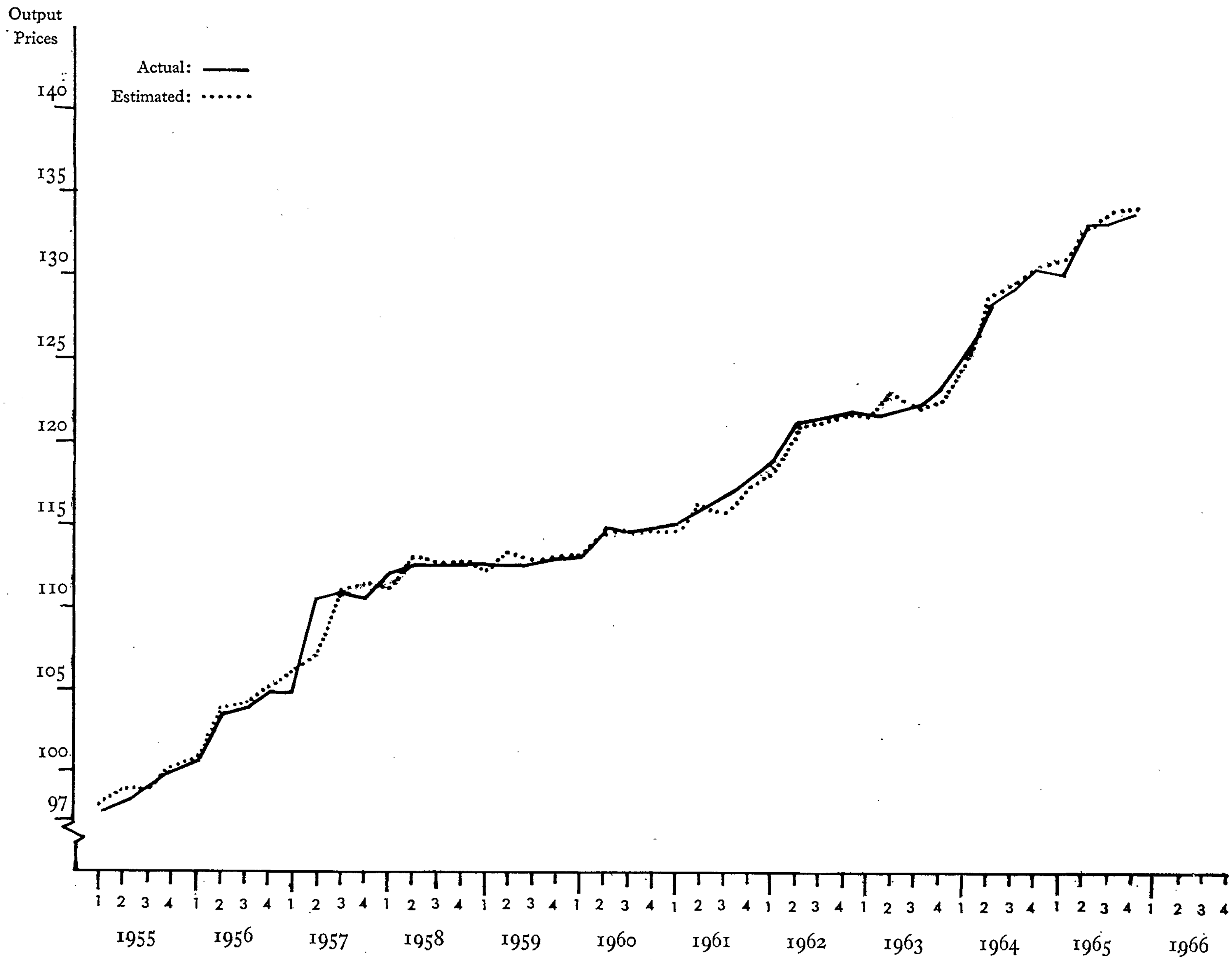


FIGURE V: FORECASTS: MODEL II

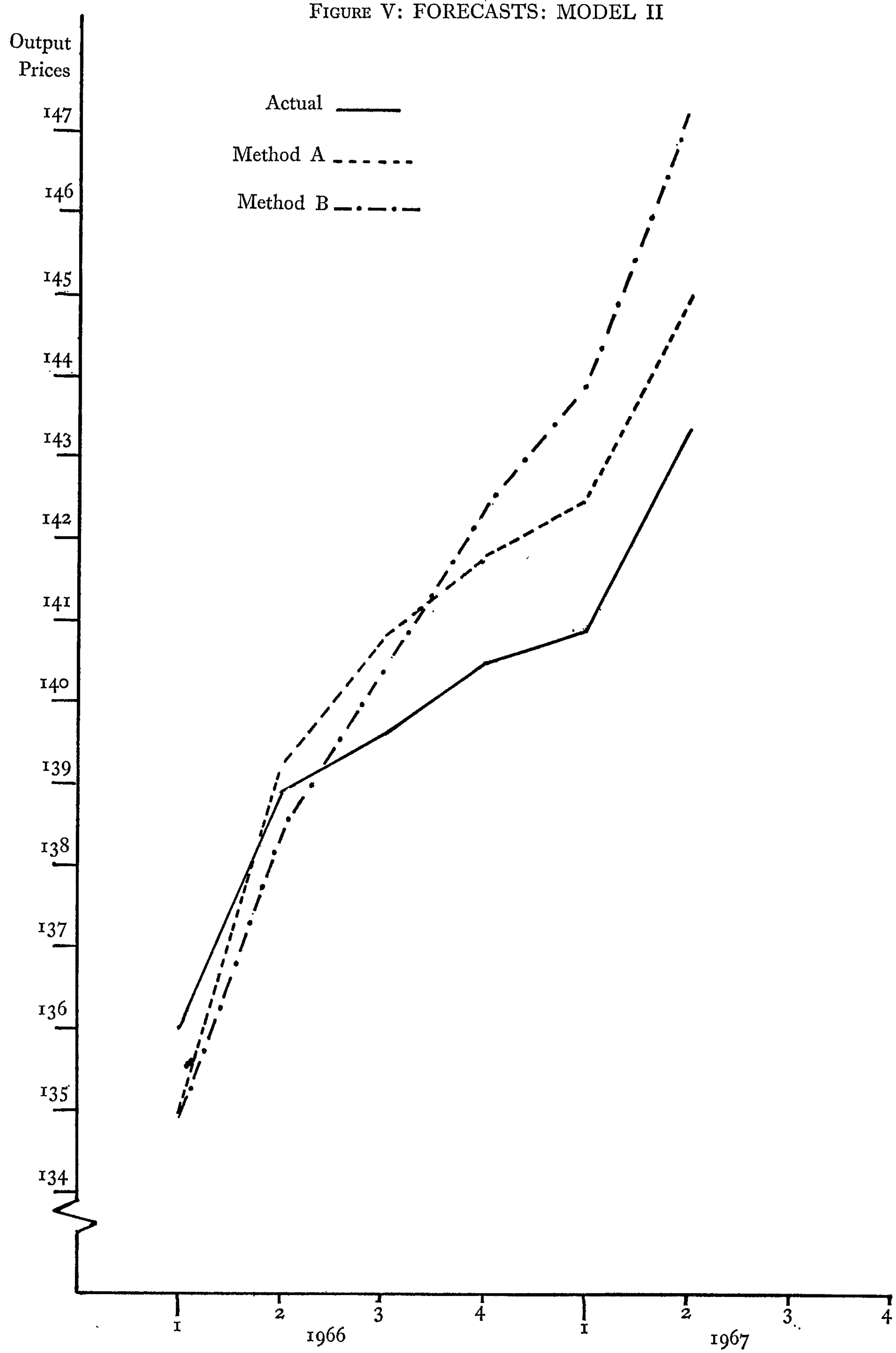


Figure IV compares the actual and estimated price levels over the period 1955-65, using Model II.

Once again, the equation proved unsatisfactory for the analysis of time lag structures, and further calculations were necessary. These are reported in Section 6 below. The equation proved useful for short-term forecasting over the six quarters following the end of 1965. Using the techniques explained for Model I, two methods of forecasting were tried and the results are shown in Table IV and Figure V.

Again, there is little to choose between the two methods in the early stages. However, method B estimates show a tendency to diverge from the actual in the last two quarters. Nevertheless, as can be seen in Figure V, both methods are successful in forecasting the turning points, both in direction and timing.

A comparison with the estimates obtained using the Model I price equation shows that for both methods, Model I gives closer estimates over the whole range. This is particularly noticeable in the two sets of A results. The ratio of estimated to actual remains fairly constant for Model I, while that for Model II tends to increase as time goes on.

Conclusion on regression equations

It would appear, therefore, that for short-term forecasting of output price levels, the Model I price equation is preferable. It is of interest to note, however, that in both Models I and II the forecasting performance of the "best" equation showed only a small improvement over any other equation. It could be argued, therefore, that for forecasting purposes virtually any one of the equations summarised in Tables I and II would be useful.

TABLE IV: ACTUAL AND ESTIMATED OUTPUT PRICE OF TRANSPORTABLE GOODS INDUSTRIES

		Actual Output Price Index	A		B	
			Estimated output price index	Estimated as percentage of actual	Estimated output price index	Estimated as percentage of actual
1966	I	136·0	134·9	99·2	134·9	99·2
	II	138·9	139·2	100·2	138·4	99·6
	III	139·6	140·8	100·9	140·4	100·6
	IV	140·5	141·8	100·9	142·4	101·4
1967	I	140·9	142·5	101·1	143·9	102·1
	II	143·3	144·9	101·1	147·2	102·7

6. TIME LAGS: MODEL I

In an attempt to establish the structures of the distributed lag effects of changes in labour cost and input price, on output price, the assumption of a geometric tail to the distributed lags was modified. Instead a series of four equations was used. In the first equation each of the lagged explanatory variables was "cut off" after the current quarter. To take account of the excluded terms the dependent variable, lagged by one quarter, was introduced as a further explanatory variable. In the second equation each lagged explanatory variable was "cut off" after the second term (i.e., only the current and immediately preceding quarters' values were included), and the dependant variable, now lagged by two quarters used to account for the excluded terms. In the third and fourth equations respectively, the lagged explanatory variables were "cut off" after the third and fourth terms, and the dependent variable was lagged by three and four quarters. In each case, the regression coefficient of the lagged dependent variable gives an approximate estimate of the proportion of total effect which has not manifested itself in output price at the time of the "cut off"[1]. These results are shown in Table V.

On the basis of the Durbin-Watson d-statistic there is no reason to reject the assumption that the disturbance terms in equation (1) are randomly distributed. The d-statistic for equation (2) is inconclusive, which means that positive autocorrelation may or may not be present. The d-statistics for equations (3) and (4) indicate significant positive autocorrelation[2].

The presence of autocorrelation may be due to the omission of an important explanatory variable. We suspect that this variable may be the level of activity in the economy. Since the interest lies in distilling out the effect of changes in the level of activity in the structure of the time lag relationship between input costs on one hand and output price on the other, it was necessary to take account of the autocorrelation by means other than by including the level of activity as an additional explanatory variable. This was done by repeating regressions (2) to (4) using first differences in place of the original data. By this means it is possible to estimate the structure of the time lag relationship between input costs and output price on the assumption that the effect of the level of activity remains neutral.

[1]*This method is discussed in more detail in Appendix A.*

[2]*A fuller discussion of these points is contained in Appendix A.*

Table V: LAG DETERMINATION, MODEL I: REGRESSION RESULTS

Eq. No.	Constant	Q_1	Q_2	Q_3	$\left(\frac{W}{\pi}\right)$	$\left(\frac{W}{\pi}\right)_{-1}$	$\left(\frac{W}{\pi}\right)_{-2}$	$\left(\frac{W}{\pi}\right)_{-3}$	M	M_{-1}	M_{-2}	M_{-3}	Dependent Variable	*d*-Statistic	$\frac{F}{F_{\cdot 05}}$
1	−0·110	0·003	0·014	0·003	0·152				0·153				0·796 P−1	2·38	
	(3·38)	(0·90)	(3·99)	(0·72)	(2·91)				(2·94)				(16·33)		
2	−0·192	0·008	0·016	0·017	0·302	−0·088			0·227	0·038			0·696 P−2	1·65	
	(5·31)	(1·30)	(3·98)	(3·93)	(3·60)	(0·96)			(1·64)	(0·26)			(12·28)		
3	−0·268	−0·005	0·005	0·006	0·308	0·040	−0·065		0·198	0·044	0·140		0·593 P−3	1·27	
	(7·01)	(0·84)	(0·92)	(1·24)	(3·15)	(0·27)	(0·60)		(1·29)	(0·18)	(0·88)		(9·60)		
4	−0·330	0·001	0·001	0·007	0·300	0·101	−0·019	0·000	0·173	−0·031	0·324	−0·016	0·480 P−4	1·08	
	(7·22)	(0·12)	(0·10)	(1·02)	(2·70)	(0·59)	(0·11)	(0·00)	(0·97)	(0·11)	(1·17)	(0·09)	(6·45)		

Table V (*a*)

Eq. No.	Constant	Q_1	Q_2	Q_3	$\left(\frac{W}{\pi}\right)$	$\left(\frac{W}{\pi}\right)_{-1}$	$\left(\frac{W}{\pi}\right)_{-2}$	$\left(\frac{W}{\pi}\right)_{-3}$	M	M_{-1}	M_{-2}	M_{-3}	Dependent Variable	*d*-Statistic	$\frac{F}{F_{\cdot 05}}$
1	−0·110	0·003	0·014	0·003	0·152				0·153				0·796 P−1	2·38	868·39
	(3·38)	(0·90)	(3·99)	(0·72)	(2·91)				(2·94)				(16·33)		
2 (*a*)	0·463	0·341	1·247	0·768	0·107	0·078			0·317	−0·006			0·110 P−2	2·36	4·58
	(2·38)	(0·76)	(3·39)	(2·10)	(1·22)	(0·88)			(2·21)	(0·04)			(0·77)		
3 (*a*)	0·352	0·130	0·662	0·673	0·131	0·091	−0·018		0·310	−0·079	0·241		0·169 P−3	2·57	4·55
	(1·84)	(0·28)	(1·57)	(2·03)	(1·51)	(1·00)	(0·20)		(2·26)	(0·53)	(1·72)		(1·27)		
4 (*a*)	0·329	0·381	0·606	0·547	0·118	0·115	−0·003	−0·021	0·343	−0·107	0·238	0·078	0·154 P−4	2·69	3·69
	(1·50)	(0·80)	(1·38)	(1·20)	(1·29)	(1·22)	(0·03)	(0·23)	(2·38)	(0·70)	(1·56)	(0·52)	(1·06)		

The Statistic $F = \frac{R^2/(k-1)}{(1-R^2)/(n-k)}$ where R^2 is the coefficient of determination, n the number of observations and k the number of parameters to be estimated, may be used to test the association between the dependent and independent variables. If F is greater than an appropriate critical value from the F tables then the association is said to be significant. This column shows the ratio of F to the corresponding critical value at a ·05 level of significance. In all cases there is a significant association.

Table V (a) summarises the results. Equation (1) is repeated to complete the table.

Each equation yields an estimate of the long-term effect of a change in labour costs, and in input costs, on output prices. It is also possible to estimate the proportions of each of these long-term effects which takes place after any given number of quarters. These estimates appear in Table VI(a)[3].

Table VI (*a*): LONG TERM EFFECT ON OUTPUT PRICE OF CHANGES IN INPUT COSTS

Equation Number	Labour Cost	Input Price
1	·745	·750
2 (*a*)	·208	·349
3 (*a*)	·245	·568
4 (*a*)	·247	·652

The estimates of the long term effects from the last three equations are reasonably consistent. The discordant note struck by equation (1) may be due to the fact that only current input prices are included in the equation.

Judging from our earlier results, lagged values of this variable are likely to be at least as important in the explanation of current output prices, and their omission may be affecting the results. The arithmetic means of the other estimates indicate that the long term effect of a change in labour costs on output price will be .233, and that of a change in input prices will be .523. This means that a ten per cent increase in labour costs will eventually raise output prices by about 2⅓ per cent, and a similar increase in input prices will eventually raise output prices by about 5¼ per cent.

Table VI(b) attempts to establish the time which we would expect to elapse between the occurrence of this ten per cent increase in labour costs and the time when output prices have risen the full 2⅓ per cent, and similarly for the ten per cent increase in input prices. (The calculations are described in Appendix A.)

Table VI (*b*): CUMULATIVE PERCENTAGES OF LONG TERM EFFECT FELT ON OUTPUT PRICE

Period elapsed	Due to labour cost	Due to input price
One quarter	65·2	29·3
Two quarters	79·4	59·5
Three quarters	87·6	90·2
Four quarters	89·7	105·5

[3]The calculations are described in Appendix A.

It is seen that in the current quarter output prices react much more quickly to a change in labour costs than to a change in input prices. Within three months 65 per cent of the effect of a labour cost change has been felt on output prices, while in the same period only 29 per cent of the effect of an input price change has been felt. On the other hand the full adjustment to labour cost changes is more protracted. After a year something like 10 per cent of the long term effect has yet to be felt while the long term effect of an input price change has been completed in less than 12 months.

Table VI (b) may be adjusted by simple subtraction to show the percentages of the long term effect occurring in any given quarter. This adjustment is shown in Table VII.

Table VII: PERCENTAGE OF LONG TERM EFFECT FELT ON OUTPUT PRICE

Period	Due to labour cost	Due to input price
In current quarter	65·2	29·3
One quarter later	14·2	30·2
Two quarters later	8·2	30·7
Three quarters later	2·1	9·8

The difference in the two distributed time lag structures can clearly be seen. That for labour costs is concentrated in the current quarter and thereafter tails off rapidly. For input prices there is a slight increase in the percentage of long term effect occurring one quarter and two quarters later. This seems plausible since manufacturers are likely to hold stocks of raw materials, and to have unfulfilled orders so that an increase in input costs is unlikely to induce them to increase their output price for some time. These results are consistent with the earlier conclusions regarding the modal points of the distributed lags.

In summary, then, we may say that, in the absence of any influence from the level of activity in the economy as a whole, a 10 per cent increase in labour costs in the transportable goods industries will lead to a 2⅓ per cent increase in output price after about a year and a half. A 10 per cent increase in input costs will lead to a 5¼ per cent increase in output price after just over nine months.

TABLE VIII: LAG DETERMINATION, MODEL II: REGRESSION RESULTS

Equation No.	Constant	Q_1	Q_2	Q_3	W	W_{-1}	W_{-2}	W_{-3}	M	M_{-1}	M_{-2}	M_{-3}	π	π_{-1}	π_{-2}	π_{-3}	Dependent Variable	d Statistic	$\frac{F}{F \cdot 05}$
1	0·023 (0·31)	0·003 (0·65)	0·014 (3·80)	0·002 (0·42)	0·069 (1·47)				0·144 (2·46)				—0·058 (0·75)				0·821 P–1 (17·02)	2·31	
2	0·018 (0·19)	0·005 (0·71)	0·016 (3·52)	0·017 (3·57)	0·231 (3·11)	—0·103 (1·36)			0·184 (1·16)	0·129 (0·73)			0·429 (0·81)	—0·576 (1·03)			0·679 P–2 (8·87)	1·59	
3	—0·045 (0·40)	—0·008 (1·09)	—0·001 (0·23)	0·004 (0·67)	0·183 (2·03)	0·102 (0·81)	—0·143 (1·55)		0·222 (1·29)	—0·104 (0·39)	0·409 (1·93)		—1·312 (1·22)	—1·868 (0·95)	0·418 (0·42)		0·516 P–3 (5·66)	1·14	
4	—0·051 (0·30)	0·001 (0·12)	0·000 (0·01)	0·001 (0·11)	0·178 (1·61)	0·092 (0·61)	0·015 (0·10)	—0·092 (0·82)	0·242 (1·10)	—0·096 (0·29)	0·274 (0·85)	0·291 (1·15)	1·447 (1·07)	—2·063 (0·84)	1·197 (0·48)	—0·738 (0·62)	0·348 P–4 (2·67)	1·09	

TABLE VIII (a)

1	0·023 (0·31)	0·003 (0·65)	0·014 (3·80)	0·002 (0·42)	0·069 (1·47)				0·144 (2·46)				—0·058 (0·75)				0·821 P–1 (17·02)	2·31	749·62
2 (a)	0·659 (2·00)	0·341 (0·73)	1·242 (3·19)	0·755 (2·03)	0·083 (1·15)	0·054 (0·75)			0·309 (2·06)	—0·002 (0·01)			—0·495 (0·60)	0·176 (0·21)			0·098 P–2 (0·66)	2·43	3·69
3 (a)	0·547 (1·74)	—0·113 (0·23)	0·588 (1·28)	0·641 (1·93)	0·111 (1·56)	0·054 (0·73)	—0·026 (0·37)		0·230 (1·55)	—0·041 (0·26)	0·257 (1·73)		0·015 (0·02)	—1·486 (1·27)	1·187 (1·42)		0·163 P–3 (1·19)	2·62	3·67
4 (a)	0·581 (1·69)	0·163 (0·29)	0·542 (1·05)	0·557 (1·08)	0·092 (1·22)	0·072 (0·90)	—0·017 (0·21)	—0·012 (0·16)	0·272 (1·63)	—0·091 (0·51)	0·266 (1·58)	0·059 (0·33)	—0·049 (0·05)	—1·195 (0·91)	0·676 (0·51)	0·284 (0·31)	0·096 P–4 (0·60)	2·69	2·61

7. TIME LAGS: MODEL II

Following the procedure adopted with Model I, a further attempt was made to establish the time lag structures of the Model II price equation. Table VIII summarises the initial results. The Durbin-Watson d-statistics for equations 2, 3 and 4 indicate the presence of positive autocorrelation. As before, these regressions were repeated using first differences of each data series in place of the original observations. This had the desired effect of removing the autocorrelation as can be seen from Table VIII (a). For ease of reference, equation 1 is also included.

Following the line of reasoning in the previous section, estimates of the respective long term effects of changes in average hourly earnings, input price and labour productivity on output price are obtained from each equation in Table VIII(a), and are shown in Table IX.

TABLE IX: LONG TERM EFFECT ON OUTPUT PRICE OF A CHANGE IN INPUT COSTS

Equation number	Earnings	Input price	Labour Productivity
1	·385	·804	—·324
2 (a)	·152	·340	—·354
3 (a)	·166	·533	—·339
4 (a)	·149	·560	—·314

The estimate of the long term effect of input price from equation 1 seems unduly large compared with those from the other equations. However, the estimates of the long term effect of labour productivity are consistent. The estimate of the long term effect of earnings from equation 1, although larger than any of the three is nevertheless reasonably consistent with the results obtained using the Model I price equation. For these reasons it was decided to use all four equations to obtain average long term effects. These are shown below in Table X.

TABLE X: LONG TERM EFFECT ON OUTPUT PRICE OF A CHANGE IN INPUT COSTS

Earnings	Input Price	Labour Productivity
·213	·559	—·333

The results indicate that a ten per cent increase in average hourly earnings would eventually have the effect of raising output price by just over 2 per cent; a similar increase in the price of raw materials would eventually lead to an increase of about 5½ per cent in output price. If productivity were to increase by ten per cent, output price would eventually fall by 3⅓ per cent.

Table XI attempts to establish the speed with which output price would react to these changes by showing, in each case, the percentage of the long term effect which has made itself felt on output price after a given period of time.

TABLE XI: CUMULATIVE PERCENTAGES OF LONG TERM EFFECT FELT ON OUTPUT PRICE

Period elapsed	Due to earnings	Due to input price	Due to labour productivity
One quarter ..	32·4	25·8	17·4
Two quarters	64·3	54·9	95·8
Three quarters	65·3	79·8	85·3
Four quarters	63·4	90·5	85·3

In the current quarter output prices react more quickly to a change in average hourly earnings than to a change in either input prices or labour productivity. At the end of three months 32 per cent of the effect of a change in earnings has been felt on output prices as compared with 26 per cent of the effect of an input price change and 17 per cent of a labour productivity change. As with the Model 1 price equation, it is found that the adjustment of output price to an earnings change takes longer than for the other variables. After a year, only about 65 per cent of the long term effect has worked through the system. This slowing down of the process of adjustment could explain the fact that the cumulative percentage for four quarters is slightly smaller than that for three quarters.

The adjustment of output price to a change in input price seems much more rapid. At the end of a year less than 10 per cent of the full effect remains unaccounted for.

The estimated percentages for labour productivity are less satisfactory. The findings in section 5 lead one to suspect that recent productivity changes exert very little influence on Irish entrepreneurs' pricing policy so that the conclusion that as much as 17.4 per cent of the long term effect occurs in the current quarter is questionable.

This overestimation would also seem to apply to the second quarter, by which time it is estimated virtually 95 per cent of the full effect has taken place. Previous indications are that the greatest weight occurs in the third or fourth quarter. The present estimates are rendered more suspect by the fact that the cumulative percentage of the full effect appears to fall after the second quarter.

A further investigation into the structure of the time lag of the effect of labour productivity changes on output price was carried out by repeating the regressions in Tables VIII and VIII(a) at a higher level of significance.[1] This procedure drops from the

[1]The level of significance used was 10 per cent.

TABLE XII: LAG DETERMINATION, MODEL II; REGRESSION RESULTS (10 PER CENT. LEVEL OF SIGNIFICANCE)

Eq. No.	Con-stant	Q_1	Q_2	Q_3	W	W_{-1}	W_{-2}	M	M_{-1}	M_{-2}	M_{-3}	π	π_{-1}	π_{-2}	π_{-3}	Dependent Variable	*d* Statistic
1*			0·013 (4·70)		0·039 (3·88)			0·142 (4·21)								0·822 P–1 (19·63)	2·2825
2*			0·014 (3·82)	0·012 (3·31)	0·104 (4·09)			0·267 (6·48)					−0·101 (1·70)			0·730 P–2 (15·97)	1·4175
3*		−0·009 (2·65)			0·243 (5·60)		−0·084 (2·06)	0·188 (2·48)		0·230 (2·66)				−0·180 (2·92)		0·608 P–3 (11·80)	1·3454
4*					0·236 (8·54)			0·196 (2·48)		0·200 (1·73)	0·298 (2·49)	0·451 (2·09)			−0·730 (3·30)	0·341 P–4 (4·16)	1·0765

TABLE XII (*a*)

1*			0·013 (4·70)		0·039 (3·38)			0·142 (4·21)								0·822 P–1 (19·63)	2·2825
2* (*a*)	0·709 (4·95)		1·020 (4·54)	0·521 (2·29)				0·267 (3·04)									2·0967
3* (*a*)			0·638 (2·35)	0·801 (3·62)	0·150 (3·19)			0·276 (3·02)		0·230 (1·92)						0·264 P–3 (2·46)	2·4704
4* (*a*)				0·672 (2·99)	0·164 (3·37)			0·204 (2·24)		0·367 (3·52)						0·221 P–4 (2·02)	2·4350

regression equations those variables whose regression coefficients are not significantly different from zero. The criterion used is the t-test which examines the ratio of the estimated coefficient to the estimate of its standard error. If the ratio is below a critical level, determined by the level of significance at which the test is conducted and the number of degrees of freedom,[2] then the variable will not be included in the regression since it has not been shown to be adding significantly to the explanation of the output price. It might be expected that this would eliminate current productivity as an explanatory variable. The regression results, using both original data and first differences, are summarised in Tables XII and XII(a).

The productivity variable was not significant (on the basis of the t-test) in any of the regressions using first differences. In equation 1* current productivity (π) was included but was not found to add significantly to the explanation of output price. Both π and π_{-1} were included in equation 2* but only π_{-1} was found to be significant. In equation 3*, π, π_{-1}, and π_{-2} were included but only π_{-2} was significant. In equation 4*, π, π_{-1}, π_{-2} and π_{-3} were included, only π and π_{-3} being significant. The retention of π was somewhat surprising, especially since its coefficient has a positive sign. One would expect an increase in labour productivity to be associated with a fall in output price, so that the relationship should be characterised by a negative sign for the productivity coefficient. However, the sum of the coefficient of π and π_{-3} is negative. In general therefore these results are in agreement with expectations and with the results of Section 5.

Unfortunately equations 2*, 3* and 4* are subject to autocorrelation. The estimated long term effect of a change in labour productivity on output price, based on these four equations, is -·314. This agrees closely with the estimate based on the equations in Table VIII (a), and indicates that a three per cent increase in labour productivity would reduce output price by one per cent. The length of time necessary for this one per cent fall in prices is examined in Table XIII.

TABLE XIII: CUMULATIVE PERCENTAGES OF LONG TERM EFFECT FELT ON OUTPUT PRICE

Period elapsed	Due to labour productivity
One quarter ..	0
Two quarters ..	32·2
Three quarters ..	57·3
Four quarters ..	88·9

[2]The number of degrees of freedom is found by subtracting the number of coefficients to be estimated in the regression from the number of observations on which the regression is based. With a 10 per cent. level of significance the critical *t*-value is around 1·3, its exact value depending on the number of degrees of freedom involved.

This shows that in the current quarter entrepreneurs do not adjust prices in the light of labour productivity changes. This is consistent with the pricing hypothesis which the Model II price equation represents, *viz.* that entrepreneurs are concerned with long term trends of productivity rather than with short-run changes when fixing price levels. After two quarters 32.2 per cent of the long-run effect has been felt on output prices, i.e., prices would fall by about ⅓ per cent in response to a 3 per cent increase in productivity after six months. At the end of nine months prices would have fallen by just over ½ per cent, and after a year prices would have fallen by ⅘ per cent.

These price changes can only be regarded as approximations, since the equations from which they are derived are subject to autocorrelation. This has the effect of reducing the accuracy of the estimates in the sense that they are subject to wider fluctuations than estimates from equations whose residuals are non-autocorrelated. Even with this qualification they are more consistent with the findings thus far, so that the evidence seems to favour their acceptance in preference to the first estimates.

The weights, or percentages of long term effect, occurring in specific quarters may be found from the cumulative percentage tables by a series of subtractions. The weights are shown in Table XIV.[3]

TABLE XIV: PERCENTAGE OF LONG TERM EFFECT FELT ON OUTPUT PRICE

Period	Due to earnings	Due to input price	Due to labour productivity
In current quarter	32·4	25·8	0
One quarter later	31·9	29·1	32·2
Two quarters later	1·0	24·9	25·1
Three or more quarters later ..	34·7	20·2	42·7

This indicates that a ten per cent increase in average hourly earnings will push up output prices by about ·7 per cent (i.e., ·324 of 2·13) in the current quarter. By the end of the second quarter prices will have risen a further ·7 per cent. At the end of nine months a further ·74 per cent increase in prices is in the pipeline.

The effect of a ten per cent increase in input prices will work through to output prices in almost equal instalments over four quarters. Thus in the current quarter, output prices will rise by 1.4 per cent (i.e., ·258 of 5·59). In the second quarter they will rise a further 1·6 per cent, and in the third quarter by a

[3]These results are tentative since the estimates for earnings and input price are taken from the regression equations at a 99·99 per cent. level of significance while those for productivity are taken from the regression equations at a 10 per cent. level of significance.

further 1·4 per cent. The remaining 1·1 per cent increase will take place in the fourth and following quarters.

A ten per cent increase in productivity will not affect output prices in the current quarter. At the end of the second quarter prices will have fallen about one per cent. At the end of the third quarter they will have fallen a further .8 per cent. The remaining 1.3 per cent decrease in prices will take place in the succeeding six months or so.

Conclusion on time lags

(*a*) The estimated total effect of a change in labour cost on output price (Model I) is very close to the estimated total effect of a change in average hourly earnings on output price (Model II). This is consistent with the view that pricing policy is not sensitive to current changes in productivity. The estimated lag structure for earnings is not as well established as that for labour cost, and indicates a longer period of adjustment than that estimated for labour cost. This is perhaps due to the influence of productivity changes entering towards the end of the lag structure for labour cost.

(*b*) The estimates of the total effect of an input price change on output price from both models are also in close agreement, as are the estimated lag structures.

(*c*) The difficulty of establishing the lag structure of the productivity effect on output price may be due to the lag of several quarters during which productivity changes have little or no effect on output price. It does not appear to be due to the use of a trend of productivity in the regressions, because the substitution of actual productivity for trended productivity did not improve the results.

8. EFFECTS OF UTILISATION OF CAPACITY

The hypothesis to be investigated in this part of the paper is that the process of full-cost pricing may be modified by the amount of excess capacity which entrepreneurs have available: entrepreneurs may be willing to cut their margins, perhaps by delaying price increases, when activity is at a low level and may seek an expansion of their margins, perhaps by anticipating price increases, when the economy is booming. The technique used to explore this hypothesis is to compare actual output prices, P, with the prices estimated on the bases of the best equations from Models I and II (see Figures II and IV), $\hat{P}$, and to compare the differences between these two series with an indicator of the utilisation of capacity. Since the estimated series is based on a pure full-cost pricing equation and is hence not influenced by variations in the utilisation of capacity the deviations of P from $\hat{P}$ ought to show up the effects of variations in utilisation, if such effects are present.

The deviations of estimated prices from actual prices can be conceived in two ways, either as the absolute difference between P and $\hat{P}$ at a given point of time, or as the length of time required for P to reach the level attained by $\hat{P}$ at a given point of time. The first series is represented by the vertical differences between the series of P and $\hat{P}$ charted in Figures II and IV; the second series is represented by the horizontal differences between the two series.[1] These two versions of the deviations correspond to the two formulations of the modified full cost-hypothesis set out on page 1 above. Excess capacity may be seen as having its effect either on the average margin which entrepreneurs add to variable costs or on the length of the time-lag between changes in variable costs and changes in output prices.

Capacity and utilisation of capacity

The estimates of capacity and utilisation of capacity presented here are similar in broad conception to the estimates produced by Professor F. W. Paish in his study of industrial capacity and inflation in the United Kingdom[2]. The general method is to take production at a low level of unemployment as an indicator of industrial capacity. The percentage rate of unemployment in transportable goods industries reached a low level—about 3½%—in the third quarter of the boom year of 1955; the four-quarterly moving average of the production index for transportable goods reached its peak in the fourth quarter of the same year and it has been assumed that capacity was fully utilised at that time, i.e., that the volume of production for that date is an indicator of capacity.[3]

Unemployment again fell to around 3½ per cent in the third quarter of 1961 and it is tempting at first sight to assume that the growth of production between 1955 and 1961 is an indicator of the growth of capacity. But there is a clearly marked change of pace in the Irish economy in 1958 and it cannot be assumed that the rate of growth of capacity proceeded smoothly through that date. Unfortunately the movement of the unemployment rate gives little

[1]For a discussion of some of the problems involved in measuring the horizontal differences, see Appendix B.

[2]F. W. Paish, *Output, Inflation and Growth,* Ch. 17.

[3]This base is only used for comparison of levels of capacity utilisation. It is not implied that this represented maximum possible production at that time.

guidance over the period for whereas between the last quarter of 1955 and the second quarter of 1958 the moving average of the unemployment rate increased by almost one third, the index of industrial production fell by only 2½ per cent. It seems probable therefore that some increase in capacity was taking place even though there was considerable excess capacity available.

The estimates of capital stock[4] over the period give some confirmation to this impression. Nevin's estimates of mid-year capital stock of Irish manufacturing industry show an increase of 1.4 per cent per annum between 1955 and 1958, a movement from £220.6 millions to £230.1 millions at 1958 prices. In the absence of any other indicators it has been assumed that capacity increased at the same rate as capital stock, that between the last quarter of 1955 and the second quarter of 1958 capacity increased by 0·34 per cent per quarter.

After the second quarter of 1958 it has been assumed that capacity increased at an annual rate of 7 per cent per annum. The bases for this assumption are two: (a) the trend rate of growth of production between 1959 and 1964 was of the order of 7 per cent, (b) the capacity index calculated in this way gives a figure for utilisation of capacity of over 99 per cent in the third quarter of 1961 which is fairly consistent with the fact that unemployment had again fallen below 3½ per cent by that date.

Extension of the capacity index beyond 1964 at an annual rate of growth of 7 per cent produces an increasing divergence between the capacity index and the production index. This corresponds with general impressions of the state of the economy during these years. For example the target growth rate for industry under the Second Programme was 7 per cent per annum for the years 1964-70; the actual growth rate for the years 1964-1967 was 5·8 per cent, mainly because of the "slow rate of increase in 1965 and 1966 when domestic demand was sharply curtailed."[5]

Two factors were operating to slow the rate of growth of capacity during this period. First, there was a reduction in the trend rate of growth of employment in transportable goods industries after 1964. The average annual rate of growth of employment between 1959 and 1963 was about three per cent; between 1964 and 1967 it was under 1 per cent. Second, there was a slowing down in the rate of growth of investment in industrial plant and equipment. After a period of rapid growth between 1959 and 1963 Gross Fixed Capital Formation in the category "other machinery and equipment" showed only a marginal increase between 1963 and 1964. There was some recovery in 1965 but in 1966 investment under this heading showed a decrease on the 1965 level.

On the other hand there is evidence that as a result of adaptation grants, the increasing use of consultants in industry and the general emphasis on the need to increase competitiveness to meet the challenge of entry to the E.E.C., Irish industry was increasing its efficiency over the period[6]. It is difficult to judge the overall effects of these conflicting influences upon capacity. Some observations of output at very low levels of unemployment would have provided an indication of output at or near full capacity levels, but unemployment in transportable goods rose steadily after 1964 so that no guidance is forthcoming from this source.

In the absence of a solid basis for the capacity index it has been necessary to fall back on a broad guess: it has been assumed that after the fourth quarter of 1963 capacity grew marginally slower than during the preceding five years, at an annual rate of 6.5 per cent compared with 7 per cent. for the earlier period. Some support for this choice of growth rate is given by the fact that the implied utilisation of capacity is closely correlated with the movements of employment between 1964 and 1967; (see Figure VIII).

The capacity index is plotted, with the moving average of production, in Figure VI. The index rises at 1·35 per cent per annum between the end of 1955 and the second quarter of 1958, at 7 per cent per annum between 1958 and the end of 1963 and thereafter at 6½ per cent per annum. Figure VII shows utilisation of capacity, i.e., production expressed as a percentage of capacity.

Comments on the Capacity Index

The estimates of productive capacity presented here rest on two general assumptions: first, that capacity changes fairly smoothly through time, that it is not subject to sharp annual fluctuations; and second that output at low levels of unemployment is a fairly reliable indicator of normal capacity output. The first of these assumptions is not too difficult to justify. Net investment in fixed assets may vary from year to year; but these variations are likely to be small in relation to the outstanding stock of fixed assets in transportable goods industries so that short-term variations in the growth of productive potential emanating from this source are probably small. The other major sources of increased output per head, general improvements in the quality of organisation

[4]Nevin, E., "The Capital Stock of Irish Industry", Economic Research Institute, Publication No. 17.

[5]*Second Programme of Economic Expansion. Review of Progress* 1964/1967 Para. 1.04.

[6]*Review of Progress*. Para. 5.09.

Figure VI: TRANSPORTABLE GOODS INDUSTRIES: PRODUCTION (4 QUARTER MOVING AVERAGE) AND CAPACITY

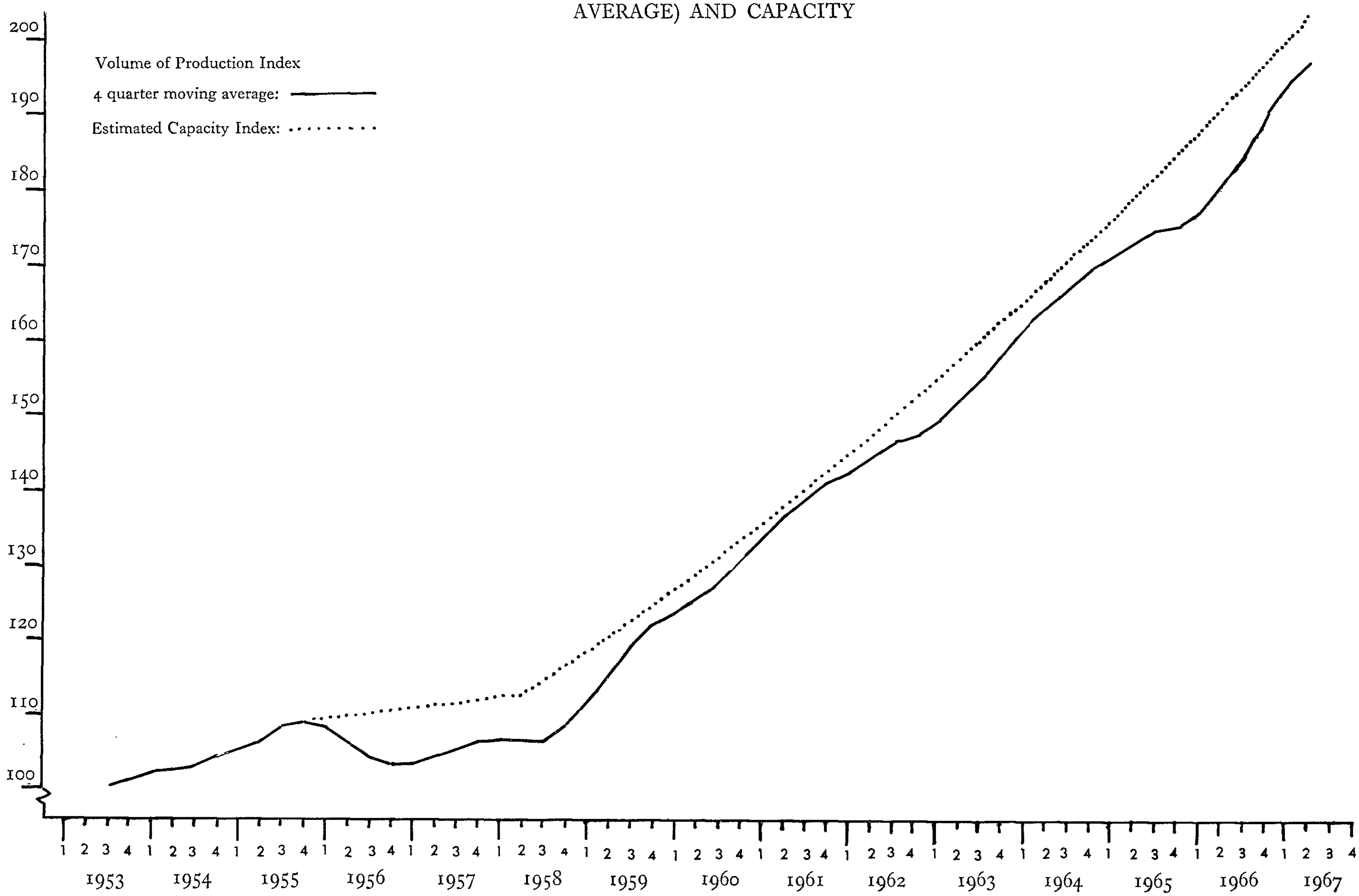
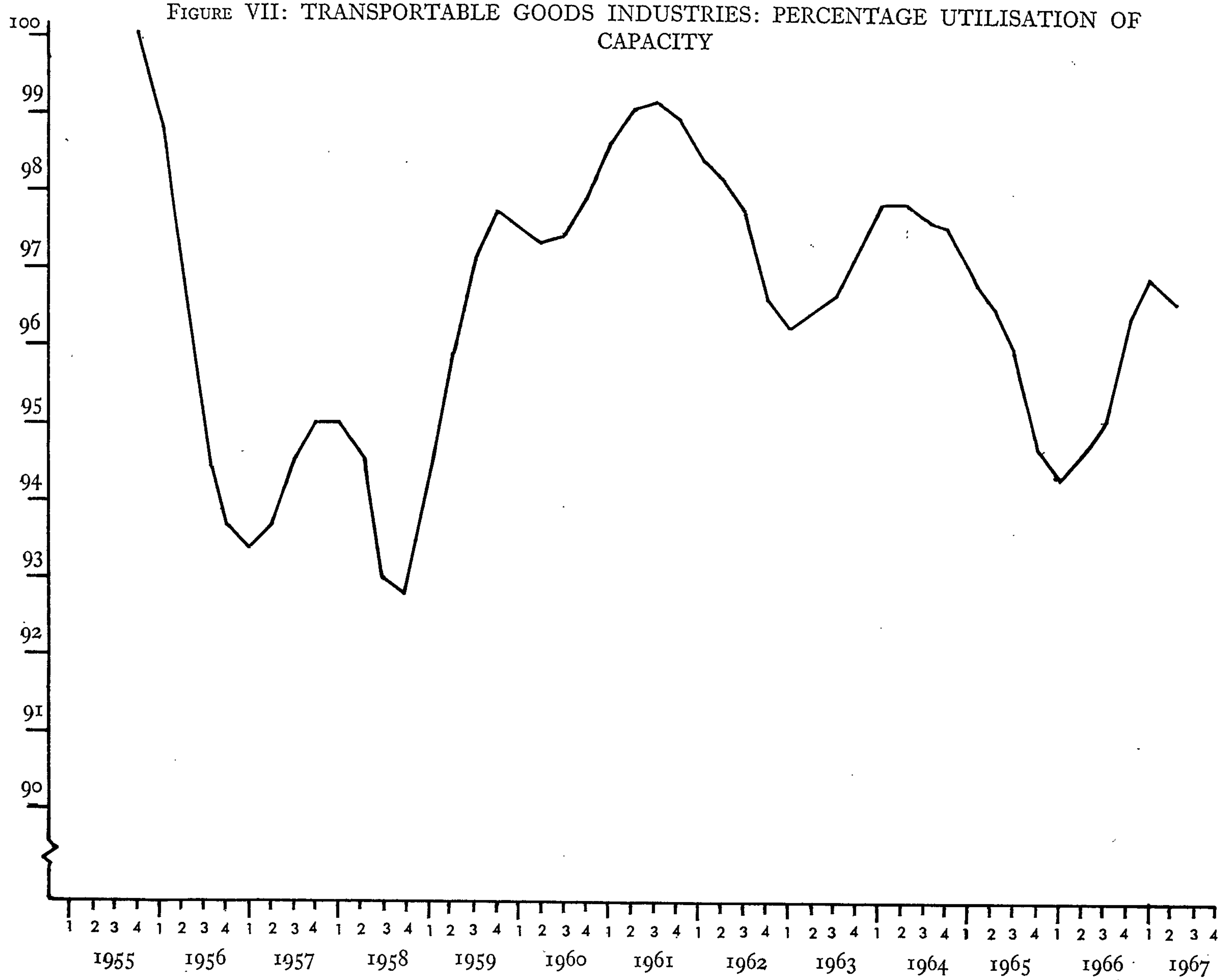


FIGURE VII: TRANSPORTABLE GOODS INDUSTRIES: PERCENTAGE UTILISATION OF CAPACITY



and management, are, by their very nature, likely to exert their effects smoothly through time.

It is not suggested that the rate of increase of output per head does not vary through time; as has already been noted, there is evidence that the rate of growth of labour productivity measured in terms of output per head accelerated rapidly after 1958, and accelerated again after 1963. But the year to year variations in the rate of growth are probably sufficiently small to ensure that a smooth curve linking outputs at similar levels of utilisation of capacity separated by a small number of years gives a reasonable approximation to the annual movements of capacity.

The second assumption is more troublesome in an Irish context. The implication of the assumption is that short-term variations in unemployment are an indication of deviations from the "normal" labour force associated with the full capacity output of industry and that output at a very low level of unemployment is an indicator of full capacity output. The lowest levels of unemployment achieved in any economy will depend to a large extent upon the nature of the labour market in the economy, the level of labour turnover and the overall demand for labour, the incentives to register for unemployment benefit or alternative employment, the propensity to emigrate when job opportunities diminish and other factors. In the United Kingdom, for example, unemployment has occasionally fallen to around 1 per cent of the insured labour force; in Ireland the lowest figure reached for unemployment in industries producing transportable goods in recent years was around 3½ per cent.

This in itself would not raise serious difficulties for the calculation of the capacity index if the rate of unemployment associated with full capacity operation could be assumed to remain fairly constant through time. But lack of sensitivity of the unemployment rate to changes in employment would mean that changes in unemployment could not be used as advance indicators of changes in the *utilisation* of capacity. In Figure VIII unemployment and utilisation of capacity have been plotted together. There is fairly clear visual evidence of the inverse correlation between the two series with turning points in early 1957, late 1958, mid-1961 and mid-1964. The relative dimensions of the movements of the two series, however, show considerable irregularities: between 1957 and 1961, for example, the unemployment rate fell by about 3 percentage points, from around 6½ per cent. to around 3½ per cent.; utilisation of capacity rose by about 5½ percentage points, from under 93½ per cent to just over 99 per cent. Between 1961 and 1963, on the other hand, a rise of 0.4 percentage points in the unemployment rate was associated with a fall of over 3 percentage points in the utilisation of capacity. Moreover there is conflicting evidence for the end of the period under review: the index of utilisation of capacity turned upwards after the first quarter of 1966 and appears to have moved upwards during the last half of 1966 and the early months of 1967; during the same period the unemployment rate moved steadily upwards also.

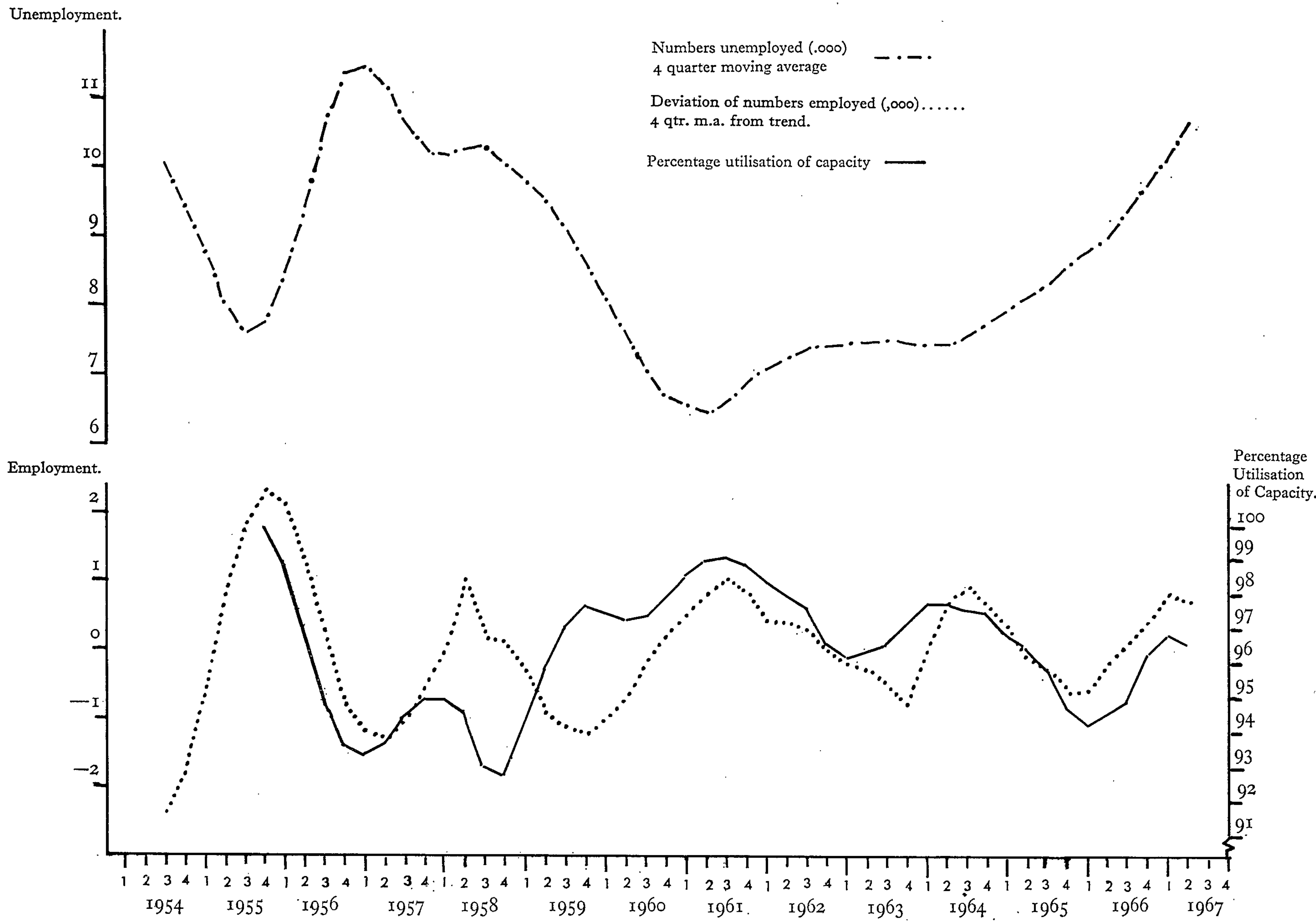
Since the trouble with the unemployment figures is that they do not adequately reflect changes in employment the utilisation index might be expected to be more closely related to the index of employment itself. In Figure VIII deviations from the trend of employment[7] are plotted with the utilisation index. The scales have been chosen so that the ranges of the variations in the indices are roughly similar. With the exception of the year 1959 the correlation between the two series appears to be fairly close, not only in the timing but in the amplitude of the movements. Broadly speaking a change of about one percentage point in employment—measured as a deviation from the trend—is associated with a change in the utilisation of capacity of about 3 percentage points.[8]

The inverse relationship between the movement of employment and the movement of unemployment is not close, however. For example, the employment index reflects the rise in utilisation during 1966 and 1967 with the curious result that during this period employment and unemployemnt in transportable goods industries are rising simultaneously.

[7]The trend consists of three straight lines fitted to the periods 1955–58, 1958–1963 and 1964–1967; the three periods were identified by inspection. The overlapping points on the straight lines were smoothed by interpolation.

[8]In the United Kingdom fluctuations in utilisation appear to be about twice as large as the associated fluctuations in employment which are in turn about 2½ times as large as fluctuations in unemployment. Cf. Godley, W. A. H. and Shepherd, J. R., "Long Term Growth and Short-term Policy", *National Institute Economic Review*, No. 29, August, 1964. Paish, F. W., "How the Economy Works", *Lloyds Bank Review*, April, 1968, p. 15.

FIGURE VIII: TRANSPORTABLE GOODS INDUSTRIES: EMPLOYMENT, UNEMPLOYMENT AND PERCENTAGE UTILISATION OF CAPACITY



9. UTILISATION AND PRICES

The hypothesis to be tested is that the mark-up which entrepreneurs add to variable costs, or alternatively the structure of the lags between cost changes and price changes, are influenced by the degree of utilisation of capacity. Statistically, the mark-ups and lag structures estimated in Sections 4 to 7 above can be regarded as averages for the period 1955-1965. If the hypothesis is correct, prices estimated on the basis of equations (5) and (6) above will tend to be greater than actual prices when the utilisation of capacity is low, and less than actual prices when utilisation is high. Similarly, the lag structure will tend to be elongated when utilisation is low and telescoped when utilisation is high.

The first version of the hypothesis was tested by measuring the difference between actual and estimated prices at each point of time. The units of measurement are in index numbers of output price and these measurements will be referred to as the vertical differences. The second version was tested by measuring the time lag between the date that estimated price was at a particular level and the date that actual price reached the same level. The unit of measurement is time, and the measurements are referred to as the horizontal differences.

Figure IX (a) shows vertical differences plotted against percentage utilisation of capacity. The scatter of points suggests some support for the hypothesis: there is a tendency for actual prices to be above estimated prices (i.e., for the vertical differences to be positive) when utilisation is high, and for actual prices to be below estimated prices when utilisation is low.

Four points stand out from the others in that they indicate actual prices *above* estimated prices when utilisation was low. It is significant that these points represent the four quarters of 1957—a year in which, by any standards, conditions were exceptional in the Irish economy.[1] An attempt has been made to take some account of this factor by the somewhat statistically dubious procedure of leaving the data for 1957 out in the calculation of the regression equation and the coefficient of determination.

The linear regression equation of vertical difference on utilisation was

$$V = -11{\cdot}281 + 0{\cdot}116U$$
$$(5{\cdot}09) \quad (5{\cdot}10)$$

The coefficient of determination (R^2) was 0.45. When data for 1957 were included the coefficient of determination was 0.19. When the data for 1957 are ignored the scatter assumes a markedly curvilinear character. A second degree curve fitted to the data yielded the equation

$$V = 57{\cdot}387 - 1{\cdot}311U + 0{\cdot}007U^2$$
$$(0{\cdot}55) \quad (0{\cdot}60) \quad (0{\cdot}66)$$

The coefficient of non-linear determination (R^2) was 0·46.

Thus 46 per cent of the variation in the vertical differences is explained by a second degree relationship between the vertical differences and percentage utilisation of capacity. A second degree relationship implies that at any given level of capacity utilisation the upward movement of profit margins due to an increase in capacity utilisation will be greater than the downward movement that would result from a fall in capacity utilisation. In other words, it would appear that entrepreneurs are more prone to increase profit margins in good times than they are to decrease them in bad times.

The estimated relationship indicates that when production is operating at about 97 per cent of capacity, the level of activity does not exert any influence on profit margins, i.e. the vertical difference between P and $\hat{P}$ is zero. To some extent, therefore, 97 per cent utilisation of capacity may be regarded as the norm, since it is the level at which entrepreneurs have no incentive to change profit margins. If the level of activity was 3 per cent below the norm this would cause a negative vertical difference of 0·35 percentage points. This difference, however, must be seen in relation to price changes rather than price levels. Thus the average annual increase in output price over the period 1955 I to 1965 IV was 2·5 per cent. If the percentage utilisation of capacity at any time were as low as 94 per cent, then a typical annual price increase might be reduced by about 0·35 percentage points, i.e. 14 per cent of the price increase would be absorbed by reducing profit margins. Similarly, if at any time the level of activity were 3 per cent above the norm, this might cause a positive vertical difference of 0·45 percentage points, i.e. expanding profit margins would add on a further 18 per cent to a typical annual price increase.

Because this relationship accounts for less than half the total variation in the vertical differences, these results cannot be regarded as conclusive. It may well be that the effect of utilisation on profit margins is more complex than the simple relationship examined here. For example, entrepreneurs may take account not only of the level of activity, but also of changes in the level of activity. A preliminary attempt to examine this possibility was made by regressing vertical differences on first differences of

[1] In 1957, stringent remedial measures were taken to counteract the balance of payments crisis of 1956. The effect was a sharp contraction in industrial output and in the utilisation of capacity. Cf. *Economic Conditions in Ireland and Portugal,* O.E.E.C., 1957, p. 8.

the level of activity. The results were not significant; but it remains possible that a relationship involving *both* the level of utilisation and the direction of its movement would yield a more conclusive connection between the two. In the present study, it was not possible to pursue the question further.

Figure IX (b) shows horizontal differences plotted against percentage utilisation of capacity. The scatter of points suggests some support for the hypothesis that the lag structure will tend to be elongated when utilisation is low, and to be telescoped when utilisation is high. Once again the observations for 1957 are an exception, and as before, were omitted from the following estimations. One further point is noteworthy. The observations for 1958, while in keeping with the hypothesis, are somewhat large. This highlights a difficulty in the measurement of horizontal measurements: because actual output prices were constant throughout 1958 the horizontal differences became very large.[2]

The scatter of points suggested a linear relationship. When 1957 was excluded, the results were

$$H = 58{\cdot}971 - 0{\cdot}605U$$
$$(7{\cdot}63) \quad (7{\cdot}59)$$

The coefficient of determination was 0·65. (When 1957 was included the coefficient of determination was 0·54.)

There is, therefore, fairly strong evidence to support the hypothesis that the lag structures are not constant over time, but vary with the level of activity.

The estimated relationship indicates that when production is operating at around 97 per cent. of capacity, the level of activity does not exert any influence on the distributed lag structures between changes in input prices and the resultant output prices. This agrees broadly with the estimated "normal" level of utilisation from the vertical differences. A deviation of one per cent. in either direction from the normal level of capacity utilisation will result in a change of just over a half of one quarter in the lag structures. Thus if utilisation is one per cent. below normal, the lag structures would be prolonged by something like 1½ to 2 months. This may appear large in comparison with the estimated effect of utilisation on the vertica differences, i.e., on profit margins; but it must be borne in mind that the initial impact of variable cost changes on output price is quite large so that an elongation of the time lag structure might only result in a prolongation of the later (and much smaller) effects.

[2]This difficulty is discussed in more detail in Appendix B.

A similar analysis was conducted for the vertical and horizontal deviations from the Model II price equation. On the whole the results were less satisfactory than those for Model I. In the interests of completeness, however, the results are summarised in Table XV.

TABLE XV: COEFFICIENTS OF DETERMINATION: MODEL II

	Vertical differences		Horizontal differences	
	Linear	Second degree	Linear	Second degree
With 1957	·03	·07	·45	·46
Without 1957	·18	·21	·51	·54

Conclusions on Utilisation and Prices

(*a*) The results indicate that entrepreneurs' pricing policy is probably influenced by the level of activity when the percentage utilisation of capacity deviates from a "normal" level of around 97 per cent.

(*b*) The mark-up which entrepreneurs add to variable costs will, on average, be reduced by about 14 per cent. if percentage utilisation of capacity is 3 per cent. below normal, and will be increased by about 18 per cent. if percentage utilisation of capacity is 3 per cent. above normal.

(*c*) The time lag after which the total effects of changes in variable costs are manifest in output price will be prolonged (or shortened) by just under 2 months for each percentage point deviation below (or above) the normal percentage utilisation of capacity.

(*d*) Although there is evidence that price changes may be influenced by the utilisation of capacity, the coefficient of determination indicates that this relationship should not be used other than as an indication of the direction of the adjustments which should be made. Exact adjustments, in the form expressed in (*b*) and (*c*) above, may give an impression of precision which could be misleading.

FIGURE IX (*a*): TRANSPORTABLE GOODS INDUSTRIES: VERTICAL DIFFERENCES (4 QUARTER MOVING AVERAGE) AGAINST PERCENTAGE UTILISATION OF CAPACITY

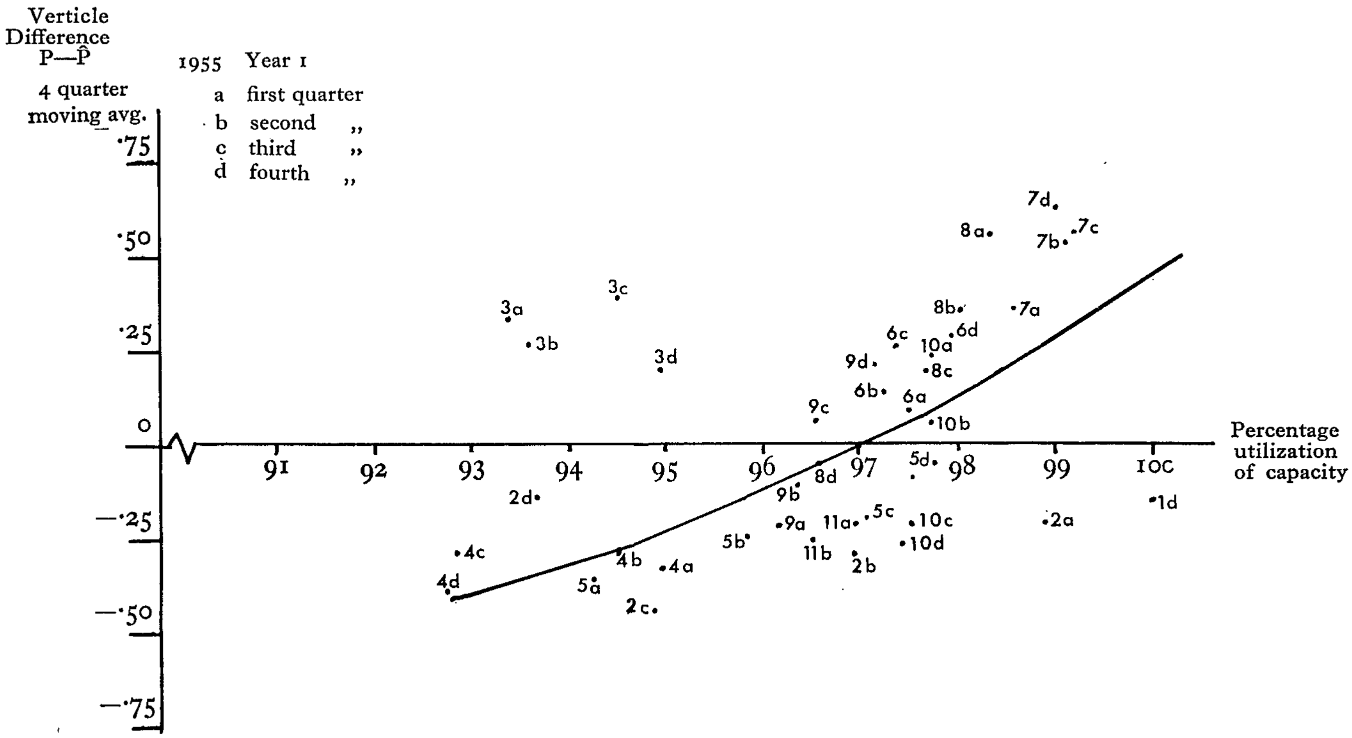
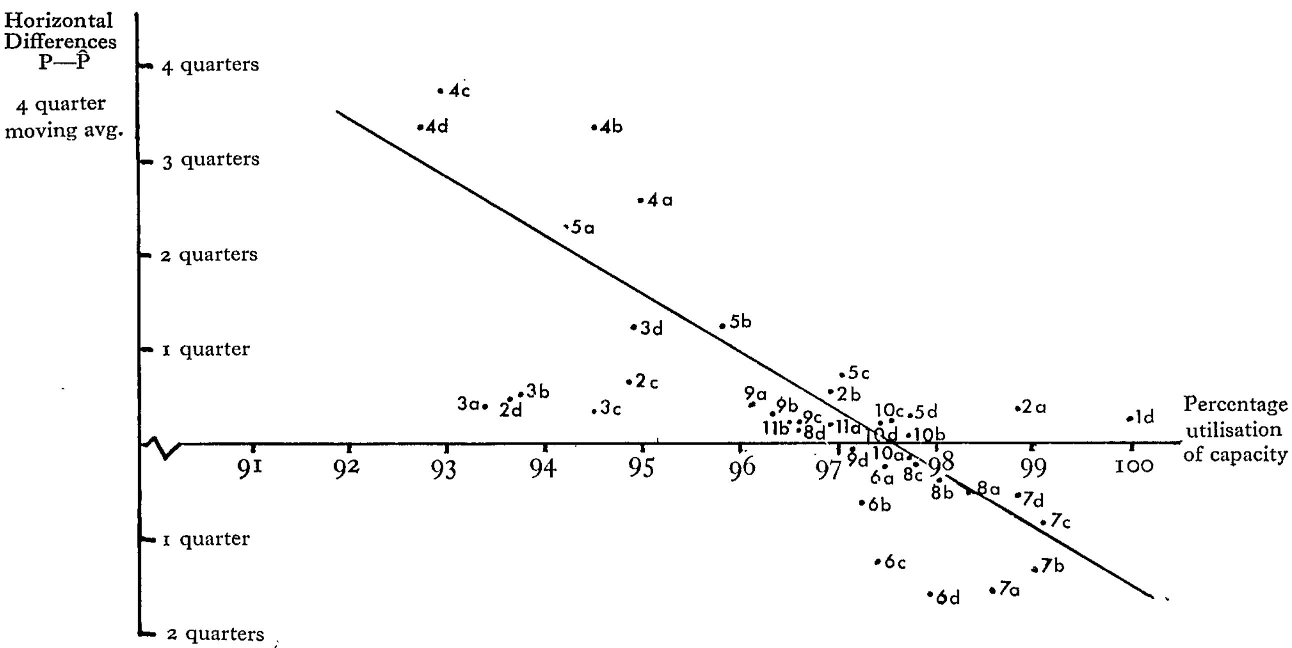


FIGURE IX (*b*): TRANSPORTABLE GOODS INDUSTRIES: HORIZONTAL DIFFERENCES (4 QUARTER MOVING AVERAGE) AGAINST PERCENTAGE UTILISATION OF CAPACITY



10. CONCLUSIONS AND APPLICATIONS

The initial stimulus to the investigation carried out in this paper was the difficulty involved in forecasting the size and timing of the price changes which might be expected to follow from changes in labour and input costs. This difficulty becomes acute when entrepreneurs' decisions are likely to be influenced by the existence of significant amounts of excess capacity. It was particularly obvious at the end of 1966 and beginning of 1967 when the price increases expected to follow from the 10th Wage Round in 1966 seemed somewhat slow in materialising.

The regression results of sections 6 and 7 have been used to estimate time lags between cost changes and price changes. These suggest that about 65 per cent. of labour cost changes are passed into output prices almost immediately and 90 per cent. within one year; about 30 per cent. of material costs changes are apparent in prices almost immediately, another 30 per cent. at the end of the following quarter and the whole effect in slightly less than a year.

The regression results of Section 4 have been used to develop a forecasting equation for prices. This equation is of the form

$$\hat{P} = -0{\cdot}122 + 0{\cdot}147\frac{W}{\pi} + 0{\cdot}305M - 0{\cdot}318M_{-1} + 0{\cdot}184M_{-2} + 0{\cdot}793P_{-1} + 0{\cdot}009Q_1 + 0{\cdot}011Q_2 + 0{\cdot}004Q_3 \quad (5)$$

On the basis of the equation, price forecasts have been simulated for 1966 and the first half of 1967. Figure III shows how these estimated prices compared with actual price movements during 1966 and 1967. In every case the estimated price falls within 1 per cent. of the corresponding actual price; moreover the estimated series correctly predicts the timing and direction of turning points.

The results outlined above are based on the implicit assumption that the utilisation of capacity has no effect on pricing behaviour, i.e., that prices are determined on a full cost rather than a modified full cost basis. Thus the estimated prices in Figure III, Section (4) are based on the assumption that capacity is being utilised at or near the average rate for the period 1955–1965, i.e., around 97 per cent.

The results in Section 9 show some evidence supporting the hypothesis that price formation is affected by utilisation of capacity. The equation $V = 57{\cdot}387 - 1{\cdot}311U + 0{\cdot}007U^2$ (where V is the adjustment to the estimated price and U is utilisation) suggests that if utilisation of capacity is 3 percentage points below the norm of 97 per cent., the contraction of profit margins might reduce a typical annual price increase by about 14 per cent., i.e., from 2·5 per cent. to 2·15 per cent. Moreover the relationship is non-linear; a 3 percentage point increase in utilisation above the 97 per cent. norm might add about 18 per cent. to a typical annual price increase.

Alternatively the equation $H = 58{\cdot}971 - 0{\cdot}605U$ (where H is the time lag adjustment) shows that a 3 percentage point fall in utilisation of capacity below the 97 per cent. norm might add about 20 weeks to the normal structure of time lags between cost changes and price changes.

It must be emphasised, however, that although there is evidence to support the modified full cost hypothesis the level of statistical significance of the evidence is not high. At best the coefficient of determination for the relationship between utilisation and time lags is 0·64. This suggests that the results should be used to indicate the general direction in which price forecasts should be adjusted to take account of utilisation and, perhaps at most, to indicate the broad orders of magnitude of the adjustments.

This becomes particularly apparent when an attempt is made to adjust the simulated price forecasts for 1966 and 1967 to account for the utilisation of capacity. For much of the period covered, utilisation of capacity was significantly under the "normal" level of 97 per cent., and column 4 of Table XVI shows the adjustments that have to be made to estimated prices to take account of this factor. Comparison of column 4 with column 3, the difference between estimated price and actual price,

TABLE XVI: THE EFFECT OF UTILISATION ON PRICE FORECASTS

		1	2	3	4	5	6
		Price estimated on basis of Equation 5, $\hat{P}$	Actual Price P	$P-\hat{P}$ seasonally adjusted	Adjustment of $\hat{P}$ for Utilisation	Length of time required for P to reach $\hat{P}$ (quarters)	Adjustment of lag for Utilisation (quarters)
1966	I	134·8	136·0	+0·08	−0·30	+0·1	+2·0
	II	139·0	138·9	−0·06	−0·27	+0·3	+1·8
	III	140·5	139·6	−0·42	−0·23	+0·6	+1·6
	IV	141·3	140·5	−0·80	−0·08	—	+0·8
1967	I	141·9	140·9	—	−0·02	—	+0·4
	II	144·2	143·3	—	−0·05	—	+0·6

gives an indication of how far the adjustment is successful in improving the forecast. Similarly column 6 of Table XVI shows the adjustment that has to be made to the lag structure to take account of the low level of utilisation. Comparison of column 6 with column 5, the additional time required for actual prices to reach the levels predicted by equation (5), gives some indication of the success of the adjustment procedure.

In Table XVI the regression equation has been used to predict prices during 1966 and the first two quarters of 1967. At the time of writing, these results were as up-to-date as was practicable because of the lag in the publication of the basic data. In column 3 the series terminates with the last quarter of 1966 because $(P-\hat{P})$ is calculated as a four quarter moving average to eliminate seasonal factors and the final two quarters are therefore not available. In column 5, the series terminates with the third quarter of 1966 because of the seasonal adjustment process and also because a reading for the time lag for actual prices to reach the level estimated in the second quarter is not yet available—this requires the information on the actual price index later in the year.

The points where the comparison can be made are too few to enable any general conclusion to be drawn on the value of adjustment taking into account the degree of utilisation of capacity. The four comparable observations in columns 3 and 4 indicate that in three cases the "sign" in the adjustment is in the appropriate direction. Two of these adjustments (in the third and fourth quarters of 1966) would improve the estimated price level by bringing it closer to the actual. In columns 5 and 6 there are three comparable observations, all of which show the correct "sign" and each of them improves the value of estimated lag.

As was noted in Section 1, the NIEC was surprised by the slow rise in output prices after the sharp increase in average hourly earnings in the second quarter of 1966. The evidence presented here suggests that the low level of utilisation of capacity contributed to the slow rise in output prices during 1966 and early 1967.

These observations cannot be claimed to bring the estimated prices, or lags, into close approximation with those that actually occurred. Some of the adjustments, although in the "right" direction still leave unexplained (or random) divergences. However, as is suggested above, they are of value in indicating the *direction* if not the *exact size* of adjustments to account for variations in utilisation.

This is to be expected in the light of the low values of R^2 for the relationships which are being applied. It should, however, be remembered that the production figures for 1966 and 1967 on which utilisation of capacity is based, are unrevised preliminary figures. Moreover there is some conflicting evidence about the precise movement of both capacity and utilisation during the period. In particular there is the fact—apparent from Figure VIII—that during these months employment and unemployment in transportable goods industries appear to have been moving in the same direction.

The prediction of prices into the future, using these techniques might be a useful adjunct to macro-economic forecasts.

This type of prediction is, however, dependent on the availability of forecasts of earnings and input prices. Such forecasts are probably already available in the Government departments concerned and it is hoped that these can be brought together to provide better estimates of price changes for the immediate future.

APPENDIX A

STATISTICAL PROBLEMS

(i) Time Lags

In economic affairs it is generally recognised that there is likely to be a lapse of time between cause and effect. Even allowing for a time lag the effect is unlikely to occur all at once, rather it will tend to take place gradually. This piecemeal occurrence of the effect is referred to as a distributed time lag.

There are good reasons for assuming that the relationship between output prices and prime costs in transportable goods industries is subject to distributed time lags. If, for example, the price of raw material inputs were to change, manufacturers might not increase output prices while they still had stocks of raw material bought at the old price. Again they may have unfulfilled orders to deliver, contracted for at the original output price. A third reason might be that manufacturers may take time to reorganise their pricing policy. These may be summarised under the headings of technological, institutional and subjective.[1] A similar argument might also be advanced for justifying the assumption of a lagged relationship between earnings changes and changes in output price, though the absence of stockpiles of labour might indicate a time lag of shorter duration than in the case of raw materials. In general therefore, output price at any given time will depend not only on current levels of earnings and input prices, but also on past levels. This dependence may stretch over a considerable number of time periods, so that the price equation may be written

$$P = k + \sum_{i=0}^{n} a_i W_{-i} + \sum_{j=0}^{m} b_j M_{-j} \qquad (1)$$

where n and m are some large numbers, and a_i and b_j represent respectively the partial effect on current output price of earnings and input price levels i and j quarters previously. Assuming that output price is eventually fully adjusted to earnings and input price changes, the a_i and b_j must each have a finite sum. In each case this finite sum represents the *total* effect on output price of a change in earnings or input prices.

The a_i and b_j indicate the form or shape of the two distributed lags over time. The analysis of these distributed lags will attempt to answer three questions.

(i) What is the total effect on output price of a change in earnings and of a change in input prices, i.e. what are the respective sums of the a_i and the b_j?

(ii) What is the total length of the lag in each case, i.e. how many time periods elapse before the a and b values are zero or approximately so?

(iii) What is the modal period of each distributed lag? This is answered by isolating the quarter or quarters in which the largest a and b values occur.

Before outlining the statistical methods used to answer these questions it is necessary to consider some of the estimation problems which are likely to arise.

(ii) Estimation Problems

The primary purpose of this study is the prediction of future levels of output prices in the transportable goods industries. A secondary objective is the estimation of the relationship over time between prime cost changes and output price changes. The choice of priorities here influenced the approach to the estimation difficulties. These latter may be summarised under two headings

(*a*) autocorrelation;
(*b*) multicollinearity.

(*a*) *Autocorrelation*

In the simplest case where a variable y is expressed as a linear function of one other variable x and a random disturbance term u (which summarises all other factors exerting an influence on y) the relationship may be written as

$$y_t = a + bx_t + u_t \qquad (2)$$

where a and b are constants to be estimated, and the subscripts indicate that the relationship holds true for a number ($t = 1, 2, \ldots n$) of time periods. For the valid use of the least-squares method of estimation of a and b it is necessary to assume that the disturbance terms are independently distributed random variables with mean zero and (unknown) variance σ^2.

There are circumstances in which it would be unreasonable to assume that all these conditions on

[1]For a full discussion of the points raised here see L. M. Koyck, *Distributed Lags and Investment Analysis*, North-Holland Publishing Co., Amsterdam (1954).

the u_t are met. For example, if some or all of the influences summarised in the u_t are such that their current values are largely determined by their values at some previous time, this relationship between current and past values might be transmitted to the u terms.[2] This means that a relationship of the general form

$$u = \sum_i p_i u_{-i} + E \qquad i = 1, 2, 3 \ldots\ldots\ldots (3)$$

exists between u terms, so that the value of u at any time depends on its values at some previous times. The E terms are now assumed to possess the properties previously outlined for the u_t. Under these circumstances it is seen that the u_t are no longer fully random and successive values of u_t are not independent. The disturbance terms are then said to be autocorrelated.

If the disturbance terms in (2) are autocorrelated, the application of the least squares method of estimation will still yield unbiased estimates[3] of a and b, but the sampling variances of these estimates will be larger than those which can be obtained by effecting a data transformation to allow for autocorrelation. A further consequence, which is of particular importance here, is that any predictions made by using the original data will be subject to unnecessarily large sampling variances.

In the present study it is suspected that the level of activity in the transportable goods industry exerts some influence on the level of output prices. As argued above[4] the level of activity is more likely to affect the structure of the distributed time lags between prime costs changes and output price changes, and hence it is not explicitly included in the price relation. The direct effect, if any, of the level of activity on output price must therefore be assumed included in the disturbance term. It is unlikely that the level of activity is a random variable whose value at any given time is independent of all previous values. Were this the case, the level of activity would be subject to wide fluctuations from quarter to quarter. This simply does not happen. A high value in one quarter tends to be followed by a high value in the next and so forth. To the extent therefore that the level of activity influences price levels rather than the speed of adjustment of price levels, there is a danger that the disturbance term in the price relation will be autocorrelated.

[2]It is possible that the effect of one variable may cancel that of another. On the other hand, if the variables tend to move in phase, or if one variable exerts a predominant influence, this will tend to influence the u terms.

[3]If a large number of samples each consisting of the same number of pairs of observations on x and y are used to obtain estimates of b, these estimates will not be identical. If, however, the mean of these estimates is equal to the true value of b, then the estimates are said to be unbiased. Similarly for a.

[4]See section 8 above.

For this reason the residuals from each least squares regression were tested for randomness using the Durbin-Watson d statistic.[5] Where there was evidence of autocorrelation, the regressions were repeated using first differences.[6] This assumes that the relationship between the error terms is of the form,

$$u = pu_{-1} + E \qquad (4)$$

where $p = 1$, or approximately so. While positive autocorrelation is more likely to occur, the use of first differences may introduce negative autocorrelation. This may also be tested for using the Durbin-Watson statistic. In general it was found that the use of first differences resulted in satisfactory values for d.

(b) *Multicollinearity*

This problem arises when explanatory variables are so closely correlated with each other that it becomes difficult to estimate their separate effects on the dependent variable. It is likely to arise here because of the introduction of current and lagged values of both earnings and input price variables in the price equation. It is necessary therefore to reduce the number of similar variables in the regression equation while at the same time taking some account of those which are omitted.[7] To this end it is often useful to make the assumption that the coefficients decrease in geometric progression after some point in time. Thus the price equation (1) may be rewritten,

$$P = k + a\sum_{i=0}^{\infty}\lambda^i W_{-i} + b\sum_{j=0}^{\infty}\lambda^j M_{-j} + u \qquad (5)$$

where λ, the geometric coefficient has a value (as yet unknown) between zero and plus unity. For estimation purposes it is necessary to assume that λ is common to both the earnings and the input price coefficients. This is not quite so strong an assumption as may appear at first, since the geometric coefficient need not be introduced in the same time period for the earnings and input price. Preliminary investigations[8] showed that the effect of a change in earnings was greatest in the current quarter and thereafter tailed off rapidly. The effect of a change in input prices tended to be greatest after a lag of two to

[5]See Durbin, J., and Watson, G. S., "Testing for Serial Correlation in Least-Squares Regression", parts I and II, *Biometrika*, 1950 and 1951.

[6]Forecasts would then also be made using first differences. See Cochrane, D., and Orcutt, G. H., "Application of Least Squares Regressions to Relationships Containing Autocorrelated Error Terms", *J. Am. Statist. Assoc.*, vol. 44 (1949), pp. 32–61.

[7]A fuller discussion of this problem may be found in Klein, L. R., "The Estimation of Distributed Lags", *Econometrica*, vol. 26, (1958), pp. 553–565.

[8]See section 4 above.

three quarters. Hence the geometric coefficient was introduced after the first quarter for earnings and after the third quarter for input price. The price relation was then reduced to

$$P = k(1-\lambda)+aW+b_0M+(b_1-\lambda b)M_{-1} +(b_2-\lambda b_1)M_{-2}+\lambda P_{-1}+(u-\lambda u_{-1}) \quad (6)$$

This was the form used in many of the estimations. The problem of multicollinearity has been substantially reduced by introducing the lagged dependent variable in place of more historical values of W and M.

On the assumption of a geometrically distributed time lag, the total effect of a change in earnings is given by $a\left(\frac{1}{1-\lambda}\right)$, and that of a change in input price by $[b_0+b_1+b_2\left(\frac{1}{1-\lambda}\right)]$.It is also possible to estimate more historical values of a and b and thus determine the point after which they become negligible.[9] This will indicate the approximate time required for the total effect to manifest itself.

If least-squares regression is used to estimate the coefficients in (6), with $(u-\lambda u_{-1})$ treated as a composite disturbance term, the presence of P_{-1} as an explanatory variable will yield biased estimates of the coefficients, since the disturbance term $(u-\lambda u_{-1})$ is not independent of P_{-1}. Nevertheless if the $(u-\lambda u_{-1})$ terms are not autocorrelated, the estimates will have the desirable property of consistency.

However, if the u terms in (5) are serially independent, then $(u-\lambda u_{-1})$ is autocorrelated and hence the least-squares estimates in (6) will be inconsistent as well as biased.[10] In practice it was found that the disturbance terms in (5) were significantly autocorrelated while those in (6) were apparently random, using the Durbin-Watson test. However, Durbin and Watson[11] point out that "the tests . . . apply only to regression models in which the independent variables can be regarded as 'fixed variables'. They do not, therefore, apply to autoregressive schemes and similar models in which lagged values of the dependent variable occur as independent variables." Nerlove and Wallis[12] have also shown that in these circumstances the Durbin-Watson statistic is biased towards 2, so that the presence of autocorrelation may not be detected.

In the present case, however, there is a possibility that the disturbance terms in (6) are random. This would arise if the coefficient p, of u_{-1} in (4) was equal to (or approximately so), the coefficient λ of P_{-1} in (6). The disturbance term in (6) could then be written as $(pu_{-1}+E-\lambda u_{-1})\simeq E$. Since the E terms are assumed to be mutually independent over time, the disturbance terms in (6) would be free from autocorrelation. In view of what has been said above, however, any conclusions on this point are tentative.

Where forecasting was the primary objective it was found that equations of the form shown in (6) yielded good results both in order of magnitude and in timing turning points. It seemed reasonable therefore to accept such equations as suitable for forecasting. However, when attempts were made to analyse lag structures it was found that the influences of the labour cost and input price variables were obscured because although multicollinearity had been reduced, the high correlation between P and P_{-1} tended to diminish the significance of the other coefficients. Hence it was often necessary to adopt another method of estimation to establish the lag structures.

This alternative method consisted of using a series of regression equations each based on a slightly different assumption about the geometric tail to the distributed lag. Consider a simplified price equation in which output price depends solely on earnings and where the relationship is subject to a distributed lag of indefinitely long duration,

$$P = a_0W+a_1W_{-1}+a_2W_{-2}+a_3W_{-3}+\dots \quad (7)$$

The following regression equations may be used in an attempt to estimate the total effect of a change in earnings on output price, and also the effects occurring in each time period,

$$P = a_0W+hP_{-1}+u \quad (8)$$

$$P = a_0W+a_1W_{-1}+hP_{-2}+u \quad (9)$$

$$P = a_0W+a_1W_{-1}+a_2W_{-2}+hP_{-3}+u \quad (10)$$

and so on. In each case the coefficient of the lagged price term provides an estimate of the proportion of total effect unaccounted for in the periods for which W values are included in the equation. Thus, for example, the total effect in (9) is $(a_0+a_1)(1+h+h^2+\dots)$, and the effect occurring after the first two time periods is $h(a_0+a_1)(1+h+h^2+\dots)$, so that the proportion of total effect occurring after the first two time periods is h. The sum of the coefficients of W and W_{-1} then represents a proportion equal to $(1-h)$ of the total effect, so that the total effect is estimated as $(a_0+a_1)/(1-h)$.

By using a series of such equations it was possible to estimate the proportion of total effect occurring in each time period as well as the total effect. Since the various assumptions about the time-form of the

[9] With the assumption of a geometric tail to a distributed time lag structure the coefficients will never actually equal zero. However, by including a large enough number of time periods the coefficient may be taken as close to zero as is desirable.

[10] A fuller discussion of these points may be found in Johnston, J., *Econometric Methods*, McGraw-Hill, (1963), Chap. 8.

[11] *Op. cit.*, Part II.

[12] Nerlove, M., and Wallis, K. F., *Econometrica*, Vol. 34, 1966, pp. 235–238.

distributed lag relate to time periods other than the current one, the equations may be expected to yield reasonably consistent estimates of the total effect.

The Durbin-Watson test showed that the error terms in (8) were random. However, the comments made earlier about the error terms in the first method of estimation also apply to equation (8). If, as seems to be the case, the errors follow a first order autoregressive scheme, then the errors in equations (9), (10) and so on will be autocorrelated. This may be seen by examining equation (9) again. Repeated substitution for lagged P terms gives

$$P = a_0W + a_1W_{-1} + ha_0W_{-2} + ha_1W_{-3} + h^2a_0W_{-4} + h^2a_1W_{-5} + \dots + e$$

Thus the error term in (9) is composed of $(e - he_{-2})$, which would only be random if the e terms followed a second order autoregressive scheme with parameter equal to h.

In practice it was found necessary to estimate equations (9), (10) etc. using first differences.

Seasonal Adjustments

It was decided not to use seasonally adjusted data in the regressions, but to take account of seasonal fluctuations by using specific seasonal variables.[13] These are so-called dummy variables, i.e., unobserved variables which take the value zero or unity. This method of allowing for seasonal variation is statistically more satisfactory since it takes account of the degrees of freedom used up.

The regression equations took the form

$$P = k_0 + k_1Q_1 + k_2Q_2 + k_3Q_3 + a_0W + \dots \quad (11)$$

Where the Q terms are the seasonal variables, and

$$Q_i = \begin{cases} 1 \text{ in the } i\text{th quarter} \\ 0 \text{ in other quarters} \end{cases}$$

Only three seasonal variables are used with the constant term, otherwise the estimation of the coefficients in (11) would be impossible due to perfect multicollinearity.[14]

This form of seasonal correction is linear and additive, and assumes that the price relation makes parallel shifts from quarter to quarter. Thus in the first quarter the constant term is (k_0+k_1); in the second, (k_0+k_2); in the third, (k_0+k_3); and in the fourth (k_0).[15]

The inclusion of three seasonal variables uses up three additional degrees of freedom in the estimation of k_1, k_2, and k_3. The seasonal variables do not relate to any particular variable, but represent seasonal variation in the equation as a whole.

[13] See, for example, Klein *et al.*, "Econometric Model of the United Kingdom", Oxford University Institute of Statistics, monograph No. 6, (1961).

[14] The formula for $\hat{\mathbf{B}}$, the least-squares estimate of $\mathbf{B}$, in $P = \mathbf{XB} + u$, is

$$\hat{\mathbf{B}} = (\mathbf{X}^1\mathbf{X})^{-1} \ \mathbf{X}^1\mathbf{P}$$

which involves inverting the product $(\mathbf{X}^1\mathbf{X})$. In the case of perfect multicollinearity the inverse cannot be obtained.

[15] See Daniel B. Suits, "Use of Dummy Variables in Regression Analysis", *Journal of American Statistical Association*, Vol. 52 (1957), pp. 548–551.

APPENDIX B

Comparing actual and estimated prices

In figures II and IV the regression equations which are considered most satisfactory in Models I and II, respectively, are plotted and shown with the actual price index for transportable goods over the period 1955–1965. The figures are shown for the last month of each quarter (March, June, September and December).

To examine the proposition that the differences between estimated and actual prices might be related to the general level of activity in the sector as a whole, two sets of data were extracted from each Model.

Firstly, the difference between actual and estimated prices at any given date was measured. This provided a series of observations which it was expected would show that actual prices would be higher than estimated when the level of activity was high (or the amount of unutilised productive capacity was low). These "vertical differences" were available from the regression analysis and could also be read off directly from the graph.

Secondly, the difference *in time* between the quarter in which the estimated price level reached a particular value and the quarter in which the actual price level reached the same value was measured. When actual price lagged behind estimated price then the expectation was that this would be correlated with periods when the level of activity was low. These "horizontal differences" were ***not*** available from the regression analysis and had to be obtained by interpreting the data as they are shown in the graphs.

If there had been significant fluctuations in prices both "up" and "down", it was possible that the procedure outlined in the previous paragraph would have given ambiguous answers. However, there was only one point of time at which a "horizontal difference" could have been interpreted in either direction and the choice was made on the basis of the direction of the difference in the preceding quarter.

A further complication of the measurement of "horizontal differences" occurred when actual prices remained fairly static in 1957–58. This period of stable prices was unique in the period under review and it meant that any divergence of the estimated from the actual prices was magnified in terms of the time taken for the actual prices to reach the estimated levels.

Initially both vertical and horizontal differences were tested with an index of the level of activity. However, as a result of a series of further tests, the method eventually chosen was to use a four quarter, centred, moving average of these differences. The results are shown in Section 9.

APPENDIX C

Data and Sources,

All the data used are published in the Irish Statistical Bulletin. For some series figures are available for each month, but in the case of average hourly earnings, numbers employed and hours worked the figures relate to a week in the last month of each quarter. Since the estimation of time lags forms a major part of this study it was considered desirable to relate each series as nearly as possible to the same point of time. For this reason the figure for the last month in each quarter was used in preference to the arithmetic mean of three monthly figures which would have placed the observation in mid-quarter.

Data from the Quarterly Industrial Production Inquiry are later revised in the light of returns from the appropriate Annual Census of Production. The latest Census available at the time of this study was for 1965.

Output price,

is the Wholesale Price Index for the Total Output of Industry which is published for each month in Table 9 of the Wholesale Price Index Numbers. It includes goods flowing from the transportable goods industry to personal consumption, agriculture, exports, industrial and agricultural capital. It also includes the flow of goods from the construction industry (which does not form part of the transportable goods industry) to home capital. Investigation showed that the price index of output from the construction industry moves very closely in line with the composite price index. Furthermore, the weighting for the construction industry price is only 6 per cent. of the total weighting. It was not considered necessary, therefore, to attempt any modification of the Total Output of Industry price series.

Earnings,

is Hourly Earnings in Transportable Goods Industries and is taken from the Quarterly Industrial Production Inquiry. The figures relate to industrial workers only and are for the middle week of the last month of the quarter. They are published in Quarterly Inquiry series, Table 3: "Earnings and Hours Worked".

Numbers employed.

The figures are from the Quarterly Industrial Production Inquiry. They include proprietors, salaried employees and wage earners, but exclude outside piece-workers, and are an estimate of the total numbers employed in transportable goods industries during the last month of the quarter. They are published in Quarterly Inquiry series, Table 2: "Estimated number of persons engaged".

Numbers unemployed.

The figures are the numbers of unemployed insured persons on the live register. They are found by extracting a sub-total of the Transportable Goods Industries category from the Live Register Statistics table: "Unemployment Among Currently Insured Persons". The figures are published monthly and relate to the middle of the month.

Hours worked.

The figures are from the Quarterly Industrial Production Inquiry. They are the average hours worked per week by wage earners (i.e., industrial workers) in transportable goods industries in the middle week of the last month of the quarter. The source is the same as for Earnings.

Index of Volume of Production,

covers the output from the transportable goods industries sector of the economy and is taken from the Quarterly Industrial Production Inquiry. It is estimated on the basis of a sample of 1,600 establishments during the quarter. It is published in Quarterly Inquiry series; Table 1A.

Input Price,

is the Wholesale Price Index of Total Materials for use in all Industry which is published for each month in Table 6[1] of the Wholesale Price Index Numbers. It includes materials flowing from agriculture and the rest of the world to industry and the building industry. Again, no adjustment was made for the flow of materials to the building industry because of its small weighting and because the price index for this flow moved closely in line with the total price index.

[1]Before June 1957 it was published in Table 7.

		Output Price 1953=100	Earnings Oct. 1953=100	Numbers Employed 000's	Numbers Unemployed	Hours worked	Index volume of Production 1953=100	Input Price 1953=100
1954	I	99·2	102·5	152·2	11,951	43·8	95·8	98·1
	II	98·3	103·6	154·5	11,072	43·3	104·6	97·9
	III	96·9	103·1	154·8	8,885	44·8	104·9	97·7
	IV	97·2	104·2	156·5	9,289	45·2	105·4	99·1
1955	I	97·5	105·7	153·1	9,978	44·5	100·2	98·6
	II	98·1	107·2	155·8	8,583	44·4	109·5	98·3
	III	99·1	109·0	158·4	5,880	44·9	107·3	98·8
	IV	100·0	114·3	159·6	6,348	45·4	113·5	100·9
1956	I	100·6	114·4	154·2	9,199	44·5	106·1	99·1
	II	103·5	116·0	154·8	10,573	44·3	108·8	103·2
	III	103·9	115·4	153·9	9,101	44·9	101·2	105·2
	IV	104·8	116·2	153·9	10,967	45·0	105·8	107·6
1957	I	104·8	116·1	147·2	13,995	44·4	98·3	107·3
	II	110·6	117·9	150·2	11,958	44·3	108·8	108·0
	III	110·9	117·7	151·0	8,765	45·0	101·6	108·7
	IV	110·6	121·8	152·1	9,009	45·6	110·9	109·5
1958	I	112·0	122·9	147·7	11,791	44·6	103·2	106·5
	II	112·6	124·6	149·9	11,161	44·5	110·8	104·4
	III	112·6	124·8	151·3	8,812	44·8	102·7	103·8
	IV	112·6	125·7	152·4	9,620	45·4	109·3	105·7
1959	I	112·6	125·5	150·2	11,366	44·6	104·2	104·6
	II	112·6	128·1	155·2	9,640	45·1	122·7	103·8
	III	112·8	128·4	154·6	8,174	45·4	119·2	104·8
	IV	113·1	132·4	155·6	8,048	45·7	123·0	106·6
1960	I	113·3	134·0	156·8	9,752	44·4	119·0	105·2
	II	114·9	137·3	160·7	7,385	44·9	130·7	105·2
	III	114·8	137·3	161·4	6,094	45·0	125·2	105·4
	IV	115·0	140·0	163·5	6,339	45·6	130·8	106·4
1961	I	115·3	140·2	164·3	7,353	44·7	129·9	104·2
	II	116·0	143·4	168·0	6,527	44·9	143·5	104·8
	III	117·0	145·4	169·2	5,756	44·6	136·5	105·8
	IV	118·0	154·7	170·1	6,125	44·5	142·7	107·5
1962	I	119·2	158·1	170·2	8,602	43·8	137·6	105·9
	II	121·4	163·3	172·1	7,627	43·9	152·4	106·8
	III	121·6	164·4	174·1	6,106	44·5	140·7	107·1
	IV	122·0	167·3	176·4	6,824	44·7	153·8	108·6
1963	I	121·8	165·4	175·1	8,978	43·6	141·8	107·1
	II	122·2	168·7	176·5	7,686	44·3	154·9	108·2
	III	122·5	169·8	179·8	6,171	44·6	153·1	109·6
	IV	123·6	171·8	181·3	7,021	44·8	164·0	111·5
1964	I	125·6	182·8	180·9	9,019	44·0	155·1	111·8
	II	128·6	191·9	183·3	7,312	44·6	170·2	115·1
	III	129·4	191·9	184·9	6,308	44·2	165·8	116·2
	IV	130·6	193·5	185·2	7,277	44·3	172·2	117·6
1965	I	130·3	192·9	181·3	9,574	43·5	165·3	114·5
	II	133·4	196·8	183·4	8,185	44·0	179·4	116·6
	III	133·5	197·9	184·8	6,915	44·0	171·4	118·6
	IV	134·0	200·8	185·2	8,109	44·2	182·2	120·1
1966	I	136·0	201·9	182·6	10,200	43·4	169·0	119·1
	II	138·9	213·3	182·8	9,620	43·8	179·5	122·1
	III	139·6	220·9	187·9	7,501	44·2	187·3	123·9
	IV	140·5	224·2	187·8	9,064	44·2	194·7	125·8
1967	I	140·9	226·2	184·5	12,367	43·4	185·6	123·3
	II	143·3	230·7	187·0	10,389	43·5	206·3	124·6

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