Journal of the Statistical and Social Inquiry Society of Ireland
Vol. XXXI

EVALUATING METHODS FOR SHORT TO MEDIUM TERM COUNTY POPULATION FORECASTING

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(read before the Society, 7 March 2001)

Abstract: Public services provision and land use planning are crucially dependent on accurate population forecasts. Despite their importance, particularly for planning at the local level, population forecasts for Irish counties are not readily available. A number of different methods could be used to calculate such forecasts, but it is not clear which of these possible methods produces the most accurate forecasts. This paper assesses the data requirements and methodology involved in the implementation of the various techniques, and evaluates the forecasting performance of a number of different methods in terms of the forecast error associated with each method over the period 1991 to 1996. The results of this paper show that simple share extrapolation techniques perform well compared with the more elaborate cohort component model that is widely used for national projections.

Keywords: Population forecasts, share extrapolation, cohort component model.
JEL Classifications: J11, R23.

1. INTRODUCTION

Public services provision and land use planning are crucially dependent on accurate population forecasts. Such forecasts are particularly important at the local (county) level, where they should determine planning decisions such as the provision of water and sewerage facilities, schools, hospitals etc. As such, one would expect such forecasts to be produced on a regular basis and be readily available. However, this is not the case and rigorous county population projections are produced rarely and only for a few counties (e.g. Morgenroth, 2001, Brady Shipman Martin, 1999). In contrast, national forecasts are produced regularly by the CSO (Central Statistics Office, 1988, 1995, 1999) and more recently the CSO has published regional projections (Central Statistics Office, 2001).

One factor which may have prevented the production of county level projections is the choice of the appropriate method that should be applied. A number of different methods could be used to calculate such forecasts. These include trend extrapolation methods, the life table/cohort component method, time series modelling and econometric modelling. It is, however, not clear which of these possible methods produces the most accurate forecasts. Furthermore, issues of ease of implementation and data requirements of these methods have not been examined in the Irish context.

The lack of county population projections may also be due to the fact that they are likely to be subject to substantial error. This arises since population trends are at least in part dependent on future policies, such as the zoning of land. Since such policies are not known in advance, but may significantly impact on the dynamics of the population in small areas such as counties, it is difficult to precisely predict population changes in the future. This increases the forecast error, particularly if the forecast horizon is very long. As a result it is not advisable to project too far into the future and hence the focus of this paper is on the short to medium term. Nevertheless, the forecasting methods tend to use current trends which assume no significant changes to policy. Thus, if major policy changes occur the outcome regarding population is likely to be different than that predicted.

This paper will outline in detail the data requirements and methodology involved in the implementation of the various techniques, and will then evaluate the forecasting performance of the different methods, in terms of the forecast error associated with each method when applied to projecting county populations from 1991 to 1996. In doing so, the paper will for the first time apply such a large set of techniques to forecast Irish county population. Crucially, it will provide a more comprehensive evaluation of the various methods than has hitherto been available, since other papers on the evaluation of population forecasts have used a more restrictive set of methods (e.g. Smith, 1987), or were conducted in relation to population forecasts of larger spatial units (e.g. Smith and Sinicich, 1992). This paper is thus not concerned with explaining historical population trends for Irish counties, which was the subject of a paper by Walsh (2000), neither is it concerned with a detailed evaluation of recent trends in fertility or migration (see Fahey and Russel, 2001 on fertility and Punch and Finneran, 1999, Barrett, 1999 or Fitz Gerald and Kearney, 1999, on migration).

This paper is organised as follows. Chapter 2 describes in detail the different methods that will be utilised. Chapter 3 outlines data requirements and assumptions necessary to implement the various methods. Chapter 4 contains the projections for 1996 and a comparison of the projection accuracy of each method. Chapter 5 puts forward a set of county population projections utilising the most accurate method and, finally, chapter 6 summarises the main findings and highlights areas for future research.

2. ALTERNATIVE PROJECTION METHODS

There are many methods that can be used to generate population projections at the county level. These include the well-known cohort component method, simple extrapolation methods, regression based extrapolation, correlated indicators, time series methods (ARIMA) and structural econometric models. Here, the focus will be on all bar the latter two methods, since the time series methods require a long time series of equal periodicity and preferably at a high frequency which is not available for Irish counties[1]. Furthermore, the construction of a structural econometric model of Irish county populations, which would incorporate internal and external migration and fertility, is beyond the scope of this paper.

2.1 Cohort Component/Life Table

At the national level, the most widely used projection method is probably the cohort component/life table method. This involves disaggregating the Census data by cohort and then moving these cohorts along their life cycle. Thus, deaths are subtracted from each cohort according to mortality rates from the life table. The mortality rates can be adjusted for expected improvement in life expectancy. Births are calculated on the basis of age specific fertility rates and these are subject to infant mortality. Finally, assumptions need to be made about migration, both internal and external.[2] This method is thus based on the fundamental balancing equation of population growth which defines population growth as the result of births minus deaths plus net migration for each county, which is defined as follows:

$$g_i = (B_i - D_i) + (I_i - E_i) \qquad (1)$$

where: g_i denotes the increase in the population of county i;
B_i denotes the number of births in the county;
D_i denotes the number of deaths in the county;
I_i denotes the number of immigrants into the county;
E_i denotes the number of emigrants out of the county.

The first term in parenthesis thus defines the natural increase of the population and the second term in parenthesis defines net migration into the county. Clearly, the latter incorporates both internal migration in the country and external migration to and from other countries.

The population at a particular point in time, say period 1, is thus equal to the population in the base period 0 plus the net increase in the population between the base period and period 1:

$$P_{i1} = P_{i0} + g_i \qquad (2)$$

Projections are then constructed by assuming or estimating numbers of births deaths and migration.

Thus, this method is intuitive and deals with the basic factors that determine the size of the population. However, the drawback of this method is that it requires strong assumptions regarding fertility, mortality and migration. The latter are particularly difficult at the regional and county level. Furthermore, while dealing with these issues, they are not accounted for in a behavioural model. On the other hand, this method yields detailed results not only of the total size of the population but also of the gender balance, age balance, number of deaths and number of births.

2.2 Simple Trend Extrapolation

A simpler method of projecting county populations is the trend extrapolation method (Smith and Sincich, 1992). This involves identifying the trend of the total population or the share of the national population of a county, which is then used to project the population forward, assuming that this trend is stable up to the projection horizon. Clearly, this again is a strong assumption which may not hold in practice, particularly if developments take place that cause a structural break in the evolution of the population e.g. an economic crisis that leads to large scale emigration.

In order to outline these techniques it is useful to first define the relevant variables that are used. The projected total population is denoted P_{if} where i denotes the county. In order to identify the trend, data is required for two points in time between which the trend is measured. This period is denoted the base period, which covers y years and the projection horizon x years. At the start of the base period, a population P_{i0} is observed and then, at the end of this period, a population P_{i1} is observed. Using these two variables, the average annual growth rate between the start and the finish of the base period, r, can be calculated. Using this notation, two simple extrapolation techniques, namely linear (LINE) and exponential (EXPO) extrapolation, can be defined as follows:

Method 1: Linear extrapolation (LINE)

$$P_{if} = P_{i1} + \frac{x}{y}\left(P_{i1} - P_{i0}\right) \tag{3}$$

Method 2: Exponential extrapolation (EXPO)

$$P_{if} = P_{i1} \exp(rx) \tag{4}$$

Another simple extrapolation method that makes use of existing national projections is the method of share extrapolation, where instead of the trend in the absolute size of the population, the trend in the share of the national population that resides in the county is used. In order to define the derivation of this method, three additional variables are required. First, since this method utilises existing national projections, let this be denoted by PS_f. Furthermore, the national population at the start of the base period is PS_0 and the total national population at the end of the base period is denoted PS_1. The simple share extrapolation method (SHARE) is then given as:

Method 3: Shares of state population (SHARE)

$$P_{if} = PS_f \left[\frac{P_{i1}}{PS_1} + \frac{x}{y} \left(\frac{P_{i1}}{PS_1} - \frac{P_{i0}}{PS_0} \right) \right] \quad (5)$$

The techniques described in this section are distinct from the cohort component/life table methods that are commonly used for national projections. The advantage of these simpler trend methods is that they require less data, which makes them particularly suitable for population projection at a spatially disaggregated level; data for some variables required for the cohort component method may not be available. Furthermore, they are easily implemented, yielding quick results. The disadvantage of these methods is that they use past trends to predict the future, whereas the cohort component model tracks individual cohorts on the basis of an assumed life expectancy.

2.3 Regression Based Extrapolation

A method that is closely related to the simple trend extrapolation methods described above is that of regression based share extrapolation (see for example Cantanese, 1972 and Klosterman, 1993). The distinguishing feature of this technique is that the projected share is generated using regression techniques which are applied to more than two data points. The use of these regression techniques results in a smoothing out of the estimated trend.

This technique involves estimating a regression model with the dependent variable being the share of the national population in a particular county and the independent variable is time. However, rather than simply assuming a linear functional form, a number of different functional forms are estimated and the one which fits best, say according to the R^2, is chosen. Of course, there are many possible functional forms, including non-linear ones (see Cantanese, 1972 and Klosterman, 1993 for examples). Here, the focus is on functional forms that are either linear or that can be linearised. Specifically, the simple linear model, the power function/log-linear model and the exponential model are used. Adding a constant to the relationship described above, these are given as:

1. **Linear**

$$S_i = \alpha + \beta T \quad (6)$$

2. **Log Linear** (power function)

$$S_i = \alpha T^{\beta} \quad (7)$$

which can be linearised by taking logs to yield the following:

$$\log S_i = \alpha + \beta \log T \tag{8}$$

3. Exponential

$$S_i = \alpha\beta^T \tag{9}$$

which can again be linearised by taking logs to yield the following:

$$\log S_i = \log \alpha + (\log \beta)T \tag{10}$$

In all cases α and β need to be estimated, which is simplified through the choices of these simple functional forms since these estimates can be easily obtained using standard Ordinary Least Squares (OLS) techniques. Once the different models have been estimated and the parameters from the best fitting regression recovered, these can be used to predict the share of the population in the future. Since the sum of these predicted shares is unlikely to be exactly 100, it is necessary to adjust the shares accordingly. Once this is done, the predicted national population can be allocated to each county according to these predicted shares, yielding county level population projections.

2.4 Correlated Indicators (Electoral Register)

The final method considered here uses data other than the Census data in order to apportion changes in the population. The main criterion for choosing such variables is that they must be highly correlated with the total population. For example, the electoral register that is updated annually can be used to estimate the population. In order to implement this method a similar approach to the regression based share extrapolation method can be used. However, this is applied to the ratio of people on the electoral register to the number of persons in the county, at the census dates. This ratio is then regressed on time, using the three functional forms outlined above. Again the functional form is chosen according to best fit and the parameters of this estimation are then used to project the ratio of electors to the population at a point in time. Then the population at that point in time can be estimated if the number of persons on the electoral register is known. This means that this method can not be used to project the population to a future date, but this method may nevertheless prove useful in providing estimates of the population in the intercensal period or before census figures are available. Of course, a lagged version of this method could be employed to provide actual forecasts, but this would require the estimation of a time series model with lags, which is not feasible with the available data since the periodicity is not constant.

Again, using this approach requires strong assumptions which may not hold in practice. However, this method can be applied with relative ease and it has the added advantage that it can be extended to relate population movements to any variable that is thought to be highly correlated with population.

3. DATA, ASSUMPTIONS AND CALCULATIONS

The previous chapter described the techniques that will be used to generate county population projections for 1996. In this chapter the data requirements and assumptions that are needed to construct the projections will be outlined and the projections will be generated.

Since the trend extrapolation methods are the simpler methods it is useful to start with these. They merely require data on county populations for at least two years in the case of the simple methods and for more than two years in the case of regression based techniques. This data can be easily obtained from the Census of Population, which has been carried out in Ireland since 1841. The last census preceding 1996 for which the projections are to be calculated was in 1991. It is then straightforward to estimate the trend in the case of the simple techniques. Of course, a choice has to be made regarding the starting point for the base period. The obvious choice is 1986, so that the trend is estimated over the 5 year intercensal period that immediately precedes the projection period. However, one may also take the view that a longer term trend might reflect better the evolution of the population, so that 1981 could also be used as the start for the base period.

The SHARE and regression based techniques also require national level population projections from which the county populations can be obtained, once predicted population shares have been constructed. Here, two possible sets of projections are available, namely the CSO projections published in 1988 and those published in 1995 (see CSO 1988 and CSO 1995). In each case a number of different projections are put forward by the CSO reflecting different migration and fertility assumptions, which are denoted by M and F. These are shown in Table 1.

The table shows that while there are ten different sets of assumptions, the projections for a number of these are the same, which means that only five different values are available to be used in the SHARE method and the regression based share extrapolation (REG).

Table 1: CSO Population Projections for 1996

	Migration (M)	Fertility (F)	
		F1	F2
1988	M1	3,620,000	3,620,000
1988	M2	3,500,000	3,500,000
1988	M3	3,410,000	3,410,000
1995	M1	3,588,000	3,586,000
1995	M2	3,588,000	3,586,000

Source: CSO (1988): Population and Labour Force Projection: 1991 – 2021
CSO (1995): Population and Labour Force Projection: 1996 – 2026.

An important decision regarding the regression based share extrapolation method is the choice of time period over which to estimate the time trend. On the one hand a minimum number of observations is required for estimation, while on the other hand going back too far in time may give rise to estimates of the trend that bear no relationship with recent trends. The period that was chosen for the estimation was 1979 to 1991 (just 4 observations) which resulted in a good fit in most cases. However, for a few counties a slightly longer sample period was required to achieve a reasonable fit of the estimated relationship.

The results of the regression for the best fitting functional form for each county are reported in Table 2. The table shows that in most cases the fit of the regression equation is extremely good. It also shows that no one functional form dominates in terms of best fit, which justifies the use of the three different functional forms. Furthermore, the estimated coefficients show that these differ quite substantially, with some counties having a positive trend while others have negative trend in the share of the national population.

Table 2: Regression Results for the Regression Based Share Extrapolation (REG)

	Estimation Period	Constant	Time	R^2	Functional Form
Carlow	1979-1991	-0.1865	0.1214	0.77	Log-linear
Cavan	1979-1991	2.5761	-0.7846	0.97	Log-linear
Clare	1979-1991	0.1379	0.2933	0.83	Log-linear
Cork	1979-1991	2.7758	-0.1163	0.79	Log-linear
Donegal	1966-1991	1.6850	-0.1441	0.40	Log-linear
Dublin	1966-1991	2.6352	0.2685	0.61	Log-linear
Galway	1979-1991	1.2804	0.0219	0.98	Exponential
Kerry	1979-1991	5.0694	-0.1007	0.99	Linear
Kilkenny	1979-1991	0.5102	0.0141	0.96	Exponential
Kildare	1979-1991	-4.3448	0.4902	0.99	Linear
Laois	1971-1991	0.7470	-0.1271	0.35	Log-linear
Leirtim	1979-1991	1.5039	-0.1147	0.99	Exponential
Limerick	1979-1991	1.7857	-0.0162	0.86	Exponential
Longford	1979-1991	1.5642	-0.0439	0.98	Linear
Louth	1971-1991	0.4234	0.1908	0.74	Log-linear
Mayo	1979-1991	6.3073	-0.1977	0.99	Linear
Meath	1979-1991	-2.6426	1.3514	0.95	Log-linear
Monaghan	1979-1991	1.9645	-0.0317	0.95	Linear
Offaly	1979-1991	2.1904	-0.0329	0.88	Linear
Roscommon	1979-1991	3.2482	-0.1107	0.99	Linear
Sligo	1979-1991	2.4658	-0.0570	0.99	Linear
Tipperary N.R.	1979-1991	2.4312	-0.6981	0.99	Log-linear
Tipperary S.R.	1979-1991	3.5607	-0.0896	0.99	Linear
Waterford	1966-1991	0.7131	0.0868	0.34	Log-linear
Westmeath	1971-1991	2.0381	-0.0170	0.60	Linear
Wexford	1979-1991	0.6714	0.1420	0.80	Log-linear
Wicklow	1979-1991	-0.8390	0.2254	0.99	Linear

Note: The dependent variable is the share of the national population.

For the correlated indicators method, the number of persons on the electoral register is required (of course other variables could also be utilised). This can be obtained from the CSO Statistical Abstracts (various issues). Here the method is applied using data from 1961 to 1991. This is used to generate the ratio of electors to the population for each census year over that period. This ratio has been rising, reflecting the changing age structure of the Irish population. The regression results of the best fitting method are shown in Table 3. Again, the fit is generally very good indicating that the estimated relationships have a high within sample forecasting accuracy. Also notable is the positive estimated trend for all counties.

Table 3: Regression Results for the Correlated Indicators Extrapolation

	Estimation Period	Constant	Time	R^2	Functional Form
Carlow	1961-1991	-1.7152	0.08670	0.95	Exponential
Cavan	1961-1991	0.0403	0.04485	0.95	Linear
Clare	1961-1991	-0.9860	0.04120	0.89	Exponential
Cork	1961-1991	-1.2387	0.05470	0.87	Exponential
Donegal	1961-1991	-0.9824	0.04113	0.89	Exponential
Dublin	1961-1991	-0.2097	0.05786	0.89	Linear
Galway	1961-1991	-0.0256	0.04612	0.91	Linear
Kerry	1961-1991	-1.3600	0.06701	0.94	Exponential
Kilkenny	1961-1991	-1.3187	0.05982	0.95	Exponential
Kildare	1961-1991	-1.4053	0.06245	0.92	Exponential
Laois	1961-1991	0.1145	0.03530	0.86	Linear
Leirtim	1961-1991	-1.1659	0.05872	0.94	Exponential
Limerick	1961-1991	-1.4671	0.06924	0.94	Exponential
Longford	1961-1991	-1.1288	0.04998	0.96	Exponential
Louth	1961-1991	-1.2411	0.05489	0.78	Exponential
Mayo	1961-1991	-2.8177	0.90907	0.83	Log-linear
Meath	1961-1991	-1.5021	0.07204	0.92	Exponential
Monaghan	1961-1991	-1.1594	0.05214	0.93	Exponential
Offaly	1961-1991	0.0267	0.04132	0.91	Linear
Roscommon	1961-1991	-1.0284	0.04449	0.93	Exponential
Sligo	1961-1991	0.2369	0.02995	0.86	Linear
Tipperary N.R.	1961-1991	-1.3234	0.06222	0.91	Exponential
Tipperary S.R.	1961-1991	-1.5545	0.07656	0.94	Exponential
Waterford	1961-1991	-1.2046	0.05243	0.82	Exponential
Westmeath	1961-1991	-1.7916	0.09191	0.93	Exponential
Wexford	1961-1991	-1.4238	0.06766	0.92	Exponential
Wicklow	1961-1991	0.1454	0.03423	0.76	Linear

Note: The dependent variable is the ratio of the electors to the total population at the census dates.

The cohort component method requires more data than the other methods. First, it requires the population of the 1991 census to be split by gender and cohorts, which is readily available from the Census. Secondly, survival rates are applied to each cohorts to reflect the number of deaths. These can be obtained from the CSO Life Tables. Here, Life Table No. 11, which was derived for the years 1985 to 1987 and which can be found in the CSO Statistical Abstract, is utilised. While there may well be differences in the survival rates between countries it assumed that these are equal across all counties. The third requirement are data regarding fertility. Here age specific fertility rates are applied to the female cohorts of child bearing age. These can be calculated using the data on births contained in the Report on Vital Statistics, 1991 and the number of females in the different age groups which is available from the Census. This yields one-year age-specific fertility rates that can easily be converted to 5-year rates. In contrast to the case of survivorships, these are allowed to vary between counties and county specific fertility rates are applied. Of course, fertility has been declining, so for the projections three different assumptions regarding fertility are applied. These are (1) the fertility rates of 1991 are applied unchanged (F1), (2) fertility rates that change at half the rate that applied between 1986 and 1991, and (3) fertility rates that continue to change at the rate of change observed over the period 1986 to 1991.[3] Applying the rates to the cohorts of females of child bearing age yields the total number of births. Of course, not all children survive so that these births are subject to an infant mortality rate which is calculated at 7.60651011 per 1000 births.[4] Also, it is assumed that 51.4 per cent of births are male.[5]

Finally, assumptions have to be made regarding migration, both internal and external. This is the most difficult aspect of the cohort component methodology; migration flows are influenced by economic conditions both at home and abroad, changes in attitude, and changes in policy which are not known in advance. These issues are particularly important for county population forecasting since an outflow of a relatively small number of people due to migration can be quite significant as a percentage of the total population in that county. With regard to internal migration, figures are available from the census, in that it records the number of persons who were resident in a different county one year previous. This allows net internal migration to be estimated for each county for a one year period. In the absence of other research that might suggest the trend in these migration figures it is convenient to assume that these absolute numbers are constant over the following 5 year period and these are set out in Table 4.[6] In order to generate the age and gender breakdown of these internal migration figures age and gender shares were applied. While these do vary between counties, for simplicity it was decided to apply the average national rates to all counties. While this might impact on the age and gender specific numbers, it will not impact on the total number of persons, which is the relevant number for the comparison in projection performance that will be carried out below.

Table 4: Assumed Net Internal Migration 1991-1996

County	Net internal migration	County	Net internal migration
Carlow	140	Louth	-450
Cavan	-910	Mayo	-4200
Clare	-1260	Meath	515
Cork	-1695	Monaghan	-855
Donegal	45	Offaly	-1530
Dublin	16035	Roscommon	-1945
Galway	3690	Sligo	-655
Kerry	-1675	Tipperary N.R.	-1835
Kilkenny	-530	Tipperary S.R.	-2275
Kildare	4970	Waterford	-105
Laois	-1150	Westmeath	-1030
Leitrim	-610	Wexford	-2925
Limerick	150	Wicklow	1210
Longford	-1120		
State			0

The issue of international migration is more difficult to deal with. While both Hughes and Walsh (1980) and Sexton, Walsh, Hannan and McMahon (1991) deal with international migration at the county level derived from figures contained in the Census, these refer to earlier periods. Nevertheless, in the absence of other information, the pattern of international migration that was estimated for the 1981 to 1986 period by Sexton, Walsh, Hannan and McMahon (1991) is used here. This pattern is applied to the migration assumptions used by the CSO in making their population projections (CSO, 1988) which are set out in Table 5. The total numbers of net international migration are then allocated according to the shares derived from Sexton, Walsh, Hannan and McMahon (1991). Thus, some counties experience net international immigration while most experience emigration. Furthermore, following the CSO assumptions, migration is equally split between males and females; in terms of age distribution, that assumed by the CSO is applied.

Table 5: Assumed Net International Migration for the State, 1991-1996

Cohort	M0	M1	M2	M3
0-4	0	0	-2000	-4000
5-9	0	0	-2000	-4000
10-14	0	0	-2000	-2000
15-19	0	-14000	-24000	-34000
20-24	0	-50000	-70000	-80000
25-29	0	-18000	-24000	-38000
30-34	0	2000	-4000	-12000
35-39	0	0	-2000	-6000
40-44	0	0	0	0
45-49	0	0	0	0
50-54	0	0	0	0
55-59	0	0	0	0
60-64	0	0	0	0
65-69	0	5000	5000	5000
70-74	0	0	0	0
75-79	0	0	0	0
80-84	0	0	0	0
85+	0	0	0	0
Total	0	-75000	-125000	-175000

Note: M0 indicates zero net migration. The other numbers were taken from CSO, 1988: Population and Labour Force Projection: 1991 – 2021, Table J.

Clearly the assumption regarding internal and particularly international migration are important but unlikely to represent the actual pattern of migration over the period 1991-1996. Therefore, another migration assumption is added, namely that there is no net international migration (M0).

4. PROJECTIONS AND COMPARISON OF PROJECTION PERFORMANCE

Having dealt with the derivation and data requirements for the different methods in the previous chapter, this chapter outlines the estimation results and deals with the main objective of this paper, which is to compare these with the actual population as enumerated by the 1996 Census of Population and to identify which is the most accurate method.

The detailed results of the different methods are presented in Table 7.2 and Table 7.3. A cursory examination of these tables reveals that overall all methods except the correlated indicators method underpredict. This reflects the performance of the national predictions used for the various trend extrapolation methods, which is to a great extend explained by deviations of the actual migration patterns from the assumed ones.

However, while it is clear that the predictions are not perfect and in most cases below the actual population of 1996, a more formal evaluation of the predictive performance of the different methods is needed. In order to accomplish this a number of measures are calculated. First, in order to identify whether a particular method is biased towards under or over predicting, the number of counties for which each method under predicts is counted. Second, the number of extreme deviations, that is deviation of more than 10 per cent from the actual figure recorded in 1996, are shown in the third column of that table. Clearly, if a method gives rise to many such extreme observations its results should be only cautiously used since, if used for planning purposes, such deviating projections could lead to a substantial misallocation of resources. The third measure, the largest absolute deviation, also refers to this type of deviation. Finally, the mean absolute deviation is a useful measure of the average accuracy of each projection method, as is the root means squared error (RMSE).

These indicators of predictive performance are found in Table 6. The first column of that table confirms that most methods underpredict in the majority of cases, with the exception of the correlated indicators (electoral register) method that overpredicts in a majority of cases. The second column provides important information in that only the cohort component method yields extreme deviations, as also confirmed by the third column which shows that these deviations are as large as 20 per cent. The simpler methods perform considerably better in this regard with the best performance achieved by the simple share method using 1988 M1F1 national projections. In this case, the largest deviation is just under 3 per cent.

With regard to the more usual measures of predictive performance, namely the mean absolute deviation and the root mean squared error, a similar pattern emerges. In general the cohort component results are less accurate although some of the other results also show high values of the last two measures. Again the simple share method using 1988 M1F1 national projections has the highest accuracy according to these measures with a remarkable mean absolute deviation of less than 1 per cent. It also results in the lowest root mean squared error (RMSE). Nevertheless, some of other predictions and in particular the one for the simple share method using 1988 M3F1 projections does not perform nearly as well. Of course, this is a result of the accuracy of the national projections that are used. Interestingly, the correlated indicators method does not perform particularly well, despite the fact that is incorporates data from 1996 (the electoral register of that year). Of course, other correlated measures may perform better, but using the electoral register does not result in a better forecasting performance compared to the simple extrapolation methods. The regression-based method also does not perform that well, despite being more difficult to produce.

Table 6: Measures of Projection Performance

		No. under predicted	No. extreme deviations*	Largest absolute deviation	Mean Absolute Error	RMSE
Simple Trend Extrapolation						
LINE (5)		27	0	5.95	3.39	6923
EXPO (5)		27	0	5.71	3.36	6908
SHARE (5)-88M1F1		14	0	2.96	0.87	1088
SHARE (5)-88M2F1		27	0	6.18	3.68	7635
SHARE (5)-88M3F1		27	0	8.59	6.16	13515
SHARE (5)-95M1F1		24	0	3.82	1.33	2065
SHARE (5)-95M1F2		25	0	3.88	1.38	2179
LINE (10)		25	0	3.71	1.46	4712
EXPO (10)		24	0	3.70	1.36	4609
SHARE (10)-88M1F1		14	0	2.41	0.91	1617
SHARE (10)-88M2F1		27	0	5.64	3.28	9013
SHARE (10)-88M3F1		27	0	8.07	5.77	14858
SHARE (10)-95M1F1		19	0	3.27	1.12	3402
SHARE (10)-95M1F2		19	0	3.32	1.15	3525
Regression Share Techniques						
REG-88M1F1		16	0	3.05	1.03	1921
REG-88M2F1		27	0	6.09	3.64	7539
REG-88M3F1		27	0	8.50	6.11	13357
REG-95M1F1		24	0	3.72	1.44	2385
REG-95M1F2		24	0	3.78	1.49	2471
Cohort Component Results						
M0	M0F1	18	1	10.80	3.31	8861
	M0F2	18	1	15.53	3.57	8921
	M0F3	20	1	20.25	3.95	9230
M1	M1F1	22	1	10.07	3.34	4858
	M1F2	24	1	14.80	3.71	6140
	M1F3	23	1	19.53	4.18	7507
M2	M2F1	23	0	9.58	3.72	10559
	M2F2	24	1	14.31	4.18	11588
	M2F3	24	1	19.04	4.65	12713
M3	M3F1	24	0	9.28	4.19	17291
	M3F2	24	1	13.83	4.67	18179
	M3F3	24	2	18.55	5.14	19144
Electoral Register Ratio		5	0	7.49	3.14	8140

*Extreme observations are those that differ by more than 10 per cent from the actual outcome.

5. PROJECTIONS FOR 2001 AND 2006

Having established the most accurate projection method, it is interesting to use this to produce real projections for the period from the last census (1996). Keeping with the 5-year intercensal interval, a 5-year projection involves the production of projections to 2001, which has of course passed. Thus, it is of more relevance to increase the projection horizon to 10 years, which of course increases the forecast error dramatically. The national projections that were published by the CSO in 1999 are used along with the SHARE method that performed best. Since it is not clear at this stage which of the projections provided by the CSO are the most accurate the whole set of projections is again used. The results are shown in Table 7.4.

Since these figures may be used for planning purposes, a brief comparison with the CSO projections of regional populations is in order (see CSO 2001). A number of interesting differences emerge. For example the results contained in this paper regarding the Dublin population are lower in all cases compared to the CSO projections. Overall these projections are larger then the CSO projections for the Mid-West, South-West, Mid-East, Border, Midlands and West regions but lower for Dublin and the South-East. They are therefore suggesting a somewhat different pattern of population change, with regions such as the Midlands not doing as badly as predicted by the CSO.

Of course, it is important to bear in mind that the projections for 2006 are made over a 10 year projection horizon (from 1996), which means that these projections are likely to be subject to a larger error than those produced for 1996. In order to assess this increase in prediction error it is useful to show the effect of such an increase in the projection horizon would have on predictions for 1996. Such a comparison is shown in Table 7. In this table, the first set of rows simply replicates those of Table 6 for the simple SHARE technique with a 5-year trend. The second set of rows however displays the corresponding results from a projection of the 1996 population, using the 5 year trend from 1981 to 1986 rather than that for 1986 to 1991, keeping the total national projections as before. The table clearly shows the increase in the forecast error, in terms of the largest absolute deviation, the mean absolute error and root mean squared error (RMSE). This simple analysis implies that the projections for 2006 need to be interpreted cautiously.

Table 7: Measures of Prediction Accuracy using the SHARE method to predict the 1996 county populations with for 5 and 10 year projection horizons

	No. under predicted	No. extreme deviations*	Largest absolute deviation	Mean Absolute Error	RMSE
Forecasting 5 Years ahead					
SHARE (5)-88M1F1	14	0	2.96	0.87	1088
SHARE (5)-88M2F1	27	0	6.18	3.68	7635
SHARE (5)-88M3F1	27	0	8.59	6.16	13515
SHARE (5)-95M1F1	24	0	3.82	1.33	2065
SHARE (5)-95M1F2	25	0	3.88	1.38	2179
Forecasting 10 years ahead					
SHARE (5)-88M1F1	9	0	7.54	2.18	7093
SHARE (5)-88M2F1	22	0	6.46	2.54	13807
SHARE (5)-88M3F1	25	0	8.87	4.69	19328
SHARE (5)-95M1F1	12	0	6.59	1.95	8726
SHARE (5)-95M1F2	13	0	6.53	1.95	8834

6. CONCLUSION

This paper has outlined a number of different population projection methods, and has applied these to predict the population for each county in 1996 in order to evaluate the predictive performance of each of these methods. These methods include the familiar cohort component method, simple extrapolation techniques, regression based share extrapolation and a correlated indicator method.

The results of the analysis yield a surprising result; namely, that the cohort component method performed relatively badly compared to the other methods, particularly the simple share extrapolation method. Of course, this could easily be attributed to the assumptions made in deriving the cohort component results. However, assumptions need to be made in each method and it will not be known *ex ante* which set of assumptions is correct. A researcher will always be faced with difficult choices regarding these assumptions. Furthermore, for the share extrapolation methods the assumptions are simple and do not require much research. The results found here, also concord with those found by Svanson and Beck (1994) which found particularly large absolute deviations for the cohort component method (up to 57 per cent).

It should be noted that none of the methods considered here explicitly incorporate policy variables that will have important effects on the population distribution within the country, migration decision and fertility. Incorporating these would require a structural modelling approach, which would capture the effect of policy on migration and fertility and which could, apart from prediction, could also be used to evaluate the effect of policies.

Taking the most accurate method, i.e. the simple share extrapolation, projections of county populations for 2001 and 2006 were produced. These, while adding up to the same total (by construction) as those produced for regions by the CSO, nevertheless differ significantly in that Dublin and the South-East are projected to have a lower population in these years than was projected by the CSO.

Endnotes

1. While the data is available for all census years from 1841, the periodicity is not constant i.e. the initial census years were 10 years apart, which reduced to 5 years but this series was broken since there was no census in 1976.
2. For national projections internal migration is irrelevant.
3. Details of the fertility rates can be obtained from the author.
4. This figure was derived from the CSO, 1996b: Report on Vital Statistics, 1991
5. Again this figure was derived from the CSO, 1996b: Report on Vital Statistics, 1991
6. There have been studies on migration in the past such as Hughes and Walsh, 1980, and Sexton, Walsh, Hannan and McMahon, 1991, but these were concerned with migration in the 1960s, 1970s and early 1980s, rather than the late 1980s or early 1990s.

7. APPENDIX

Table 7.1: Assumed Age and Gender Breakdown for Internal Migration, 1991-1996

	Age shares		Gender Balance	
Age	Male	Female	Male	Female
1-4	5.96	5.16	50.20	49.80
5-9	5.20	4.23	51.72	48.28
10-14	3.36	3.09	48.62	51.38
15-19	14.62	18.34	41.02	58.98
20-24	24.01	25.41	45.18	54.82
25-29	17.81	18.07	46.24	53.76
30-34	10.84	9.11	50.93	49.07
35-39	6.22	4.66	53.78	46.22
40-44	3.48	2.56	54.28	45.72
45-49	1.97	1.55	52.59	47.41
50-54	1.42	1.16	51.64	48.36
55-59	1.04	0.95	48.90	51.10
60-64	0.98	0.92	48.28	51.72
65-69	1.08	1.46	35.98	64.02
70-74	0.87	1.26	35.98	64.02
75-79	0.63	1.01	35.98	64.02
80-84	0.34	0.63	35.98	64.02
85+	0.16	0.43	35.98	64.02
Total	100	100		

Note: The figures in this table were calculated on the basis of data from the 1991 Census of Population, Volume 8 Usual Residence and Migration, Tables 11B and 11C.

Table 7.2: County Population Projections for 1996 derived using Simple and Regression Based Trend Extrapolation and Correlated Indicators Methods

	Carlow	Cavan	Clare	Cork	Donegal	Dublin	Galway	Kerry	Kilkenny	Kildare	Laois	Leitrim	Limerick	Longford
Actual 1996	41,616	52,944	94,006	420,510	129,994	1,058,264	188,854	126,130	75,336	134,992	52,945	25,057	165,042	30,166
5 year trend														
LINE (5)	40,896	51,627	90,492	408,003	126,570	1,029,159	182,176	119,629	74,084	129,065	51,344	23,567	159,343	29,096
EXPO (5)	40,896	51,640	90,493	408,010	126,579	1,029,166	182,185	119,650	74,085	129,235	51,353	23,625	159,364	29,119
SHARE (5)-88M1F1	42,167	53,241	93,307	420,700	130,516	1,061,100	187,820	123,365	76,382	133,019	52,948	24,314	164,316	30,010
SHARE (5)-88M2F1	40,769	51,476	90,214	406,754	126,189	1,025,926	181,594	119,276	73,850	128,610	51,192	23,508	158,869	29,016
SHARE (5)-88M3F1	39,721	50,153	87,894	396,294	122,944	999,545	176,925	116,209	71,951	125,303	49,876	22,904	154,784	28,269
SHARE (5)-95M1F1	41,794	52,770	92,482	416,981	129,362	1,051,720	186,160	122,275	75,707	131,844	52,480	24,099	162,864	29,745
SHARE (5)-95M1F2	41,771	52,741	92,431	416,748	129,290	1,051,134	186,056	122,207	75,664	131,770	52,450	24,086	162,773	29,728
10 year trend														
LINE (10)	41,503	52,267	92,594	414,321	129,620	1,036,374	184,537	121,456	75,050	131,923	52,886	24,147	162,104	29,874
EXPO (10)	41,523	52,279	92,674	414,418	129,665	1,036,681	184,793	121,460	75,121	134,073	52,902	24,265	162,104	29,888
SHARE (10)-88M1F1	42,124	53,003	93,995	420,461	131,550	1,051,777	187,361	123,197	76,187	134,173	53,672	24,454	164,454	30,291
SHARE (10)-88M2F1	40,728	51,246	90,879	406,523	127,189	1,016,911	181,150	119,113	73,662	129,725	51,893	23,643	159,003	29,287
SHARE (10)-88M3F1	39,680	49,928	88,542	396,070	123,919	990,762	176,492	116,050	71,768	126,389	50,558	23,035	154,914	28,534
SHARE (10)-95M1F1	41,752	52,535	93,164	416,744	130,387	1,042,479	185,704	122,108	75,514	132,987	53,197	24,238	163,001	30,023
SHARE (10)-95M1F2	41,729	52,505	93,112	416,512	130,315	1,041,898	185,601	122,040	75,472	132,913	53,168	24,224	162,910	30,006
Regression Based														
88M1F1	41,936	52,395	93,915	416,574	129,462	1,064,329	185,729	122,515	75,531	134,616	53,140	24,395	164,124	30,212
88M2F1	40,546	50,658	90,802	402,765	125,170	1,029,047	179,572	118,454	73,028	130,153	51,378	23,586	158,683	29,211
88M3F1	39,503	49,355	88,467	392,408	121,951	1,002,586	174,955	115,408	71,150	126,806	50,057	22,980	154,603	28,460
95M1F1	41,565	51,932	93,085	412,892	128,317	1,054,921	184,087	121,432	74,864	133,426	52,670	24,180	162,673	29,945
95M1F2	41,542	51,903	93,033	412,662	128,246	1,054,333	183,985	121,365	74,822	133,351	52,641	24,166	162,582	29,929
Correlated indicators														
Electoral Register	41,591	53,428	97,898	436,821	137,315	1,023,425	184,285	127,462	76,205	137,350	54,695	25,439	165,294	31,235

Table 7.2 (continued)

	Louth	Mayo	Meath	Monaghan	Offaly	Roscommon	Sligo	Tipperary N.R	Tipperary S.R	Waterford	Westmeath	Wexford	Wicklow	State
Actual 1996	92,166	111,524	109,732	51,313	59,117	51,975	55,821	58,021	75,514	94,680	63,314	104,371	102,683	3,626,087
5 year trend														
LINE (5)	89,638	106,242	106,859	50,207	57,153	49,202	53,466	56,186	72,739	92,097	60,381	101,586	99,988	3,510,795
EXPO (5)	89,644	106,331	106,870	50,218	57,168	49,271	53,481	56,210	72,770	92,098	60,399	101,587	100,026	3,510,827
SHARE (5)-88M1F1	92,432	109,581	110,166	51,776	58,940	50,754	55,138	57,946	75,018	94,954	62,270	104,746	103,071	3,620,000
SHARE (5)-88M2F1	89,368	105,949	106,514	50,060	56,986	49,072	53,310	56,025	72,531	91,807	60,206	101,274	99,654	3,500,000
SHARE (5)-88M3F1	87,070	103,225	103,775	48,773	55,521	47,810	51,940	54,585	70,666	89,446	58,658	98,670	97,092	3,410,000
SHARE (5)-95M1F1	91,615	108,613	109,192	51,319	58,419	50,305	54,651	57,434	74,355	94,115	61,719	103,820	102,160	3,588,000
SHARE (5)-95M1F2	91,564	108,552	109,131	51,290	58,387	50,277	54,620	57,402	74,313	94,062	61,685	103,763	102,103	3,586,000
10 year trend														
LINE (10)	91,829	108,687	110,346	51,344	58,585	50,574	54,397	57,289	74,239	93,141	62,059	103,563	102,173	3,566,876
EXPO (10)	91,864	108,775	111,010	51,344	58,585	50,653	54,403	57,302	74,254	93,206	62,060	103,620	102,880	3,568,113
SHARE (10)-88M1F1	93,198	110,184	112,125	52,088	59,436	51,257	55,171	58,097	75,288	94,544	62,963	105,116	103,832	3,620,000
SHARE (10)-88M2F1	90,109	106,532	108,408	50,362	57,466	49,558	53,342	56,171	72,792	91,410	60,876	101,632	100,390	3,500,000
SHARE (10)-88M3F1	87,792	103,793	105,621	49,067	55,988	48,284	51,970	54,727	70,920	89,059	59,310	99,019	97,809	3,410,000
SHARE (10)-95M1F1	92,374	109,210	111,134	51,628	58,911	50,804	54,683	57,584	74,622	93,708	62,406	104,187	102,914	3,588,000
SHARE (10)-95M1F2	92,323	109,150	111,072	51,599	58,878	50,776	54,653	57,551	74,581	93,656	62,372	104,129	102,857	3,586,000
Regression Based														
88M1F1	93,759	109,509	113,076	51,846	59,241	51,115	54,837	57,776	74,889	93,580	63,182	104,757	103,558	3,620,000
88M2F1	90,651	105,879	109,328	50,127	57,277	49,421	53,019	55,861	72,407	90,478	61,088	101,284	100,125	3,500,000
88M3F1	88,320	103,156	106,517	48,838	55,805	48,150	51,656	54,424	70,545	88,152	59,517	98,680	97,551	3,410,000
95M1F1	92,930	108,541	112,077	51,388	58,717	50,663	54,352	57,265	74,227	92,753	62,624	103,831	102,643	3,588,000
95M1F2	92,878	108,480	112,014	51,359	58,685	50,635	54,322	57,233	74,186	92,701	62,589	103,773	102,585	3,586,000
Correlated indicators														
Electoral Register	97,963	111,407	117,947	53,931	62,429	53,391	57,572	60,217	77,247	97,643	62,186	111,331	106,728	3,662,435

Table 7.3: County Population Projections for 1996 derived using the Cohort Component Method (various assumptions)

	Carlow	Cavan	Clare	Cork	Donegal	Dublin	Galway
Actual 1996	41,616	52,944	94,006	420,510	129,994	1,058,264	188,854
M1F1	42,130	52,203	89,846	412,589	131,808	1,045,289	188,139
M1F2	41,752	51,921	89,297	410,395	131,023	1,042,319	187,151
M1F3	41,375	51,638	88,748	408,201	130,239	1,039,350	186,164
M2F1	41,670	52,378	89,539	408,505	132,362	1,009,260	185,577
M2F2	41,292	52,095	88,990	406,311	131,578	1,006,291	184,589
M2F3	40,915	51,813	88,441	404,117	130,793	1,003,321	183,601
M3F1	41,210	52,552	89,232	404,422	132,917	973,231	183,014
M3F2	40,832	52,270	88,683	402,227	132,132	970,262	182,026
M3F3	40,455	51,987	88,134	400,033	131,348	967,292	181,039
	Kerry	**Kilkenny**	**Kildare**	**Laois**	**Leitrim**	**Limerick**	**Longford**
Actual 1996	126,130	75,336	134,992	52,945	25,057	165,042	30,166
M1F1	119,858	71,280	148,584	51,231	24,137	161,267	28,807
M1F2	119,238	70,541	154,967	51,053	24,019	160,729	28,749
M1F3	118,618	69,802	161,350	50,875	23,901	160,190	28,691
M2F1	119,800	70,741	147,928	51,036	24,263	157,064	28,885
M2F2	119,180	70,002	154,311	50,858	24,145	156,526	28,826
M2F3	118,559	69,263	160,694	50,680	24,027	155,987	28,768
M3F1	119,742	70,201	147,272	50,842	24,388	152,861	28,962
M3F2	119,122	69,462	153,655	50,664	24,270	152,323	28,904
M3F3	118,501	68,723	160,038	50,486	24,153	151,784	28,846

Table 7.3 (continued)

	Louth	Mayo	Meath	Monaghan	Offaly	Roscommon	Sligo
Actual 1996	92,166	111,524	109,732	51,313	59,117	51,975	55,821
M1F1	92,476	104,684	109,955	50,334	57,207	48,730	53,483
M1F2	92,076	104,233	109,385	50,028	56,863	48,582	53,160
M1F3	91,677	103,781	108,814	49,723	56,534	48,434	52,838
M2F1	92,279	105,559	109,581	50,161	57,368	49,072	52,879
M2F2	91,880	105,108	109,010	49,856	57,025	48,924	52,556
M2F3	91,480	104,656	108,440	49,550	56,696	48,776	52,234
M3F1	92,082	106,434	109,207	49,989	57,530	49,414	52,275
M3F2	91,683	105,983	108,636	49,683	57,186	49,266	51,952
M3F3	91,283	105,531	108,066	49,378	56,857	49,118	51,630

	Tipperary N.R	Tipperary S.R	Waterford	Westmeath	Wexford	Wicklow	State
Actual 1996	58,021	75,514	94,680	63,314	104,371	102,683	3,626,087
M1F1	55,449	70,436	92,920	60,621	100,967	104,114	3,568,544
M1F2	56,823	70,019	92,536	60,219	100,610	103,682	3,561,371
M1F3	58,197	69,602	92,153	59,816	100,253	103,250	3,554,212
M2F1	55,272	69,473	92,107	59,810	101,625	104,351	3,518,544
M2F2	56,646	69,056	91,724	59,407	101,267	103,919	3,511,371
M2F3	58,019	68,639	91,341	59,005	100,910	103,487	3,504,212
M3F1	55,095	68,510	91,294	58,999	102,282	104,588	3,468,544
M3F2	56,468	68,093	90,911	58,596	101,925	104,156	3,461,371
M3F3	57,842	67,676	90,528	58,194	101,568	103,724	3,454,212

Table 7.4 Predicted Population for the years 2001 and 2006 calculated using the SHARE method and CSO national predictions

	Carlow	Cavan	Clare	Cork	Donegal	Dublin	Galway	Kerry	Kilkenny	Kildare	Laois	Leitrim	Limerick	Longford
2001														
M1F1	43,505	54,576	99,977	443,223	135,647	1,123,517	203,336	134,242	79,279	152,163	55,102	25,487	172,984	30,862
M1F2	43,482	54,547	99,925	442,992	135,576	1,122,931	203,230	134,172	79,238	152,084	55,073	25,474	172,893	30,846
M1F3	43,482	54,547	99,925	442,992	135,576	1,122,931	203,230	134,172	79,238	152,084	55,073	25,474	172,893	30,846
M2F1	43,222	54,220	99,325	440,334	134,763	1,116,195	202,011	133,367	78,762	151,171	54,743	25,321	171,856	30,661
M2F2	43,188	54,177	99,247	439,988	134,657	1,115,316	201,852	133,262	78,700	151,052	54,700	25,301	171,721	30,637
M2F2	43,188	54,177	99,247	439,988	134,657	1,115,316	201,852	133,262	78,700	151,052	54,700	25,301	171,721	30,637
2006														
M1F1	45,406	56,134	106,165	466,458	141,307	1,190,996	218,536	142,657	83,302	170,614	57,246	25,845	181,020	31,491
M1F2	45,170	55,844	105,615	464,040	140,574	1,184,824	217,403	141,918	82,870	169,730	56,949	25,711	180,082	31,328
M1F3	45,036	55,677	105,300	462,659	140,156	1,181,297	216,756	141,495	82,623	169,225	56,779	25,635	179,546	31,235
M2F1	44,487	54,998	104,016	457,018	138,447	1,166,894	214,113	139,770	81,616	167,161	56,087	25,322	177,357	30,854
M2F2	44,263	54,721	103,492	454,716	137,750	1,161,016	213,035	139,066	81,205	166,319	55,805	25,195	176,464	30,698
M2F3	44,128	54,555	103,178	453,335	137,331	1,157,489	212,387	138,643	80,958	165,814	55,635	25,118	175,928	30,605

Table 7.4 (continued)

	Louth	Mayo	Meath	Monaghan	Offaly	Roscommon	Sligo	Tipperary N.R.	Tipperary S.R.	Waterford	Westmeath	Wexford	Wicklow	State
2001														
M1F1	96,295	115,504	117,526	52,760	61,437	53,503	58,530	59,814	78,260	100,635	66,633	109,774	111,430	3,836,000
M1F2	96,245	115,444	117,464	52,732	61,405	53,476	58,500	59,783	78,219	100,582	66,598	109,717	111,372	3,834,000
M1F3	96,245	115,444	117,464	52,732	61,405	53,476	58,500	59,783	78,219	100,582	66,598	109,717	111,372	3,834,000
M2F1	95,667	114,751	116,760	52,416	61,036	53,155	58,149	59,424	77,750	99,979	66,198	109,059	110,704	3,811,000
M2F2	95,592	114,661	116,668	52,375	60,988	53,113	58,103	59,378	77,689	99,900	66,146	108,973	110,616	3,808,000
M2F2	95,592	114,661	116,668	52,375	60,988	53,113	58,103	59,378	77,689	99,900	66,146	108,973	110,616	3,808,000
2006														
M1F1	100,442	119,392	125,666	54,121	63,732	54,952	61,274	61,528	80,949	106,802	70,019	115,281	120,665	4,052,000
M1F2	99,922	118,773	125,014	53,841	63,401	54,668	60,957	61,210	80,530	106,248	69,656	114,684	120,039	4,031,000
M1F3	99,624	118,420	124,642	53,681	63,213	54,505	60,775	61,027	80,290	105,932	69,448	114,342	119,682	4,019,000
M2F1	98,410	116,976	123,123	53,026	62,442	53,840	60,034	60,283	79,311	104,640	68,602	112,948	118,223	3,970,000
M2F2	97,914	116,387	122,502	52,759	62,127	53,569	59,732	59,980	78,912	104,113	68,256	112,379	117,627	3,950,000
M2F3	97,616	116,033	122,130	52,599	61,939	53,406	59,550	59,797	78,672	103,797	68,049	112,038	117,270	3,938,000

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DISCUSSION

Mr. Aidan Punch: Mr President, Ladies and Gentlemen, I welcome the opportunity of proposing this vote of thanks to Edgar Morgenroth on his paper entitled "Evaluating Methods for Short to Medium Term County Population Forecasting".

The paper uses a number of different methods to project the 1991 census figures at county level to 1996 and then compares the accuracy of these methods against the actual 1996 census data to determine *ex post* the most accurate one. The methods employed include:

1. linear and exponential extrapolation of recent county trends including shift share analysis;
2. fitting regression lines to recent county data;
3. correlating with the register of electors at county level; and
4. the author's own county projections for 1996 using the cohort component method.

Table 6 of the paper then assesses the projection performance of these methods by examining the number of counties whose populations have been underpredicted as well as providing various measures of dispersion.

The main conclusion of the paper is that:

> "*The results of the analysis yield a surprising result; namely, that the cohort component method performed relatively badly compared to the other methods, particularly the simple share extrapolation method.*"

although the author does allow that

> "*Of course, this could easily be attributed to the assumptions made in deriving the cohort component results*".

However, this conclusion is then left hanging. It is not clear whether the corollary ought to be that CSO, which as the audience will know, uses the cohort component method for official national and regional population projections, should abandon this approach forthwith and simply use shift share techniques in future. You will have detected from this provocative statement that I favour the cohort component approach to making population projections. But before singing its praises let us first look at the alternatives put forward.

In the trend extrapolation method the five-year and ten-year county trends to 1991 are simply continued forward to 1996. The linear variant is additive while the exponential one offers the user the choice of either the separately derived state figure or the sum of the county figures. Admittedly the differences are small. A lot depends on which census years are picked in assessing the so-called accuracy of these measures post hoc. For instance, if we project the 1961 population to 1966 based on the 1956 to 1961 and

1951 to 1961 trends we get largest absolute deviations of around 8 for LINE(5), EXPO(5), LINE(10) and EXPO(10) and mean absolute differences in the range 3 to 4. This could hardly be termed good in such a short run projection period, but then 1961 was a turning point in our population and the migration patterns evident in the fifties did not continue into the early sixties.

The SHARE method attempts to get the best of all worlds. On the one hand the changes in county shares from one census to the next are continued forward linearly, while on the other hand the resulting shares are then applied to exogenously determined national projections (which are invariably based on the dreaded cohort component method!). It's not entirely clear whether the resulting deviations listed in Table 6, which find much favour with the author, are due to the benefits of shift share as a technique or to good national projections or indeed to a happy confluence of both.

It is of interest at this stage to briefly examine the accuracy of the quoted CSO national projections. The 1988 report used the 1986 census as the basis for the projections. Fertility fell at a faster rate than either F1 or F2 suggested, resulting in an actual TFR for 1996 of 1.89 against a projected 2.1 and 2.04, respectively. So births were overstated. The projected increase in life expectancy to 1996 was 2 years less than achieved (for both males and females) resulting in deaths being overstated. M1, M2 and M3 assumed average annual net outflows during 1986 to 1996 of 15,000, 25,000 and 32,500 respectively against an actual figure of 12,500. The result was that M1 projected a population of 3.62m compared with the measured population of 3.63m while M2 and M3 projected 3.5m and 3.41m, respectively. So M1 was fortuitously in the ball park because of the offsetting effects of births and deaths and because it assumed that average net outward migration would be 15,000 during each of the two sub-periods 1986 to 1991 and 1991 to 1996 although we now know that migration changed from high outwards to inwards during this period.

The 1995 report, which was based on the 1991 census, would be expected to accurately predict 1996 given its closeness in time. However, while fertility and mortality were accurate, the assumptions on migration were still largely outwards resulting in the population being understated.

Coming back to the SHARE performance in Table 6, the fact that the errors increase according as the national projections deviate from the actual outturn indicates that there is a scale factor at work and that the method is at the mercy of the national projections. It is therefore surprising to note that the author appears to favour it so much. Maybe it would be better to jettison the cohort component model entirely and marry the SHARE approach to the LINE(5) or LINE(10) approaches at national level. Perversely, this would give better results for LINE(5) but worse ones for LINE(10) in projecting to 1996 compared with the results obtained for the 1986 based M1F1 projections.

Turning to the method which fits regression lines through four data points and then calibrates the shares to 100 before applying them to the national projections, it strikes me that using different functional forms for counties in order to optimise the R^2 term is purely mechanistic and underscores the absence of a coherent view on the interdependence of county populations.

The use of the Register of Electors data for population estimation suffers from a number of well-known drawbacks. The fact that its coverage only extends to those aged 18 years and over should have led the author to complement it using, say, the number of children for whom child benefit is paid, especially those up to age sixteen. Coverage of the register may also depend on whether an election is pending while there are well known county differentials. For instance, comparing the population aged 18 years and over in April 1996 with the register figures for February 1996 yields Register overestimates of 16 to 20 per cent for Donegal, Monaghan, Cavan, Meath and Leitrim while the population of the five county borough areas are all understated. In view of these shortcomings its use for current population estimates, let alone for population projections, is somewhat doubtful.

The last of the methods used is the author's own projection of the 1996 county populations using 1991 as a basis and following the cohort component approach. It is not clear what function is served by using assumptions which are clearly known to be at variance with the actual outturn and then computing measures based on the derived population, such as largest absolute difference and mean absolute error, and then decrying them for showing large values – unless of course the intention is to say that an alternative method is superior!

So what has the cohort component method got going for it? A definite strength is that it forces us to take a stance on each of the factors influencing population change. Of course this is difficult but it means that we have to nail our colours to the mast on all the components. We have to take a view on fertility rates – whether at the national level they will continue to fall in line with the European experience and whether at a regional level we will see continued convergence. We have to pronounce on how quickly Ireland will converge towards the life expectancies of other European countries while observing that there is little variation at regional level within the State. More critically we have to pronounce on the magnitude and direction of migration flows – both internal and international. This has proved to be the most difficult component to predict in past projections and will doubtless continue to be so in future projections. In the final analysis, if our projections turn out to be wrong we can at least say which of the factors is at fault. In the alternatives examined in the paper we will not be able to explain away differences except to state that the overall population trends have not faithfully followed those which were experienced in the past.

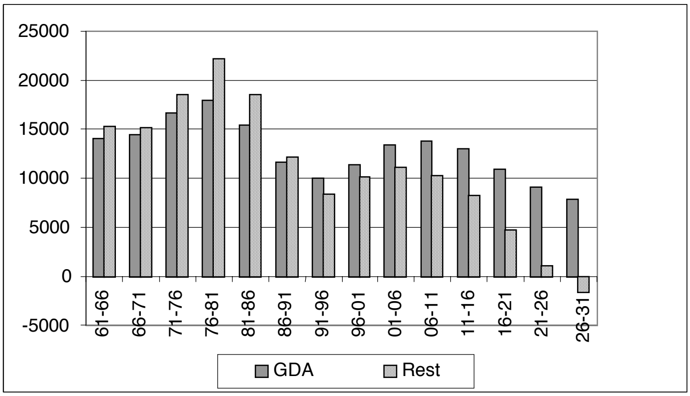
A further benefit of the cohort component method is that it provides projections of births, deaths and migrants. It also yields important age structure information which is vital to planning. It is also beneficial to look at the impact of the assumed changes in the longer term, particularly on the young and old populations. These advantages will be absent from other methods, thereby severely limiting their usefulness.

In the final part of my intervention I want to address a number of points made in the paper relating to what the author calls "real" projections to 2001 and 2006. These projections are based on continuing the linear pattern of county population shares observed during 1991 to 1996 onwards to 2001 and 2006 and then applying the derived shares to the national projections produced by CSO. Based on his analysis of using five-year trends to project forwards five years and ten years to 1996 as outlined in Table 7, he advises that the projections for 2006 need to be interpreted cautiously. I would suggest that a more plausible reason for urging caution is that they are actual projections and not forecasts of the past and that the same uncertainty applies to them as to any projections.

A further point relates to a suggestion that the projected population for the Dublin region contained in the CSO regional projections is on the high side. This has also been noted by others, including Garrett Fitzgerald in his weekly *Irish Times* column. For the purposes of analysis it is probably best to consider the Greater Dublin area versus the rest of the country. The former consists of the counties of Dublin, Meath, Kildare and Wicklow.

In order to understand the divergence between the projected trend in the population of the GDA compared with its historical one it is necessary to look at the components of the changes. The average annual natural increase for the GDA has been less than that of the rest of the country up until 1991. In the projections, however, the differential age structure going forward (with a younger population in the East) will ensure that there are more births (despite the lower fertility rates) and fewer deaths. This is shown in Figure 1.

Figure 1: Average Annual Natural Increase (actual and projected M1F2)



As usual it is the migration component which excites the greatest interest – specifically the inter-regional flows in the case of the regional projections. The picture for the last four censuses shown in Table 1 displays remarkable stability in terms of the inter-regional flows. In our projections we maintained the 1996 pattern going forward. We did this while being fully aware of the trends emerging from the QNHS up to 1999 at the time. These trends, shown in Table 2, illustrate that there has been a turn around in internal migration to the Dublin area since 1997. However, the real question is whether these trends are a temporary aberration or whether they represent a long term reversal of well established trends. It should be borne in mind in this regard that the population estimates are themselves subject to change pending the results of the 2002 census (we should have the preliminary picture by county and sex in July).

Perhaps the CSO need not be too defensive of its projections. Without wishing to steal his thunder, tonight's seconder of the vote of thanks, Dr Brian Hughes, in a paper prepared in Autumn 1999 put the population of the GDA in 2011 in the range 1.73 to 1.9 million with a greater likelihood that it would be at the higher end of that range. A paper commissioned by the Department of Environment and Local Government and prepared by consultants for the National Spatial Strategy had projections for 2010 in the range 1.75 to 2.03 million. By comparison CSO's M1F2 variant for 2011 for the GDA is 1.8 million.

I want to conclude Mr President by complimenting Edgar Morgenroth for focusing our attention on the question of both county and regional population projections at a critical time for policymaking, given the importance of the National Spatial Strategy. I must admit however that it is not clear from his paper whether he seriously intends that some of his alternative trend based measures should actually be used at an official level for policy formulation.

With that it gives me great pleasure to formally propose a vote of thanks to Edgar on your behalf.

Table 1: Census Internal Migration Matrices

Usual Residence	Usual Residence 1 year previously								
	Border	Dublin	Mid-East	Midland	Mid-West	South-East	South-West	West	Total
1996									
Border		1265	634	319	188	171	189	797	3563
Dublin	1981		3623	1283	1670	2341	2059	1946	14903
Mid-East	619	5909		464	288	556	357	356	8549
Midland	288	775	512		280	324	190	419	2788
Mid-West	318	947	349	459		739	1406	779	4997
South-East	226	1475	757	369	876		722	270	4695
South-West	228	1157	321	211	1243	965		450	4575
West	887	1320	394	709	707	292	453		4762
Total	4547	12848	6590	3814	5252	5388	5376	5017	48832
Net = In - Out	-984	2055	1959	-1026	-255	-693	-801	-255	
1991									
Border		994	495	233	144	152	138	679	2835
Dublin	1759		2598	1207	1429	2031	1653	1555	12232
Mid-East	482	3857		399	240	506	296	246	6026
Midland	150	552	367		258	252	120	338	2037
Mid-West	178	745	218	304		521	915	478	3359
South-East	177	999	492	236	517		588	224	3233
South-West	182	998	253	113	868	679		206	3299
West	594	880	264	511	492	231	263		3235
Total	3522	9025	4687	3003	3948	4372	3973	3726	36256
Net = In - Out	-687	3207	1339	-966	-589	-1139	-674	-491	
1986									
Border		924	494	220	133	120	150	628	2669
Dublin	1892		2978	1109	1255	1847	1742	1433	12256
Mid-East	755	4079		377	220	481	285	233	6430
Midland	241	498	482		232	265	114	390	2223
Mid-West	224	738	280	368		499	915	465	3489
South-East	174	944	609	293	655		573	179	3427
South-West	189	920	274	169	808	745		237	3342
West	651	987	248	471	485	184	279		3305
Total	4126	9090	5365	3007	3788	4141	4059	3565	37141
Net = In - Out	-1457	3166	1065	-784	-299	-714	-717	-260	
1981									
Border		1097	526	302	175	155	161	633	3049
Dublin	2149		2551	1274	1493	1990	1956	2114	13527
Mid-East	621	4074		449	277	620	326	293	6660
Midland	289	811	500		242	327	172	326	2667
Mid-West	292	1090	271	351		632	1007	515	4158
South-East	211	1133	562	283	533		696	170	3588
South-West	211	1215	312	184	751	811		258	3742
West	641	1103	229	398	403	215	238		3227
Total	4414	10523	4951	3241	3874	4750	4556	4309	40618
Net = In - Out	-1365	3004	1709	-574	284	-1162	-814	-1082	

Table 2: QNHS Internal Migration for Regional Authorities

Year		Border	Dublin	Mid-East	Midland	Mid-West	South-East	South-West	West	State
2001	Out	4354	10341	2999	3314	1776	3367	2830	736	29717
	In	2301	6233	5875	2037	3273	3835	1929	4234	29717
	Net	-2053	-4108	2876	-1277	1497	468	-901	3498	0
2000	Out	3997	12603	4018	3779	3066	4895	3067	863	36288
	In	3136	6867	6720	3167	3719	4049	2588	6042	36288
	Net	-861	-5736	2702	-612	653	-846	-479	5179	0
1999	Out	3842	18763	6038	2810	4046	5326	4405	3435	48665
	In	4008	10207	9822	3071	5116	6275	4513	5653	48665
	Net	166	-8556	3784	261	1070	949	108	2218	0
1998	Out	3556	12447	4628	3028	3372	3382	3393	2854	36660
	In	2156	9000	7004	2565	3820	4611	3279	4225	36660
	Net	-1400	-3447	2376	-463	448	1229	-114	1371	0
1997	Out	4224	16021	4323	2468	5842	4258	4676	3567	45379
	In	1962	12359	13813	2751	3997	3095	2913	4489	45379
	Net	-2262	3662	9490	283	-1845	-1163	-1763	922	0
1996	Out	4028	7213	3656	1922	2510	3811	3154	3467	29761
	In	1817	10260	4228	1473	2582	2873	2210	4318	29761
	Net	-2211	3047	572	-449	72	-938	-944	851	0
1995	Out	3054	6541	3526	2460	3315	3336	3879	4378	30489
	In	1703	11810	4271	1467	3506	2458	3390	1884	30489
	Net	-1351	5269	745	-993	191	-878	-489	-2494	0
1994	Out	3487	7288	3927	2518	4041	3206	3050	3623	31140
	In	2487	9577	4448	1334	2269	2948	3395	4682	31140
	Net	-1000	2289	521	-1184	-1772	-258	345	1059	0
1993	Out	3456	8003	2895	2864	4161	3497	2861	3384	31121
	In	1292	8515	5328	1243	4443	3676	2651	3973	31121
	Net	-2164	512	2433	-1621	282	179	-210	589	0
1992	Out	4332	7235	3673	2799	3859	4137	3499	3734	33268
	In	2856	11983	4985	950	3708	2274	2542	3970	33268
	Net	-1476	4748	1312	-1849	-151	-1863	-957	236	0
Avg 92-01	Out	3833	10646	3968	2796	3599	3922	3481	3004	35249
	In	2372	9681	6649	2006	3643	3609	2941	4347	35249
	Net	-1461	-965	2681	-790	44	-313	-540	1343	0
Avg 91-01	Out	3995	14035	4401	3080	3620	4246	3674	2291	39342
	In	2713	8933	8647	2718	3985	4373	3004	4929	39342
	Net	-1282	-5102	4246	-362	365	127	-630	2638	0

DISCUSSION

Brian Hughes: This important research paper by Edgar Morgenroth deals with an area of knowledge shortfall often seen as a 'black hole' by developers, plants and policy strategists.

It comes at a time of fundamental structural change in the composition of Ireland's demographic growth. Net inward migration has for the first time outpaced natural growth in the year to April 2001, as confirmed by CSO's Population and Migration Estimates.

As a member of Dun Laoghaire – Rathdown Local Authority's Economic Development and Planning Strategy Committee, I have commented in Council, on the Authority's Housing Strategy 2001-2004, that their house-building target of 1,750 units per annum is believed to be substantially short of housing requirements. Thusfar, it has proved difficult to substantiate such a judgement in the absence of short-to-medium term county population forecasts, the absence of inter-censal county-by-county population forecasts and especially in the absence of inter-censal county-by-county migration data. Edgar's field of research, in that it informs the formulation of robust methodologies will undoubtedly prove invaluable in terms of reinforcing such an argument.

In similar vein, together with Dr. Brendan Williams, Patrick Shields (who is in tonight's audience) and Stephen Walsh, my Dublin Institute of Technology (DIT) colleagues and I, some time ago reported to the four Dublin Local Authorities on their Housing requirements. Therein it was concluded that the Capital's housing market is suffering from a substantial shortfall of housing supply relative to total demand. There is a pressing need to converge to European household densities, especially given the dynamic of Natural Growth and Net Inward Migration.

DIT's conclusions have centred on this shortfall and on its negative impact on sustainable development. In summary, the Open Market Value to Distance trade-off (as per the Alonzo Bid-Rent Model) is encouraging long-distance commuting patterns. Likewise, it is leading to the artificial growth in the fast-expanding dormitory towns in outer Leinster counties and to an increased Greater Dublin Area (GDA) Authorities' responsibility to meet their Part V Social and Affordable Hosing obligations, under the 2000 Planning & Development Legislation.

The absence of migration data has in the past left research conclusions 'hanging', despite the seemingly conclusive evidence of the profound lack of affordability of GDA housing especially for first-time buyers, at least until the 2002 Census data outcome is to hand. Meanwhile the housing affordability and supply shortfall crisis deepens despite the ending of the 'Celtic Tiger' era.

Edgar's papers, both this one and last year's comprehensive review of Greater Dublin, point to the fact that for many of the methods of assessment, the results generally tend to underestimate population projections when compared with the out-turn of the 1996 Census. The simple models appear to be more accurate!

Over the 1991-1996 period it was recorded that the Republic's aggregate net *inward* migration was only 2,000 compared to a natural growth of 98,000. This contrasts markedly with the position some five years later in April 2001. In this most recent period, natural growth of 109,000 was substantially matched by a figure of 104,000 for net *inward* migration. These profoundly changing components of Ireland's demographic structure clearly point to the need to develop research methodologies so as to monitor and assess annual migration flows on a county-by-county basis and particularly to do so for the faster-growing seven counties of the Greater Dublin Area. Ultimately we should aim to provide an equivalent of the quarterly-published data for Natural growth, as outlined in Tables 7 and 10 of CSO's Vital Statistics.

The Planning and Development professions, whose working relationship is becoming increasingly complementary rather than confrontational in both nature and in practice, require the same 'comfort' for migration data and trends as are now available for natural growth at the county level. This is needed particularly in the case of Dublin City Council, South Dublin and Dun Laoghaire – Rathdown given they comprise three of the four largest 'county' populations of the State.

Table 7.1 of the paper, 'Assumed Net Internal Migration 1991-1996', shows 8 counties to be the recipients of a total 26,755 *internal* in-migrants, as against 19 counties with a similar out-migration figure for that five-year period. It should be emphasised that as Dublin's division into four Authorities only took place during the 1991-96 period, in this analysis it is recorded as just **one** county. Yet the Greater Dublin Area accounts for almost 85% of the State's total net internal migration. More pointedly, as can be seen from Table 7.1 the remaining four non-GDA counties (Carlow, Donegal, Galway and Limerick), in aggregate accounted for just 4,025 or 15% of the positive internal migration between 1991 and 1996.

For me, this analysis raises extreme curiosity as to what the respective county-by-county net internal migration flows might have been for the 1996-2001 period, in the light of the near 104,000 net total State inward Migration up to April 2001. The 2002 Census will be awaited with baited breath!

Thanks to the data sets kindly provided to me by Aidan Punch, I recently undertook some simple analysis of natural growth projections on a region-by-region basis, using the CSO's central M1F2 projections out to 2031. In doing so, I am appreciative of Edgar's view as to the limited merits of making any long-term demographic projections. Over the Christmas period, I had written to Aidan to enquire as to whether the population natural growth trend of the Rest of State of 4.5 per 1000 was a temporary aberration compared to the GDA's 8.5 per 1000 rate?

This anlaysis clearly points to fact the M1F2 differentiation will actually continue to diverge right out to the end of the 2031 projection period. More profoundly for the Rest