Is There a Stable Migration Equation for Ireland?

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Abstract

In this paper we search for a stable migration equation for Ireland over the period 1951-1995. Given the integration of the Irish and UK labour markets through a long-standing migration link we model net migration as being driven by labour market conditions in Ireland relative to the UK. As in previous macroeconomic models of net migration we find evidence of instability in the basic equation. We adopt the general-to-specific econometric methodology to search for an equation that is sufficiently general to be congruent with the data set. This allows us to identify and parameterise the source of instability in the basic equation. From there we proceed to search for a parsimonious reduction of this general equation.

Our preferred equation models net migration in the current year as a function of relative wages and relative employment in Ireland and the UK in the previous year. The results indicate that on average net migration increases by 7,695 (0.64% of the labour force) given a one percentage point increase in the Irish unemployment rate while a one percentage point convergence of Irish wages on UK wages reduces net migration by 1,344 (0.11% of the labour force). We identify two sub-periods that fully parameterise the instability detected over the full sample. In the sub-period 1978-1989 the average propensity to migrate rose (by an annual rate of 1.71% of the labour force) while in the more recent sub-period, 1990-1995, the average propensity to migrate fell (by an annual equivalent of 0.96% of the labour force) relative to the rest of the sample.

This responsiveness of labour supply to changing labour market conditions through the migration mechanism, and the consequent weakening of the Phillips Curve effect, are fundamental to our understanding of the functioning of the Irish labour market. These characteristics imply that, *ceteris paribus*, unemployment rates are lower than in a 'no migration' scenario.

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Irish migration flows in the post-war period have been significant both in absolute size and in their variability over the medium term. The traditional migration pattern since the famine was one of high rates of net emigration, principally to the USA, and low rates of return migration. This pattern changed significantly in the more recent post-war period. The absolute size of net migration flows, although still high by international standards, was lower in this later period and the incidence of return flows increased substantially. In addition the principal destination of emigrants in the 1930s switched from the USA to the UK (albeit that the USA is still an important destination for Irish emigrants).

Because of this propensity of Irish people to migrate, Irish labour supply is very sensitive to changing economic conditions. This means that the Phillips Curve effect is much less important in Ireland than in economies with relatively closed labour markets. Indeed Krugman (1997) has recently argued that the Irish economy is best characterised as a regional economy because of the openness of its labour market.

In this paper[1] we model the migration decision within a framework that characterises the Irish labour market as a regional market within the wider UK labour market. We estimate a simple, single-equation model of net migration in the post-war period. In the model the Irish migration decision is, other things being equal, driven by labour market conditions in Ireland relative to the UK. Given the integration of the Irish labour market with the UK labour market via migration, the decision to migrate will, *ceteris paribus,* be affected by relative employment prospects in the two economies and the relative return to employment in the two economies.

This equation has been used, in different variants, in several empirical studies of Irish net migration (see Barrett (1998), O'Grada and Walsh (1994) for an overview of these studies). All of these studies revealed that there are significant links between net migration and changes in both relative employment and relative wage variables, however there was strong evidence of out-of-sample parameter instability.

This instability is not surprising. Firstly the model implicitly assumes that all migration is to the UK. This assumption is likely to be problematic for the period of the early 1980s when only 60% of all emigration was to the UK with 14% going to the USA[2]. Secondly it assumes that the characteristics of the average migrant have not altered over our sample period. However the NESC (1991) report on migration indicates that both the educational profile and to a lesser extent the sex composition of emigrants altered in the period from the 1950s to the 1980s. In particular there was a sharp increase in the proportion of emigrants with third level education in the 1980s. Thirdly the model does not include any demographic variables (e.g. the natural increase in the population, the fertility rate) which determine the absolute stock of potential emigrants at any given point in time. In addition the stock of outstanding emigrants at any one period in time will determine the potential flows of return migration. Fourthly the model does not allow for the fact that the migration decision, and especially return migration, is likely to have been significantly affected by the falling real cost of international transport over our sample period. And finally we are modelling *net* migration flows where there are different push and pull forces in operation for different cohorts in driving the migration decision.

Based on this model our general equation specifies that net migration is driven by two measures of labour market conditions, the relative wage gap between Ireland and the UK and the probability of employment in Ireland relative to the UK. We adopt the so-called "general-to-specific" econometric modelling approach (Hendry, 1993) to search for a stable long-run relationship between net migration and these two labour market variables. If such a relationship does indeed exist we would expect, *ex ante*, there to be a number of detectable structural breaks (regime shifts) over the post-war period attributable to some of the omitted factors listed above. We therefore pay particular attention to tests for parameter constancy at each stage of estimation.

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[1] This paper forms part of a wider research agenda to update the key behavioural equations in the macroeconomic HERMES-Ireland model in use in the ESRI (see Bradley et al. (1989) for details).
[2] More recent estimates for 1997 suggest that the share of migrants going to the UK may have fallen to 44% of the total (Barrett, 1998).

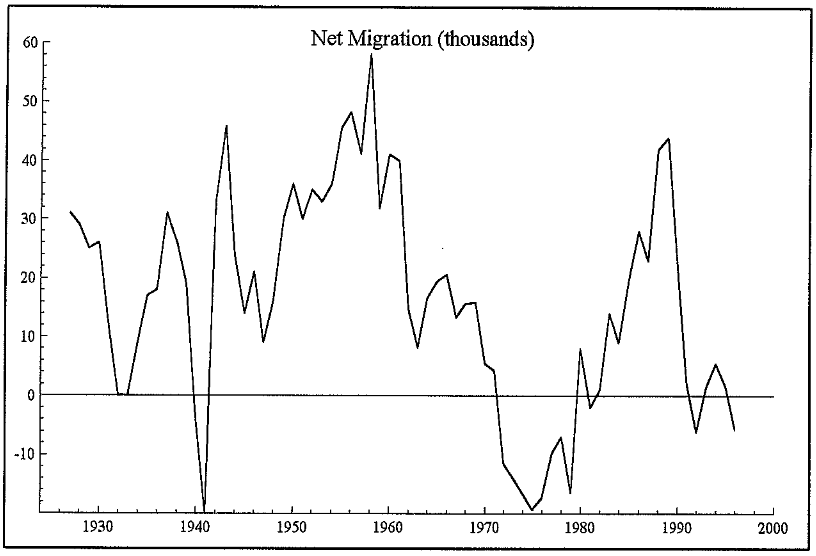
Our results confirm earlier studies that the scale of migration flows between Ireland and the UK have significantly increased the elasticity of labour supply in Ireland. This means that the policy trade-off between unemployment and (wage) inflation in Ireland is substantially weakened. On average a fall in the Irish unemployment rate of one percentage point will lead to a net inflow of migrants equivalent to 0.64% of the labour force. Thus the net impact on the unemployment rate is reduced to one third of the original reduction via migration. We estimate that given an equilibrium unemployment gap of five percentage points between Ireland and the UK, a gap that has been sustained for much of the post-war period, the relative wages consistent with zero net migration is of the order of 83% over the sample period.

We identify and parameterise two sub-periods that fully account for the instability in the full sample. In the first sub-period, 1978-1989, the average propensity to migrate rose by an annual average of 1.71% of the labour force relative to the 1951-1977 period. In the sub-period 1990-1995 the average propensity to migrate fell by an annual average of 0.96% of the labour force relative to 1951-1977 period. Furthermore our model rejects the inclusion of a lagged dependent variable. This is very important because its exclusion increases the speed of response of net migration flows to changing labour market conditions. In most of the earlier studies such lagged dependent variables were included whether or not they were statistically significant

1) A Preliminary Overview of the Data

Figure 1 shows the evolution of net migration over the period 1926 to 1996. During the post-war period net migration in Ireland recorded a net outflow of migrants in every year until the beginning of the 1970s. Cumulative net migration from Ireland over the thirty years 1942-1971 was in excess of 800,000. The 1970s was the first decade where net migration recorded a sustained inflow against a background of strong domestic growth. Over the ten-year period 1972-1981 net inward migration was an estimated 106,500. Net emigration resumed in the 1980s as the Irish economy moved into recession and domestic labour market conditions deteriorated sharply. Net migration reached a peak of 44,000 in 1989, a level not previously seen since the late 1950s, before the turnaround of recent years.

Figure 1: Net Migration 1926-1996



It was not until the early 1970s that the net migration series began to swing between positive and negative flows in a countercyclical pattern closely tracking changing fortunes in the labour market. This coincides with the period of Ireland's accession to the EC and the final phasing out of protectionism in Irish goods markets (the labour market was open prior to this time via the historic ties between Ireland and the UK and the long-standing migration link up to the 1930s with the USA). This is also the period when return migration became an important component of total migration flows reflecting a fundamental change in the nature of the migration decision. For instance it is estimated by NESC (1991, p59) that in the 1970s when gross inward migration amounted to nearly 270,000 there was still a sizeable gross outward flow of about 165,000. Cheaper travel costs and the gradual convergence of Irish living standards with our EU (especially the UK) neighbours has meant that the migration decision is no longer irreversible and that, given reasonable employment prospects, Ireland is a preferred location for former emigrants.

Recently Burda (1997) estimated the coefficient of variation of unemployment in Ireland and the UK for different sex and age cohorts over the period 1973-1995. He argues that a relatively low coefficient of variation is suggestive of a high degree of migration within that cohort. He finds that the variability of youth unemployment rates in Ireland is markedly lower than in Britain and that the variability of unemployment increases with age more sharply in Ireland than in Britain. This would suggest a high rate of migration (labour market mobility) among younger Irish workers. And indeed migration outflows from Ireland have been concentrated in younger working age cohorts (ages 15-34); even during the 1970s decade of net inflows this age group recorded a net outflow of migrants (Barrett, 1998).

We look at two economic variables measuring labour market conditions in Ireland relative to the UK. The first series, *relative employment,* measures the ratio of the employment rate in Ireland to the employment rate in the UK:

$$relemp = 1 - UR_{IRL} / 1 - UR_{UK}$$

where UR_{IRL} is the Irish unemployment rate, UR_{UK} is the UK unemployment rate. This variable is a measure of the probability of obtaining employment in Ireland relative to the UK. We would expect that, *ceteris paribus*, an increase in this variable would decrease the likelihood of emigration and increase the likelihood of immigration.

Figure 2: Relative Employment UK vs Ireland 1951-1995

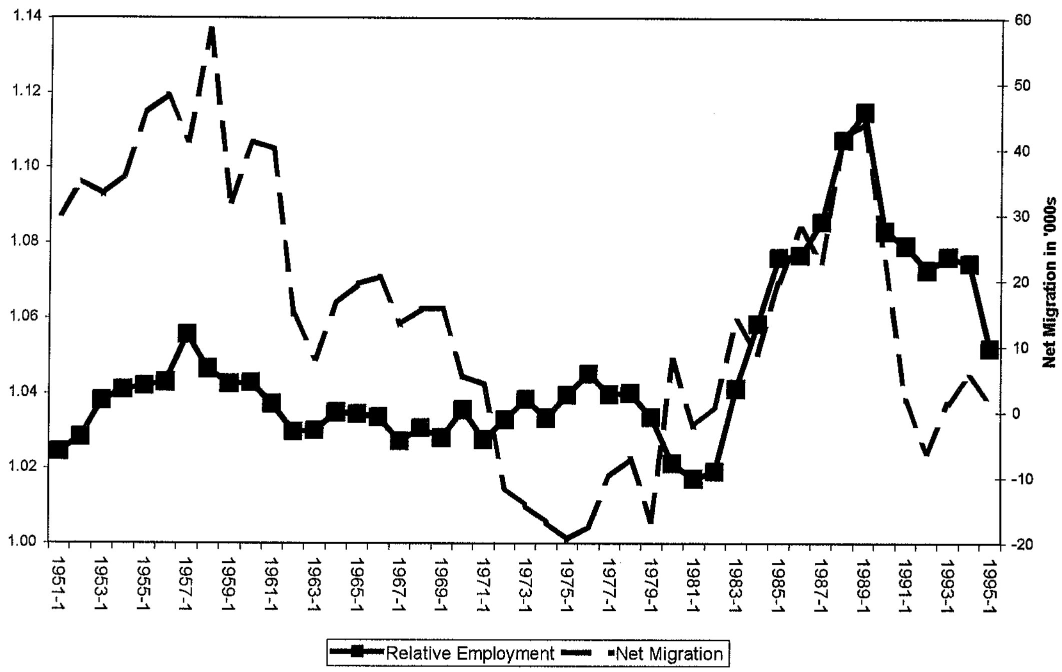


Figure 2 plots the inverse of this relative employment variable over the period 1951-1995 (net migration is plotted on the secondary y-axis for comparison). We can see that following a period of long stability the relative employment variable rose dramatically in the 1980s as the gap between Irish and UK unemployment rates widened (it rose to a high of 1.115 in 1989 compared with the 1951-1982 average of 1.035). Honohan (1984) estimated that there was a stable medium-term relationship between Irish and UK unemployment rates over the period 1962-1983 such that over time Irish unemployment would converge - through the migration mechanism – to an equilibrium relationship approximately 5 percentage points above the UK rate. A follow-up study (Honohan, 1992), which included the 1980s, confirmed that such an equilibrium relationship exists but found evidence that the relationship had weakened and that the equilibrium unemployment gap is growing over time. The upward trend in the unemployment gap in the 1980s can be readily seen from Figure 2. In the 1990s this gap started to close and estimates for 1997 (QEC, 1997) put the gap at 4.5 percentage points, close to its pre-1980s level.

There are three distinct sub-periods in the evolution of relative employment. The gradual steady decline in net migration in the 1960s culminating in net inward migration in the 1970s contrasts with the stability of the unemployment gap over that period. Indeed until the early 1980s the gap between Irish and UK unemployment rates was less than 5 percentage points. Given Honohan's estimates for the period 1962-1983 this would imply that net migration in this period was *above* the level required for equilibrium. This suggests there are other factors driving net migration in this period. In the subsequent period of the 1980s the widening of the unemployment gap is tracked by the increase in net migration. Finally the increase in the relative employment variable in the early 1990s is matched by the sharp decline in the net migration figures.

The other central factor we identify as a potential determinant of net migration is relative wages. We measure relative wages as the ratio of average industrial wages in Ireland to average industrial wages in the UK (converted at the average annual bilateral exchange rate). This measure differs from that used in Curtis and Fitz Gerald (1996) where the wage measure they use is average industrial earnings *including* employer's social insurance contributions, so that their measure is closer to a measure of relative labour costs in the two economies. For our purposes relative wages is the more relevant variable in modelling the migration decision since we are modelling the behaviour of migrants (who receive the average wage) rather than employers (who have to pay full labour costs), i.e. we are modelling the labour supply decision.

Figure 3: Relative Wages Ireland vs UK 1951-1995

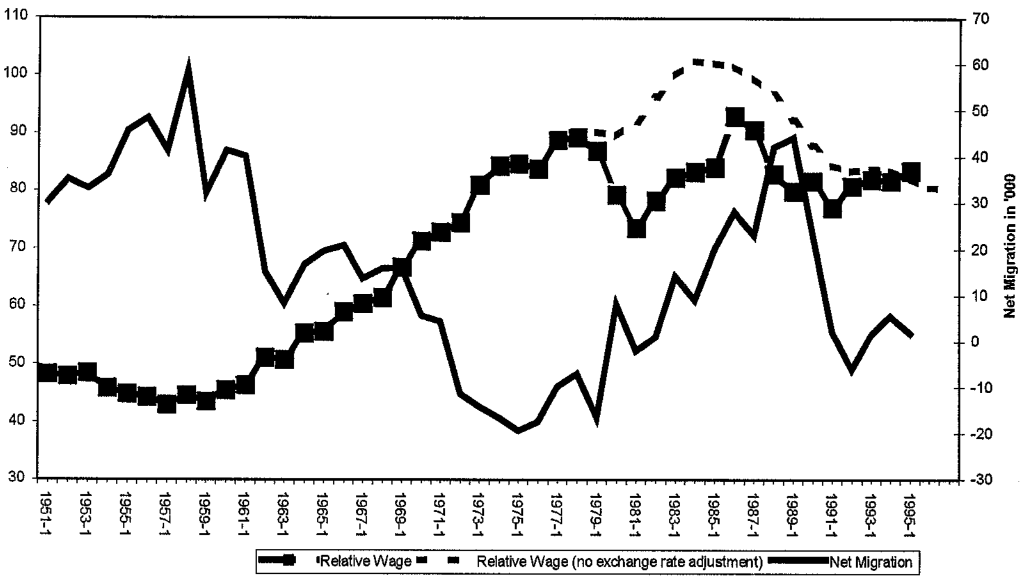


Figure 3 shows the evolution of this relative wage variable[3] together with net migration (plotted on the secondary y-axis). There are three distinct regimes in the evolution of the relative wage gap between Ireland and the UK in the post-war period. These correspond to

1. *Pre-convergence:* the years pre-1960 when the relative wage variable was constant with Irish wages on average hovering just below 46% of UK wages,
2. *Catch-up:* the 1960-1980 period of rapid convergence of Irish and UK wage rates when on average Irish wages increased from 46% (1960) to more than 81% (1980) of UK wages,
3. *Post-convergence:* the period from 1980 onwards which witnessed a return to stability with Irish wages averaging 82.4% of UK wages between 1981 and 1996.

From Figure 3 we can see that there appears to be a negative relationship between relative wages and net migration over the period to the early 1980s after which the pattern changes. Given stable relative employment prospects the wider the gap between Irish and UK wages the higher the level of net migration. This would suggest that the convergence of relative wages between Ireland and the UK through the 1960s and 1970s can go a long way towards explaining the decline in net migration in that period[4].

O' Grada and Walsh (1994) put forward an interesting structural explanation for the evolution of relative wages in terms of the changing educational profile of the average migrant. Outflows of unskilled workers will raise the skill profile of those who remain and lower the skill profile in the host country. The pure composition effect of this will be to increase the relative wage. By analogy outflows of skilled workers will lower the relative wage. In the 1960s and 1970s, the period of relative wage convergence, net migration from Ireland was mainly among the unskilled so that "[all] of the contraction in the labour force [between 1946 and 1971] was in low-income occupations such as small farmers, labourers and domestic servants."[p.108] During this period there was rapid catch-up in relative wages. In the later post-convergence period migration flows became disproportionately represented by more educated migrants (those in more high-income employment) thus lowering the skill profile of those who remained[5].

2) The Basic Equation Used in Macroeconomic Studies of Migration

We specifiy a simple linear single equation where net migration is modelled as a function of relative employment and relative wages.

$$NMA_t = m_0 + m_l relemp_t + m_w relw_t \qquad (2.1)$$

This equation specification has been used in several studies of Irish migration dating back to the 1970s. All of these studies identified significant and correctly signed effects for both the relative employment and relative wages variables, however there was strong evidence of out-of-sample parameter instability (see NESC, 1991 for a review of these studies).

In a more recent paper Geary and O'Grada (1989) estimated a version of this equation regressing net migration on the difference between Irish and UK real income and Irish and UK unemployment rates for the period 1953-1983. Their specification also includes the first lag of

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[3] The break with sterling in 1979 introduced medium-term volatility into the relative wage series attributable to medium term movements in the bilateral IR£/sterling exchange rate (Figure 3).

[4] Note that this convergence of relative wages does not map directly to a convergence in living standards since during the 1960s and 1970s the dependency ratio in Ireland was much higher than in the UK (Bradley, Fitz Gerald, Honohan, Kearney, 1997).

[5] This was the period when there was much alarm at the resource cost of the so-called "Brain Drain".

net migration and they use instrumental variables in estimation. The coefficient on relative employment is incorrectly signed and the lagged dependent variable is insignificant. They argue that these poor results are due to the omission of tax and welfare variables from the specification. By using relative *expected* income, where measures of income include factors such as the tax wedge and social welfare provisions weighted by the probability of gaining employment, the stability of and intuition behind their results improved. Their preferred specification is

$$NMA_t = b_0 + b_1 RELY_t + b_2 NMA_{t-1} \qquad (2.2)$$

where *RELY* is the ratio of UK to Irish expected income. Their results indicate that a one point increase in the relative income ratio is associated with a decrease in net migration of 1,000. Again they find that the lagged dependent variable is insignificant.

NESC (1991) estimated the net migration equation using a variety of specifications for the relative wage variable (gross and net of tax, using both market and PPP exchange rates) together with the Irish-UK unemployment ratio for the period 1953-1986. They compared this with the Geary and O'Grada specification using relative expected income and concluded that "the conventional specification is superior to the expected income specification used by Geary and O'Grada." [p122] In contrast to Geary and O'Grada they find the lagged dependent variable to be significant. Their results suggest an elasticity of net migration (per 1,000 population) with respect to relative wages of about 3, and with respect to relative unemployment of about 2 in 1986.

Barry and Bradley (1991) specify a net migration equation including the product of relative employment and relative earnings as the main exogenous variable. They include a lagged dependent variable and a dummy variable for 1980. All variables are significant and the coefficient on the lagged dependent variable is high (0.87) suggesting slow adjustment of migration to changes in relative employment and wage prospects.

All of these studies strongly concur on the importance of relative Irish-UK labour market variables in explaining net migration. Nonetheless the estimation of net migration equations is bedevilled with empirical difficulties:

1. One of more intractable problems is the poor quality of the data on net migration and the frequently very large revisions particularly at the time new Census data become available.
2. A second difficulty is that net migration flows relate to the year beginning in April while unemployment and wage data refer to the calendar year.
3. A third difficulty is that relative wages and relative employment are modelled as exogenous variables. However the importance of net migration flows to total Irish labour supply flows is such that this is not a feasible assumption. For this reason many recent studies use instrumental variables in estimation.
4. These difficulties are compounded by the fact that we are modelling *net* migration flows where there are different push and pull forces in operation for different cohorts in driving the decision to migrate or stay vis-à-vis the decision to remain abroad or to return.

In this paper we use (2.1) as our basic net migration equation. In contrast to previous studies we do not impose a dynamic structure. Instead we embed this basic equation within a general dynamic framework and test from this general model to find a more parsimonious specification that is congruent with the data. Because of a history of instability in net migration equations we also test for evidence of parameter instability.

3) The "General" Equation and Estimation Methodology

We begin with a general linear single equation embedded within a dynamic framework with maximum lag length of p. It is assumed that p is large enough to ensure that the error term is normal i.i.d. Net migration (*NMA*) is the dependent variable y, relative employment (*relemp*) and relative wages (*relw*) are included in the vector of independent variables x_t and v_t is the error term from the regression.

$$y_t = \sum_{i=1}^{p} \alpha_i y_{t-i} + \sum_{j} \sum_{i=0}^{p} \beta_{ij} x_{jt-i} + v_t \qquad (3.1)$$

This equation is an autoregressive distributed lag (ADL) model where the independent variables are assumed to be weakly exogenous with respect to the dependent variable. In our empirical estimation we initially included two lags of each variable and estimated the following equation[6]:

$$NMA_t = a_0 + a_1 NMA_{t-1} + a_2 NMA_{t-2} + b_{0l} relemp_t + b_{1l} relemp_{t-1} + b_{2l} relemp_{t-2} + b_{0w} relw_t + b_{1w} relw_{t-1} + b_{2w} relw_{t-2} + e_t \qquad (3.2)$$

where e_t is the residual from the estimated regression. Firstly this specification is tested for congruence with the data. This means testing whether the assumptions of linearity, homogeneity, normality and functional form specification are accepted by the data being modelled. At this "design stage" the issues of parameter constancy, structural breaks and relevant deterministic variables for inclusion must be addressed.

Only once a data-congruent estimated equation has been found can the static, long-run relationship be determined. The long-run coefficients on the constant term (c_0), relative employment (c_l) and relative wages (c_w) can be recovered as

$$c_0 = (a_0)/(1-a_1-a_2), \quad c_l = (b_{0l} + b_{1l} + b_{2l})/(1-a_1-a_2),$$
$$c_w = (b_{0w} + b_{1w} + b_{2w})/(1-a_1-a_2)$$

respectively. The long run "equilibrium correction mechanism" (Hendry, 1993) is then given as

$$ECM = NMA - c_0 - c_l \, relemp - c_w \, relw \qquad (3.3)$$

It is now well known that in the presence of unit roots in the three variables this equilibrium correction mechanism will be stationary only if the three variables are cointegrated. If this is found to be the case (this is tested in the empirical section below) then this ECM term can validly be included in a reparameterisation of our general equation into first-differences as follows:

$$\Delta NMA_t = d_0 + d_1 \Delta NMA_{t-1} + d_{0l} \Delta relemp_t + d_{1l} \Delta relemp_{t-1} + d_{0w} \Delta relw_t + d_{1w} \Delta relw_{t-1} + d_2 ECM_{t-2} + e_t \qquad (3.4)$$

It is easily verified that this reparameterisation does not involve any transformation of the error term in our original specification. The coefficient d_2 measures the speed of adjustment to equilibrium in a given year. At this stage we test alternative reductions of the model to reach the most parsimonious parameterisation of the dynamics consistent with data congruence.

Some recurring difficulties with empirical estimates of migration equations for Ireland have been their poor forecasting ability out of sample and their instability within sample. Therefore our main aim in this paper is to estimate a stable equilibrating migration equation for the post war period (specifically from 1951-1995) covering what has been a relatively turbulent period in the history of Irish migration.

In this paper we model net migration as being determined by relative employment and relative wages between Ireland and the UK and employ an OLS estimation procedure. This assumes that both relative wages and relative employment can be treated as weakly

[6] All estimation was performed using the PcGive package (Doornik and Hendry (1996)).

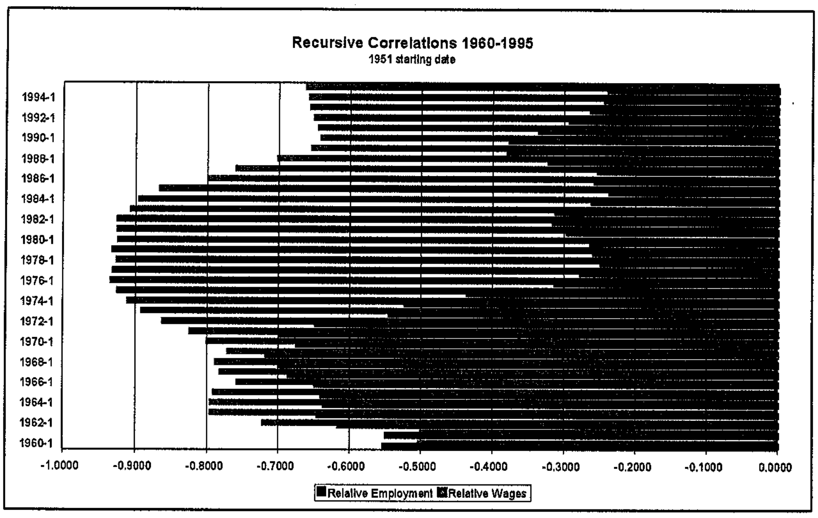
exogenous variables. While this is clearly true for UK wages and unemployment the same does not hold for Irish labour market conditions. The scale of Irish migration flows is such that it cannot plausibly be argued that they have no impact on Irish wages or Irish unemployment. For example in 1989 total net migration was equal to 3.4% of the domestic labour force. Clearly unemployment would have been far higher in that year in the absence of large migration flows. In the same way the reduction in domestic labour supply, facilitated through migration flows in the 1980s, arguably prevented the convergence of wages achieved in the 1960s and 1970s from unwinding. Several papers have attempted to address this endogeneity bias in estimation by using instrumental variables estimators for a single equation specification or SUR estimators for a system of simultaneous equations (see Barrett, 1998 for details). We check for evidence of this endogeneity bias by reestimating our preferred equation using instrumental variables[7].

4) In Search of A Long-Run Migration Equation 1951-1995

Table A.1 gives some descriptive statistics on the three variables included in our model. Both the net migration (*NMA*) and relative wages (*relw*) variables have very high standard deviations over the period. Note further that the correlation between these two variables is much higher than that between net migration and relative employment (*relemp*).

Figure 4 shows the correlation between net migration and both *relw* and *relemp* estimated recursively starting in 1951. Relative wages have a higher correlation with net migration throughout the period. This correlation between relative wages and net migration shifted downwards in the late 1980s. Looking at relative employment we can see that there is a clear downward shift in the bivariate relationship between net migration and relative employment in the mid-to-late 1970s. This is close to the fall in the responsiveness of emigration to the level of Irish unemployment detected by Honohan (1992) in the 1980s implied by the upward trend in the equilibrium unemployment gap.

Figure 4: Recursive Correlations 1960-1995



All three variables failed to reject the unit root hypothesis in levels but did not fail to reject in first differences (based on Augmented Dickey Fuller tests) suggesting that all three variables are I(1). However these results must be interpreted with caution since unit root tests are invalid in the presence of a structural break and there does appear to be some evidence of a structural break in our sample in the mid-1970s and late 1980s.

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[7] We follow the general-to-specific methodology which argues that "the basic model specification must be sound before [the use of instrumental variables]." (Doornik and Hendry(1996) p63)

M1. Autoregressive distributed lag with maximum lag of two

Table A.2 gives the diagnostic test results of estimating equation (3.2) including two lags of each variable - model specification *M1*. The overall equation diagnostics are good. There is no evidence of residual autocorrelation or non-normality and all included variables and lags are significant. The equation standard error is 8,650 per annum.

Further tests for structural breaks and parameter non-constancy in specification *M1* are plotted in Figure A.1. In recursive estimation the initialisation period was 1953-1969. The tests suggest that over the period 1970-1995 there is evidence of a structural break in 1978 and 1983 at the 5% level of significance.

M2. M1 including two shift dummies in 1978 and 1983

To test for this we included two dummy variables, *s1978* and *s1983* respectively – model specification *M2*. These are both shift dummy variables which equal 0 before 1978 (1983) and 1 thereafter. Table A.3 gives the estimation results. Neither shift dummy variable is significant although the 1978 shift dummy is significant at the 6% level. Figure A.2 shows that there is further evidence of parameter non-constancy in 1984 and 1990. We consider the non-constancy in 1984 as partly induced by the insignificant shift dummy in 1983 included in the specification (extensive testing of this model using both intercept and shift dummy variables for 1983 and 1984 confirmed this hypothesis).

M3. M2 including a third shift dummy in 1990 – the "general" model

We proceeded to include a third shift dummy variable in 1990 - *s1990*. Table A.2 gives the equation diagnostics from this estimation. The joint F-tests in Table A.3 indicate that the second lag is no longer significant and that the 1983 dummy variable is also not significant. The one-step forecast Chow test for a structural break indicates marginal evidence of parameter non-constancy in 1984 (see Figure A.3) but overall the Chow tests indicate parameter constancy at the 5% level. We treat this as our "general" model from which it is valid to test reductions to a more parsimonious specification.

M4. M3 excluding 1983 dummy and second lag

Given the insignificance of the 1983 dummy variable we proceed by excluding *s1983* and the second lag from the specification. The diagnostics are good (Table A.2) and an F-test of the validity of these reductions, moving from specification *M3* to *M4*, did not reject this more parsimonious specification (Test of model reduction: F(4, 31) = 1.4777 [0.2329]). Furthermore all tests of parameter non-constancy are now rejected at the 5% level (Figure A.4).

The solved static long run equation for specification *M4* is:

$$\underset{}{NMA} = \underset{(85.2)}{+\,793.3}\ \underset{(87.9)}{-\,723\,relemp}\ \underset{(11.4)}{-\,133.6\,relw}\ \underset{(4.6)}{+\,19.76\,s1978}\ \underset{(5.7)}{-31.09\,s1990} \qquad (M4)$$

All coefficients have the correct sign and all variables are significant. The coefficients on the dummy variables indicate that other things being equal people were more likely to migrate in the period 1978-1989 and less likely to migrate in the period 1990-1995 than in the period 1951-1977. A unit root t-test on this ECM term rejects the unit root hypothesis (unit root t-test = -6.1543**). Similarly a Wald test restricting all coefficients to equal zero is rejected (Chi^2(4) = 208.52 [.00] **).

To check for endogeneity bias we reestimated *M4* using instrumental variables (IV). The instruments we used were *{relw(-1) relw(-2) relemp(-1) relemp(-2)}*. The equation diagnostics were good and the long-run coefficients were estimated as:

$$NMA = \underset{(95.7)}{-\,718.5\,relemp}\ \underset{(12.4)}{-\,129.8\,relw}\ \underset{(92.4)}{+\,787.8}\ \underset{(4.7)}{+\,14.59\,s1978}\ \underset{(5.4)}{-\,23.13\,s1990} \qquad (M4)'$$

The coefficients from IV estimation are not significantly different from those estimated using OLS.

M5. An Error Correction Specification of M4

At this point we include this ECM term in a reparameterisation in first differences. The results of our unit root tests in Table A.1 and the test on the ECM term reported above suggest that all terms included in this differenced specification are now stationary. The ECM term excluding the shift dummies is as follows[8]:

$$ECM = NMA - 793.286 + 723.032{*}relemp + 33.641{*}relw$$

The shift dummies are included separately in the first differenced specification:

$$\underset{}{\Delta NMA} = \underset{(1.8)}{-0.0006} - \underset{(198.3)}{262.6}\,\Delta relemp - \underset{(47.7)}{47.45}\,\Delta relw - \underset{(7.2)}{28.5}\,s1990 + \underset{(4.4)}{18.11}\,s1978 - \underset{(0.2)}{0.9166}\,ECM(-1) \quad (M5)$$

The estimated equation indicates that the differenced terms on relative wages and relative employment along with the constant are insignificant. Also the constant term is insignificantly different from zero. This latter result is to be expected in modelling any variable that does not manifest growth (Hendry (1993) p558) as in the case of net migration. Further diagnostic tests reveal no problems with the model specification (Table A.2).

M6. M5 Error Correction Form in Parsimonious Form

Our final parsimonious specification includes the ECM term and the two shift dummy variables in 1978 and 1990. All variables are highly significant.

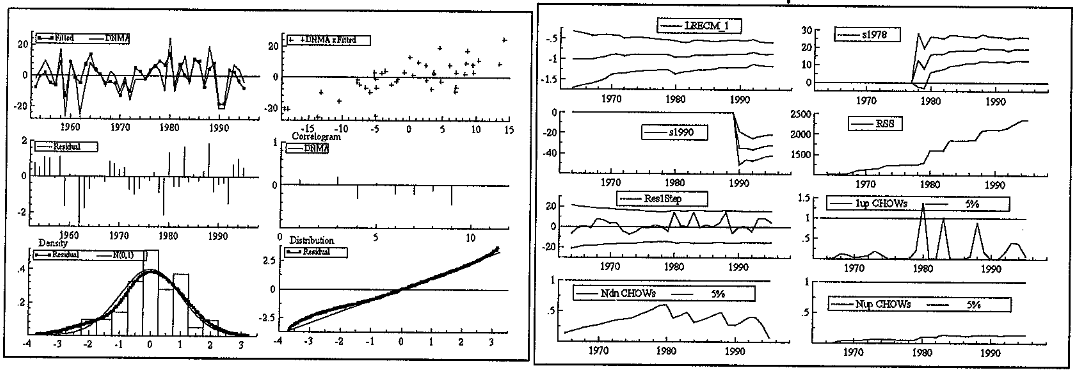
$$\Delta NMA = -\underset{(4.9)}{32}\,s1990 + \underset{(3.8)}{19.2}\,s1978 - \underset{(0.15)}{0.88}\,ECM(-1) \qquad (M6)$$

The equation diagnostics shown in Table A.2 indicate that the standard error for specification *M6* at 7,696 migrants per annum is lower than that in our initial specification *M1*. Figure 5 plots a series of goodness of fit measures for specification *M6*. The fit of the equation on average is quite close although there is a strong outlier in 1962 (standardised residual greater than 2).

As a further test on the robustness of the specification we re-estimated *M6* without imposing *a priori* the ECM term in levels in the equation specification, i.e. we freely estimated all parameters in an equation combining differences and levels of each variable. The estimated results were not statistically different from those in equation (M6).

[8] Including the shift dummies in the ECM in the first differenced specification led to heteroscedasticity and functional form misspecification together with some evidence of parameter non-constancy.

Figure 5: Goodness of Fit Measures and Chow Tests for Specification *M6*



Tests of parameter non-constancy reveal some slight evidence of a structural break in 1980 based on the one-step forecast Chow test (Figure 5), however the recursive estimates of the adjustment coefficient on the ECM term (denoted LRECM_1 in the graph) indicate how stable this coefficient has been over the entire sample period. Similarly the other Chow tests reveal no significant parameter non-constancy at the 5% level.

Finally we note that the reductions from M5 to M6 are accepted by a joint F-test (F(3,37) 1.696 [.18]). Similarly an LM test for adding the omitted variables *Δrelw* and *Δrelemp* also indicates that these reductions are valid (F(2,38) = 2.613 [.09]).

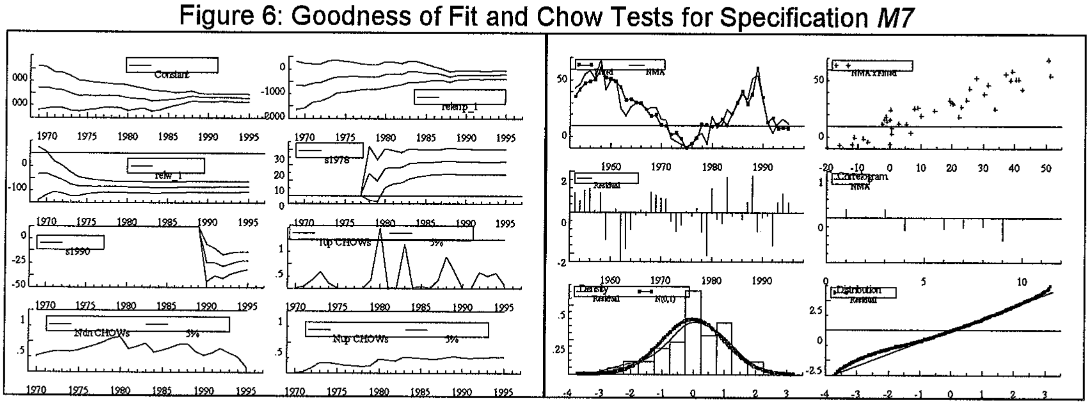
M7. Further Testing and the Preferred Specification: A Leading Indicator Model

The adjustment coefficient on the ECM term in M6 is not significantly different from minus one indicating that the equation would be more correctly specified in levels. This is supported by the tests on our general specification *M3* reported in Table A.3 where the lagged NMA term is insignificant. We report here in full the point estimates for all coefficients included in specification *M3*. Note that the lagged *NMA* term and the current *relw* and *relemp* terms are all individually insignificant.

Variable	Coefficient	Std.Error	t-value	JHCSE	PartR^2	Instab
Constant	727.15	139.07	5.229	169.12	0.4386	0.06
NMA_1	0.083369	0.14894	0.560	0.18666	0.0089	0.06
relemp	-262.59	152.48	-1.722	216.78	0.0781	0.06
relemp_1	-400.17	195.41	-2.048	286.21	0.1070	0.06
relw	-47.453	36.953	-1.284	53.802	0.0450	0.05
relw_1	-75.047	40.611	-1.848	49.546	0.0889	0.05
s1978	18.110	4.6362	3.906	5.1596	0.3036	0.03
s1990	-28.497	5.9562	-4.784	7.6654	0.3954	0.04

We tested a reduction of *M3* excluding all three of these variables, this was not rejected at the 5% level (F(3, 35) = 1.7915 [0.1668]). Table A.2 shows that the diagnostics from this specification indicate no problems and all variables are now significant (Table A.3). Figure 6 shows the estimated fit of the equation.

Figure 6: Goodness of Fit and Chow Tests for Specification *M7*



The full equation specification is:

$$NMA = +800.6 - \underset{(105.5)}{730.8}\, relemp(-1) - \underset{(9.0)}{134.4}\, relw(-1) + \underset{(3.6)}{21.95}\, s1978 - \underset{(5.4)}{35.1}\, s1990 \qquad (M7)$$

$$\qquad (101.7)$$

Figure 6 shows the recursively estimated coefficients and their standard error bands together with the Chow tests. All coefficients are significantly different from zero. As with *M6* there is some evidence of parameter instability in 1980 based on the one-step Chow test at the 5% margin[9]. Overall however the equation statistics are good indicating little instability in the estimated equation.

We use equation (M7) as our preferred specification. If we look at the standard errors reported in the previous section we can see that the estimated coefficients on the long-run coefficients in equations (M4), (M6), (M6)' and (M7) are not statistically different. Further experimentation with the precise specification of the variables used – specifying the net migration variable as a proportion of the population of working age and using the log of the relative wage - confirmed that the underlying results are not significantly altered. Thus we consider that our estimates are robust to a variety of specifications. Note further that our estimated equation does not suffer from any potential endogeneity bias problems so that instrumental variables estimation is not necessary.

Our preferred equation is in the form of a leading indicator model. Net migration in the current year is determined by relative wages and relative employment in the previous year. This formulation allows for no feedback from migration to relative wages or relative employment[10]. This may be capturing the underlying mis-match in the data series. Net migration in the current year refers to migration from April in the previous calendar year to April in the current year while the relative wage and relative employment data refer to the calendar year.

Leading indicator models are often used for short-term forecasting where "primary concerns are the constancy of [the coefficients] and the goodness of fit" (Hendry, 1993, p252). For our purposes in this paper this leading indicator formulation, while clearly partial equilibrium in nature, is useful in determining a stable causal link between changes in relative labour market conditions between Ireland and the UK on the one hand and consequent changes in net migration flows on the other.

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[9] The inclusion of an intercept dummy variable for 1980 was found to be insignificant. The coefficient estimates were not significantly different from those in equation (3). Barry and Bradley (1991) in their model of net migration also found that the year 1980 was an outlier.

[10] Using Granger causality tests O' Grada and Walsh (1994) found no evidence that emigration causes real wage growth in Ireland to rise or fall.

5) Interpretation of Results

Figure 7

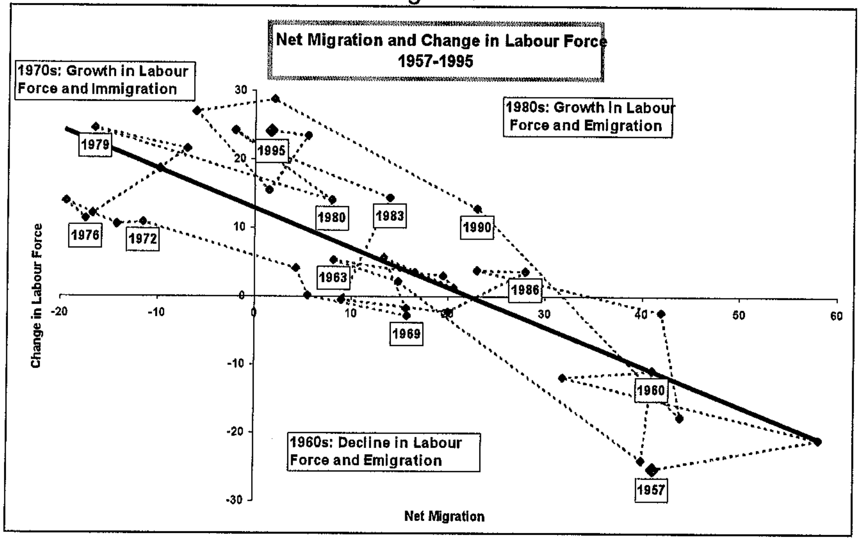

Figure 7 illustrates that there is a strong negative relationship between net migration and changes in the labour force. This relationship is central to our understanding of the determinants of labour supply. A simple linear regression fit to this relationship indicates that a unit increase in net migration is associated with a 0.58 unit decline in the labour force. We can trace this linear relationship through from 1960 when net emigration was associated with a decline in the labour force through to 1979 when net immigration was associated with an increase in the labour force. This high elasticity of labour supply, operating through the migration mechanism, has played a key role in the trade-off between inflation and unemployment in Ireland over the past 30 years.

In our model we have identified two structural breaks over the sample - the sub-periods 1978-1989 and 1990-1995. In the first sub-period the average propensity to migrate increases by an annual average of 1.71% of the labour force. In the second sub-period the average propensity to migrate falls by an annual average of 0.96% of the labour force. We can identify these changes in Figure 7. In the top left-hand quadrant we have growth in the labour force and net immigration in the 1970s. In the 1980s this relationship shifted to the right-hand quadrant where the growth in the labour force was accompanied by net emigration – an increase in the average propensity to migrate. Finally this relationship shifted back to the left-hand upper quadrant in more recent years with a reduction in the average propensity to migrate.

These structural breaks can be related to the underlying simplifications in the model mentioned in the introduction. Turning first to the increase in the average propensity to migrate in the 1980s we can see that the high rates of net immigration in the 1970s reduced the stock of mobile Irish abroad thus reducing the potential for immigration in the 1980s. Furthermore in the 1980s there was a significant increase in average levels of educational attainment among those of working age. This increased the supply of skilled labour to the Irish labour market at a time when the demand for labour was generally low (even though the demand for labour was itself also shifting in favour of more skilled labour, (Kearney, 1997)). This change is reflected in the shift towards more highly educated migrants in this period. During this period there was also a weakening of the migration flows between Ireland and the UK with a significant increase in emigration to the USA in the early 1980s. These changes occurred against a backdrop of a rise in the population in the 25-44 age group.

The high rates of net emigration in the 1980s built up a substantial stock of relatively skilled Irish abroad. Fahey and Fitz Gerald (1998, p15) show that the dominant outflow of migrants in the 1980s was in the 15-24 age cohort[11]. In the early and mid 1990s these emigrants were still young enough to be highly mobile. In more recent years the shift in demand towards more skilled labour occurred against a backdrop of a general increase in the demand for labour. Thus the increase in the average propensity to immigrate may well reflect the large stock of highly mobile skilled Irish abroad. However it is also likely that this estimated decline in the average propensity to migrate is capturing a general weakening of the links between the Irish and UK labour markets. In recent years (1994-1997) over 40% of the gross inflow of migrants were non-Irish nationals (Barrett, 1998).

Table 1 shows the estimated marginal effect on net migration of a one percentage point increase in the Irish unemployment rate, given the *actual* UK unemployment rate in each sub-period. In the period 1951-1977 a one percentage point increase in the Irish unemployment rate would have increased net migration on average by 7,467 migrants. This marginal impact increased in subsequent periods, in 1990-1995 it was close to 8,000. However when we take into account the growth in the labour force[12] between 1951 and 1995 we find that in proportionate terms this marginal effect of the unemployment rate on net migration is declining. In 1951-1977 the increase in migration caused by a one percentage point increase in the unemployment rate was equivalent to 0.66% of the actual labour force. This fell to 0.59% in the later 1990-1995 period.

Table 1

Marginal Effect on Net Migration of One Percentage Point Increase In:		
	Irish Unemployment Rate	Relative Irish-UK Wages
1956-1977	7,480	-1,344
1978-1989	7,964	-1,344
1990-1995	7,998	-1,344
1956-1995	7,695	-1,344
% of Actual Labour Force		
1956-1977	0.66%	-0.12%
1978-1989	0.62%	-0.10%
1990-1995	0.59%	-0.10%
1956-1995	0.64%	-0.11%

The marginal effect of relative wages on migration is -134.4. Thus a one percentage point increase in the ratio of Irish wages to UK wages will, other things being equal, cause a fall in net migration of 1,344 which is equivalent to 0.11% of the labour force. The convergence of Irish wages towards UK wages during the 1960s and 1970s thus forms an important part of the explanation for migration patterns in those decades.

Both of these estimated marginal effects highlight the increased elasticity of labour supply in Ireland due to migration flows. To explore this further we examine the "no migration" counterfactual. The reduced form equation between relative employment and relative wages given zero migration is as follows:

$$relemp_t = 1.096 - 0.184 relw_t + 0.03 s1978_{t+1} - 0.048 s1990_{t+1}$$

[11] The 15-24 age group accounted for 79% of total net migration in the 1986/191 intercensal period (Barrett, 1998).

[12] The labour force here refers to the actual labour force rather than the pre-migration labour force.

Figure 8

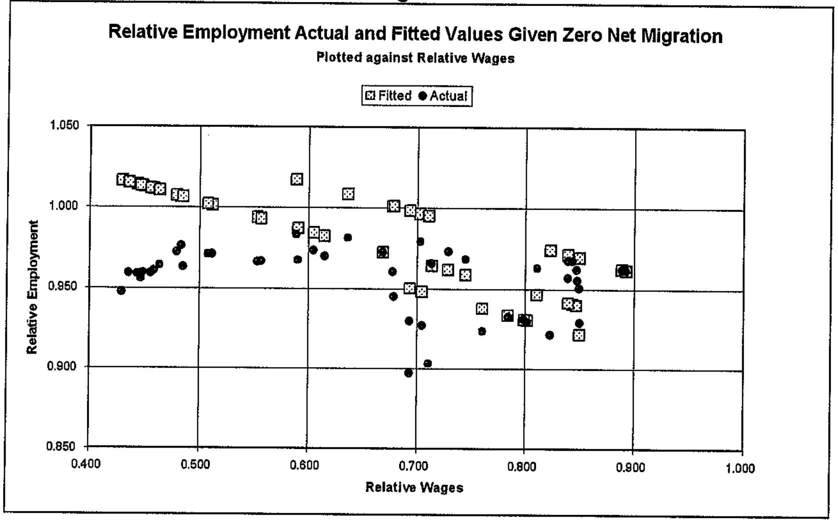

Figure 8 plots the fitted 'no migration' values of the relative employment variable from this equation against the actual values of relative wages over the period. In addition the chart includes the actual values of relative employment. There are three distinct sub-periods corresponding to the shifts in the estimated relationship in 1978 and 1990.

The interesting area of this graph is where the widest divergence between the actual and fitted values occurs in the area of low relative wages (the interval [0.4, 0.6] on the x-axis). Over this entire interval the actual values for relative employment are equal to or above the 0.95 equilibrium unemployment gap estimated by Honohan (1984). However notice the much higher *fitted* values for relative employment. The gap between the actual and fitted values is a measure of the scale of net migration. The trade-off between wages and unemployment was clearly dampened via the migration mechanism.

Figure 9

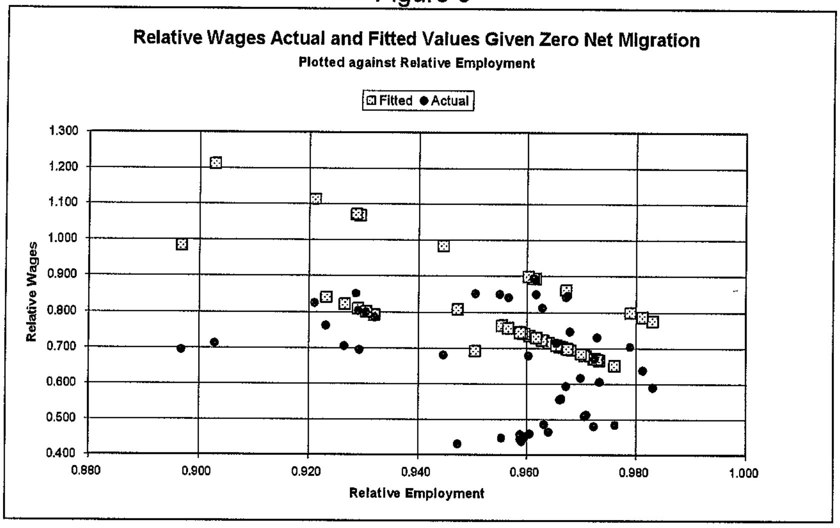

Figure 9 plots the fitted 'no migration' values for relative wages against actual relative employment[13]. Note that the fitted relative wage values never fall below 0.60. This implies that as long as relative wages were below 0.60 net migration would be positive.

[13] The inverse reduced form equation is:

$$relw_t = 5.957 - 5.438 relemp_t + 0.163 s1978_{t+1} - 0.261 s1990_{t+1}$$

If we accept Honohan's estimate of a 5% equilibrium unemployment gap then the implied relative wage given zero net migration is of the order of 0.83. On average over the sample period deviation from this combination will lead to migration flows. The relative wage is lower than one because Ireland is the preferred location for migrants.

6) Conclusion

In this paper we identify a stable parametric migration function based on a very simple underlying model. This model confirms previous research in this area that stressed the importance of the link between the Irish and UK labour markets in the post-war period both in driving net migration and in dampening the Phillips curve trade-off between unemployment and wage inflation in Ireland over that period.

Our preferred equation models net migration in the current year as a function of relative wages and relative employment in Ireland and the UK in the previous year. The results indicate that on average net migration increases by 7,695 (0.64% of the labour force) given a one percentage point increase in the Irish unemployment rate while a one percentage point convergence of Irish wages on UK wages reduces net migration by 1,344 (0.11% of the labour force). We identify two sub-periods that fully parameterise the instability detected over the full sample. In the sub-period 1978-1989 the average propensity to migrate rose (by an annual rate of 1.71% of the labour force) while in the more recent sub-period, 1990-1995, the average propensity to migrate fell (by an annual equivalent of 0.96% of the labour force) relative to the rest of the sample.

Our model is partial equilibrium in nature. It does not allow for feedback effects. This is compounded by the fact that we are modelling *net* migration flows where there are different push and pull forces in operation for different cohorts in driving the decision to migrate or stay vis-à-vis the decision to remain abroad or to return. Nonetheless it captures key features of the Irish labour market. The results indicate that the supply of labour in Ireland is very sensitive to labour market conditions. This means that the trade-off between wages and unemployment is weaker than in more closed labour markets. Significant changes in the profile of the average migrant over the period have weakened traditional links with the UK labour market in the post-war period. This weakening is likely to continue as we face into a period of substantial flows of non-Irish migrants.

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Table A.1

Descriptive Statistics and Unit Root Tests: 1951-1995

	Mean	*Std Deviation*
NMA	15.038	20.386
relemp	0.955	0.020
relw	0.688	0.167

Correlation matrix:

	NMA	*relemp*	*relw*
NMA	1	-0.237	-0.661
relemp		1	-0.395
relw			1

Unit Root Tests[14]:

	Lag	*Levels*[15]	*First Differences*[16]
NMA	1	-1.761	
NMA	0	-1.955	**-7.0275
relemp	1	-2.234	
relemp	0	-1.660	**-4.3692
relw	1	-1.555	
relw	0	-1.104	**-5.1609

[14] The Augmented Dickey Fuller tests reported here include both a constant and a trend, the substantive results were similar when a) the trend was excluded and when b) both the constant and trend were excluded.

[15] 1954-1995: Critical values: 5%=-3.519 1%=-4.19; Constant and Trend included

[16] 1955-1995: Critical values: 5%=-3.522 1%=-4.196; Constant and Trend included

Table A.2

Diagnostic Test Statistics, estimation period 1953-1995

Model:	*M1*	*M2*	*M3*	*M4*	*M5*	*M6*	*M7*
AR (2,.)	0.649 [.53]	1.551 [.23]	0.022 [.98]	0.057 [.94]	0.054 [.95]	0.349 [.71]	0.587 [.56]
ARCH(1,.)	0.048 [.82]	0.341 [.56]	1.288 [.27]	1.489 [.23]	1.579 [.22]	0.535 [.47]	0.392 [.53]
N(2)	1.623 [.44]	0.271 [.87]	5.504 [.06]	2.298 [.32]	2.298 [.32]	1.776 [.41]	1.939 [.38]
H(,)	0.643 [.81]	0.889 [.60]	0.483 [.92]	0.610 [.81]	0.307 [.96]	0.213 [.93]	0.727 [.63]
RESET (1)	0.007 [.93]	0.064 [.80]	0.003 [.95]	0.045 [.83]	0.057 [.81]	1.228 [.27]	0.046 [.83]
R^2	0.856	0.872	0.900	0.882	0.589	0.534	0.864
Std. Error	8.65	8.367	7.511	7.714	7.502	7.696	7.951
Durbin Watson	2.21	2.33	2.04	1.91	1.91	1.76	1.63

Statistical significance levels of tests are in square brackets. ** indicates significance at 1% level, * at 5% level.

The diagnostic test statistics reported are (see Doornik and Hendry (1996) for details):

1. *AR(2,.)* is a Lagrange multiplier test statistic for second order serial correlation in the residuals. Under the null of no serial correlation it has a $\chi^2(2)$ distribution presented here in an *F(2,.)* form.
2. *ARCH(1, .)* is an LM statistic for testing for first order autocorrelated squared residuals, under the null it has a χ^2 distribution presented here as an F(1,.) statistic.
3. *N(2)* tests the null of normal skewness and kurtosis, this has a χ^2 distribution under the null of normal residuals.
4. *H(,)* tests the null hypothesis of unconditional homoscedasticity and has an approximate F(,.) null distribution. It tests the alternative by estimating an auxiliary regression of the residuals on the *x*'s and their squares (x^2).
5. *RESET (1)* is an *F*-form test of functional form misspecification. It tests the null of correct specification of the original model by adding the first power of linear combinations of the *x*s.

The models estimated are:

	Model Type	*y*	*X*	Longest Lag	Dummy Variables
M1	Autoregressive distributed lag	NMA	relemp, relw	2	
M2	Autoregressive distributed lag	NMA	relemp, relw	2	s1978, s1983
M3	Autoregressive distributed lag	NMA	relemp, relw	2	s1978, s1983, s1990
M4	Autoregressive distributed lag	NMA	relemp, relw	1	s1978, s1990
M5	Error Correction Mechanism	NMA	relemp,relw, ECM	1	s1978, s1990
M6	Error Correction Mechanism	NMA	relemp, relw, ECM	1	s1978, s1990
M7	Leading Indicator Model	NMA	relemp, relw	1	s1978, s1990

Table A.3
Joint Significance Tests: Estimation Period 1953-1995

Model:	*M1*	*M2*	*M3*	*M4*	*M7*
NMA	6.679 ** [.00]	4.157 * [.02]	0.140 [.87]	0.313 [.58]	
Constant	1.376 [.25]	1.803 [.18]	7.323 * [.01]	27.339 ** [.00]	101.25 ** [.00]
relemp	8.023 ** [.00]	8.175 ** [.00]	5.080 ** [.00]	13.672 ** [.00]	79.325 ** [.00]
relw	3.590 * [.02]	4.080 * [.01]	7.939 * [.01]	15.034 ** [.00]	155.69 ** [.00]
s1978		3.360 [.08]	3.755 [.06]	15.259 ** [.00]	29.387 ** [.00]
s1983		0.394 [.53]	1.602 [.21]		
s1990			8.702 ** [.00]	22.890 ** [.00]	57.123 ** [.00]
lag=1	5.516 ** [.00]	5.036 ** [.00]	4.944 * * [.00]	3.808 * [.02]	114.72 ** [.00]
lag=2	4.929 ** [.01]	5.348 ** [.00]	0.831 [.49]		
lag=1-2	5.088 **[.00]	5.026 ** [.00]	2.586 * [.04]		
All Regressors	25.198 ** [.00]	21.994 ** [.00]	25.598 ** [.00]	37.343 ** [.00]	60.242 ** [.00]

The joint significance tests are *F*-form tests for the significance of each variable (including all lags), the significance of each lag and finally the significance of the overall regression.

<u>Tests of Parameter Constancy and Structural Breaks</u>

These graphs show tests of parameter constancy in the estimated model. These tests are constructed as follows. The model is estimated over an "initialisation period" *t=1...M-1* where the full sample runs from *t=1..T*. The model is then recursively updated in each year for *t=M,...,T*. The first quadrant in Figure 5 shows the recursively estimated one-step residuals with a 2-standard error confidence interval. The other three quadrants correspond to the estimated statistics in each year *t* of three different tests for constant parameters[17]:

1. *One-step forecast test (1up CHOWs)* tests for parameter change in year *t* against the model estimated over *t=1,...,t-1*.
2. *Break-point F-tests (Ndn CHOWs)* test for parameter change against the model estimated over the full period *t=1,...,T* (the number of forecasts goes down in sequence from *N=T-(M-1) to 1*).
3. *Forecast F-Tests (Nup CHOWs)* test for parameter change against the model estimated over the initialisation period *t=1,...,M-1* (the number of forecasts goes up in sequence from *N= M to T*).

Figure A.1: M1

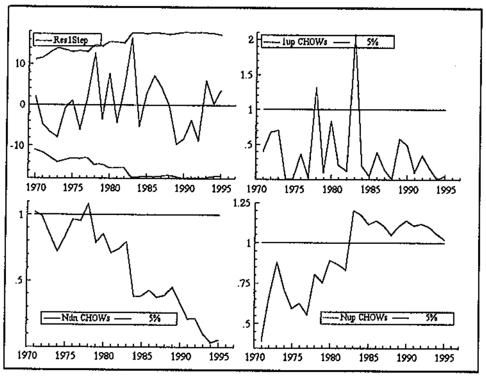


Figure A.2: M2

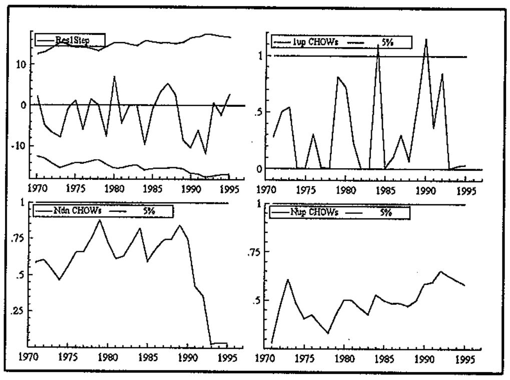


Figure A.3: M3

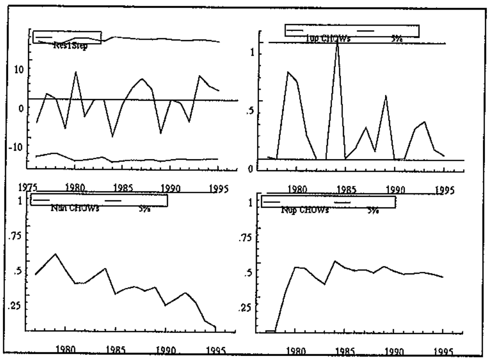
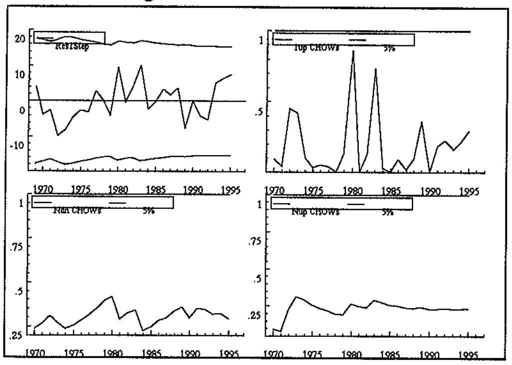


Figure A.4: M4



[17] Each graph includes the 5% significance level line.