# A Theoretical Growth Model for Ireland*

FRANK BARRY
*University College Dublin*

and

MICHAEL B. DEVEREUX
*University of British Columbia, Canada*

*Abstract:* Ireland is distinguished by the high degree of openness of its labour market and the importance of foreign direct investment (FDI) in the economy. We develop a neo-classical growth model to explore the consequence of these characteristics for the response of an economy to the kinds of shocks that are widely recognised to have been of importance in driving the Irish boom.

## I INTRODUCTION

In his discussion of Honohan and Walsh's (2002) account of Ireland's recent growth performance, Olivier Blanchard suggests that the highly elastic supplies of capital and labour available to the economy mean that exogenous shocks will have more dramatic consequences than in the standard neo-classical or "Solow" exogenous growth model. Such an economy, he argues, will behave more like the AK model of endogenous growth theory which exhibits constant returns to accumulable factors of production and in which shocks have more substantial and long-lasting effects.

The essence of the Honohan and Walsh argument is that inappropriate macroeconomic policies held Ireland back in earlier years, with the result that "… convergence, when it occurred, was telescoped into a short period". This emphasis on 'delayed convergence' grounds their analysis in exogenous growth theory. We follow them in this but take up Blanchard's suggestion by contrasting the performance and responsiveness to shocks of neo-classical

models with varying degrees of capital and labour mobility. Furthermore, we subject these models to the kinds of shocks that we believe to have been important in driving the Irish boom.

While based on the exogenous growth model, the analysis in our paper also draws inspiration from what Barry (2002a) has characterised as the major competing hypothesis to that of delayed convergence. The alternative interpretation, as initially proposed by Krugman (1997), is that of "regional boom".[1] *Regional* wages are largely determined by rates available in the wider encompassing economy with which the region shares an open labour market. Employment levels are determined therefore by labour demand, rather than, as in a typical national economy with a closed labour market, by the interaction of labour demand and supply. Labour demand is determined primarily by the region's export base (with non-tradable employment – both public and private – arising largely to service that base). In modelling Ireland, the export base can be thought of as the multinational sector.

Regional boom models have been developed by Dascher (2000) and Barry (2002b) to elucidate aspects of the Irish experience, though not in a growth-theory context.

Capital and labour inflows stimulate each other in the regional models, generating substantial "extensive growth" as well as the "intensive growth" in income-per-head terms that is the focus of convergence theory. In these models the boom ultimately comes to an end when labour inflows dry up through housing and infrastructure congestion, while dramatic growth can easily turn into dramatic decline in the event of adverse shocks. This regional perspective seems to us to be close in spirit to the model that Blanchard proposes.[2]

The model we present here represents a half-way house between the delayed-convergence and regional-boom perspectives. Since ours is an exogenous rather than endogenous growth model, there is indeed convergence to an exogenous steady state.[3] We allow for highly elastic supplies of capital

---

[1]An important distinction between the perspectives is that the first approach proposes that convergence will follow if Ireland follows the same policies as the rest of the EU. The second suggests that non-orthodox policies such as lower corporation tax rates may be required to surmount the core-periphery gap; see e.g., Borck and Pflueger (2004), which builds on Baldwin and Krugman (2004).

[2]Though Blanchard (2000) does not devote much attention to foreign direct investment (FDI), he does mention a third feature – besides the openness of capital and labour markets – that may make the Irish economy function more like the AK model: the shift towards the production of more capital intensive goods. This is associated with the FDI-intensity of the economy.

[3]This does not necessarily imply that the convergence process should stop when Ireland has reached average Western European living standards. GDP per head may continue to converge on the US; Krugman (1979).

and labour however, as in the regional-economy model.[4] Furthermore, all goods are tradable and all capital is foreign owned so the export-base perspective is embedded in our story.[5]

Having set up the model, we then submit it to several shocks which we believe capture important elements of the factors that have driven the Irish boom. The shocks are of three broad types: (i) an increase in the country's attractiveness to foreign capital, (ii) a reduction in labour-market distortions, and (iii) an increase in total factor productivity.

The first of these serves as shorthand for a number of different developments that occurred in the late 1980s and early 1990s. Honohan and Walsh emphasise the beneficial effects of fiscal stabilisation. Our modelling of this is influenced by the work of Miller, Skidelsky and Weller (1990), which was, interestingly, one of the first papers in the literature on "expansionary fiscal contraction", a phenomenon that has been much discussed in the Irish literature. This paper, and others in the literature such as Bertola and Drazen (1993) and Sutherland (1997), are based on critical levels of government debt – or "trigger points" – being reached, beyond which the effects of fiscal policy on expectations are reversed. In Miller, Skidelsky and Weller (1990), the critical level is reached when fiscal policy raises the rate on government bonds substantially through an increased risk of taxes on bond holders being imposed to prevent the public debt becoming unsustainable. We thus model fiscal consolidation as a reduction in the risk premium on investments in Ireland.[6]

Other shocks which also increase the inflow of capital for a given interest rate include the advent of the Single European Market and the substantial increase in EU regional aid flows from 1989 onwards. The Single Market led to a substantial increase in FDI inflows into Europe and between European countries, as evidenced by Dunning (1997), while the effect on Ireland was compounded by the outlawing of restrictive public procurement policies within the EU.[7] The announced reduction in the rate of corporation tax on services in the late 1990s can also be modelled in this way. This shock also captures

[4]In the extreme case of *perfect* factor mobility, our model collapses to the AK model of endogenous growth theory.

[5]Note that ours is not a growth accounting exercise such as de la Fuente and Vives (1997) and Ahearne, Kydland and Wynne (2004), which are also based on the neo-classical growth model, but a theoretical contribution, the importance of which we attempt to quantify.

[6]De la Fuente and Vives (1997) concur, suggesting that "… fiscal consolidation may have acted as a catalyst, helping to change foreign investors' perceptions of the country".

[7]MacSharry and White (2000) explain how restrictive procurement policies on the part of some of the larger EU member states had offered a strong incentive to transnational corporations to locate there rather than in Ireland. With the outlawing of these practices, the attractiveness of Ireland as a destination for FDI increased.

elements of the economic geography perspective proposed by Krugman (1997), who notes that the declining importance of conventional transport costs in international trade has made Ireland less 'peripheral' and therefore more attractive as an export platform for FDI.

Our second shock represents a decline in labour-market distortions, which Honohan and Walsh also emphasise. They note that "… wage restraint has been a hallmark of the recovery. This is partly attributable to the high levels of unemployment that had been reached in Ireland and the United Kingdom, partly to union restraint exercised in the process of centralised pay agreements (associated with tax reductions) and partly, perhaps, to reduced union power in much of the economy".

Proponents of the importance of social partnership point to the Calmfors and Driffill (1989) proposition that labour-market outcomes associated with either a "corporatist" well-organised central bargaining system or a US-type system in which labour unions have very little power are better than those generated by decentralised collective bargaining systems such as had previously prevailed in Ireland .[8] There is broad agreement at least that social partnership facilitated wage moderation by offering a forum in which it could be traded for the promise of future income-tax reductions. We model these processes as a shock that shifts the economy from an initial low-employment monopoly-union equilibrium; Oswald (1985).

Our third shock represents an increase in TFP. Crafts (2005) shows that annual TFP growth in Ireland, calculated on a GNP basis, jumped from 1.68 per cent between 1979-89 to 2.51 per cent from 1989-99. He attributes much of this to ICT production, based on inward FDI from the US.[9] This shock, therefore, we can think of as going hand-in-hand with the capital-market shock discussed above.

## II COMPARATIVE STATICS OF THE MODEL

The structure of the model, which is presented formally in the next section, is very simple, since we focus on the production side and ignore consumption decisions and the time path of consumption and saving. We have a model of imperfect labour mobility where the decision whether to work at

---

[8]The essential idea is that at both extremes labour-market outsiders have a greater voice in the determination of labour-market outcomes.

[9]In 2000, computer equipment employment in Ireland was ten times greater than that in the EU15 (as a proportion of manufacturing employment); electronic components was four times greater, and software about one and a half times (as a share of manufacturing and market services); Barry and Curran (2004).

home or abroad depends on preferences and the relative wage available in the two locations.[10] Thus labour supply and employment can be written as:

$$L = \ell(D; w/w^*) \text{ with } \ell_1, \ell_2 > 0. \tag{1}$$

where w is the domestic wage, $w^*$ the foreign wage and D is a shock term representing a reduction in labour-market distortions. The distorted labour supply schedule lies to the left of the undistorted schedule.

Imperfect capital mobility means that the cost of domestic borrowing is related to the total stock of borrowing. This equals the capital stock, which is owned in its entirety by foreign investors. Thus the required rate of return on capital is:

$$r = r^* + \Phi(S; K) \tag{2}$$

where $r^*$ is the foreign interest rate and S represents the beneficial capital-market shocks discussed earlier, with $\Phi_1 < 0$ and $\Phi_2 > 0$.

Output is given by the CRS production function:

$$Y = AF(K,L) \tag{3}$$

which yields

$$AF_L (K/L) = w \tag{4}$$

and

$$p = c(w,r)/A \tag{5}$$

With output prices exogenous (given the small open economy assumption), these five equations then determine the five endogenous variables Y, K, L, w and r.[11]

---

[10]Technically, each individual allocates part of his or her working life to the two locations so that the population with whose income per head we are concerned remains static. There is no unemployment in the formal model. Unemployment could be taken into account by introducing it as another state over which individuals have preferences. If social welfare payments remained constant throughout the analysis (as we assume the foreign wage does), the unemployment rate would then rise or fall in line with emigration, which is broadly consistent with the Irish experience.

[11]The cost function in Equation (5) is linearly homogenous. For the Cobb-Douglas production function $Y=AK^\alpha L^{1-\alpha}$ , for example, the price-cost equation is $p=c(r^\alpha w^{1-\alpha})/A$.

We subject this model to three shocks: a shock to total factor productivity A, a labour-market shock D and a capital market shock S. Noting that Equation (5) allows us express r in terms of w, we can then employ Equations (1), (2) and (4) to find the effects on K, L and w. It can easily be shown that K and L (and thus GDP, GDP per head of population, and labour productivity) rise in response to each shock, while w rises in response to the technology and capital-market shocks but falls in response to the labour-market shock. (Even in this latter case, however, GNP – which in our simple model corresponds to the total wage bill – rises.) Since K and L respond together to each of our shocks, we will concentrate on GNP, where some of the effects might be less obvious.

The model can be presented graphically, in wage-employment space, as follows. The labour-market equilibrium locus LL, is upward sloping, with slope $(1/\ell_2)$. LL is steeper the less mobile is labour (i.e., the lower is $\ell_2$). The capital-market locus KK is derived from Equations (2), (4) and (5) and is downward- sloping with a slope of:

$$- c_r \, \Phi_2 \, K/L \, / \, [c_w + c_r \, \Phi_2 \, (L/AF_L')] \quad < 0$$

The elasticity of KK lies between zero and minus one. KK is steeper the less internationally mobile is capital (i.e., the higher is $\Phi_2$). Now consider a beneficial labour-market shock D which shifts LL to the right. This reduces w and raises L, with the slope of KK ensuring that GNP rises. Furthermore, the rightward shift of LL does not depend on the degree of capital mobility. Thus the impact on GNP is higher the greater the mobility of capital.

An interesting result arises if the rightward shift of LL is independent of the degree of labour mobility, as it may be under some formulations of the labour-market shock. In this case, the flatter is LL (i.e., the higher the degree of labour mobility, denoted $LL_{HLM}$ in Figure 1), the smaller the fall in wages and the lower the increase in employment and national income. A low degree of labour mobility causes wages to fall more in response to labour-market liberalisation, giving rise to a larger increase in the return to capital, which triggers strong capital inflows and ultimately higher employment than in the case where labour is more mobile. This can be seen by comparing the equilibria at points 2 and 3, corresponding to high and low labour mobility respectively, in Figure 1.

The other two shocks, the capital-market shock and the shock to TFP, leave LL unchanged and instead shift the KK curve. Thus w and L move in the same direction in these cases. The impact on GNP of both the capital-market and the TFP shock is rising in $\ell_2$ and falling in $\Phi_2$. Thus the greater the degree

of labour mobility (i.e., the higher is $\ell_2$) and the greater the degree of capital mobility (i.e., the lower is $\Phi_2$), the greater the effect of these shocks on long-run equilibrium GNP.

Figure 1: *Outcome of a Labour-Market Shock, with Low and High Labour Mobility*
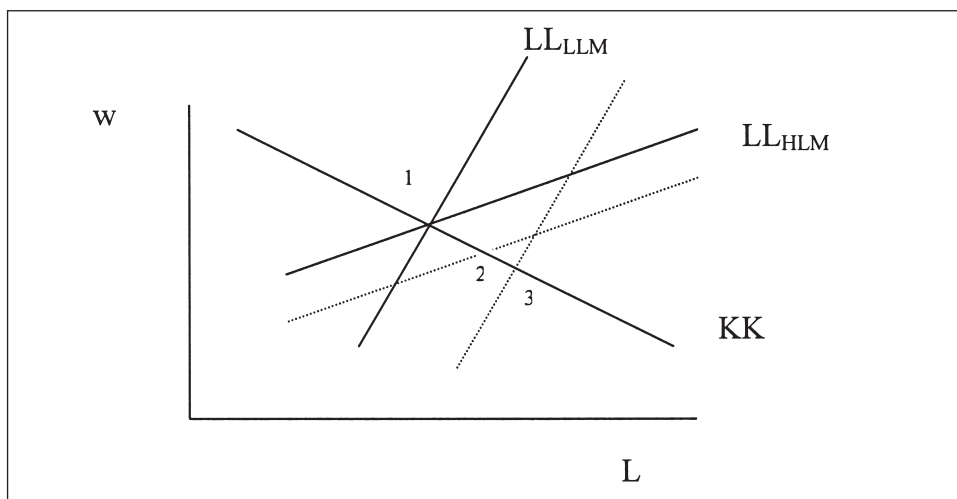


### III  THE FORMAL MODEL

We try to write down a simple, parsimonious model which can capture the main internal and external channels of importance in the Irish growth of the 1990s. As discussed above, the essential features of the analysis are a combination of high capital mobility (in the form of FDI) and labour mobility. We simplify by assuming that all capital accumulation is financed by foreign borrowing (and hence owned by foreign investors). Domestic residents receive and consume only their wage income. While this is obviously an extreme assumption, nothing of consequence in our analysis depends on it, and it has the benefit of allowing us to highlight the gap between national output and national income, or GDP and GNP, a distinction that is of great importance for the Irish economy.

The structure of the model is as follows. Throughout we will assume just one sector of production, which uses capital and labour. All capital represents FDI, and must earn a given world rate of return plus a country specific risk premium. Labour supply comes from domestic households. Households are assumed to make a choice between supplying labour in the home economy, at

the given wage rate, or emigrating abroad to work. Households are not indifferent between labour supplied in the domestic economy and working abroad – we assume that they have well defined preferences over the two alternatives.

*The Household and Labour Supply*

The household in the model has preferences over consumption C and labour supply $\ell_1$ and $\ell_2$ in the two locations 1 and 2, (where the wages in each location are $w_1$ and $w_2$, respectively) given by:

$$U = C^{\varphi}\left(\mu_1\ell_1^{1-\frac{1}{\theta}} + \mu_2\ell_2^{1-\frac{1}{\theta}}\right)^{\frac{1-\varphi}{1-\frac{1}{\theta}}}.$$

The household maximises utility subject to the budget constraint $C = w_1\ell_1 + w_2\ell_2$, and a fixed total labour supply which must satisfy $\ell_1 + \ell_2 = 1$. The idea behind this specification is that the household receives some non-pecuniary benefit from the time spent working in a given location besides the direct wage income earned. The household has a fixed total amount of labour supply it can offer, which we normalise at unity.

The first order condition for the household's choice of location is given by:

$$w_1 - w_2 = -\frac{(1-\varphi)}{\varphi}\frac{C}{\mu_1\ell_1^{1-\frac{1}{\theta}} + \mu_2\ell_2^{1-\frac{1}{\theta}}}\left(\mu_1\ell_1^{-\frac{1}{\theta}} - \mu_2\ell_2^{-\frac{1}{\theta}}\right) \quad (6)$$

Together with the constraint that $\ell_1 + \ell_2 = 1$, this describes a labour supply schedule relating $\ell_1$ positively to $w_1$ and negatively to $w_2$. Taking location 1 as the home location, we thus have labour mobility such that households move back into the home labour market as the home wage gap rises. But since workers are not indifferent between locations, wages are not equalised between them.

In addition to capturing the idea that home and foreign labour markets are linked, we also wish to analyse the consequences of labour market reform. One way to model this process is to imagine that, preceding the growth take-off, labour markets were dominated by monopoly unions. In this case, instead of Equation (6) characterising the labour supply relationship, we have a condition that is implied by the monopoly union choosing to maximise utility, taking an aggregate labour demand equation as given. This gives

$$w_1 - w_2 = \ell_1\left[\frac{\partial\ell_1}{\partial w_1}\right]^{-1} - \frac{(1-\varphi)}{\varphi}\frac{C}{\mu_1\ell_1^{1-\frac{1}{\theta}} + \mu_2\ell_2^{1-\frac{1}{\theta}}}\left(\mu_1\ell_1^{-\frac{1}{\theta}} - \mu_2\ell_2^{-\frac{1}{\theta}}\right). \quad (7)$$

This expression differs from Equation (6) only due to the first term on the right hand side, which is positive, and captures the monopoly union distortion. Since this term pushes up the required wage for each level of $\ell_1$, conditional on $w_2$, the distorted labour supply schedule lies to the left of the undistorted schedule. Without loss of generality, we then write the labour supply curve for the domestic economy as:

$$\ell_1 = \ell(w_1)\Theta, \tag{8}$$

where $\ell'(w_1) > 0$, and $\Theta$ captures all other elements that affect labour supply. In particular, a fall in the monopoly union distortion in the home economy would imply a rise in $\Theta$.[12]

*Domestic Firms*

Firms in the home economy hire labour and accumulate capital. The firm's instantaneous production function is written as

$$Y = AF(K, L).$$

We assume that $F(K, L)$ has constant returns to scale in capital and labour, and $A$ captures a total factor productivity shift variable.

The firm may purchase capital at price $q$, and hires labour at the home wage $w_1$. The firm's capital stock depreciates at instantaneous rate $\delta$. The firm will hire labour and purchase capital to satisfy

$$AF_L(K, L) = w_1 \tag{9}$$

$$(r + \delta)q = AF_K(K, L) + \dot{q}. \tag{10}$$

The second condition simply says that the return on a unit of capital should equal its opportunity cost, where $r$ is the cost of external borrowing.

*Aggregate Capital Accumulation*

We assume that there are convex costs of capital installation (or adjustment costs) in the home economy. The implication of adjustment costs is that there will be a relationship between aggregate investment and the price

---

[12]In referring to the term $\Theta$ as a 'distortion', even though it arises from a trade union maximising utility, our terminology is in line with the usual description of monopoly pricing distortions. In particular, employment is below its socially efficient level due to the presence of the $\Theta$ term.

of capital captured by the function $I = g(q)$, which satisfies the conditions $g'(q) > 0$, and $g(1) = \delta K$. The aggregate capital stock then adjusts according to:

$$\dot{K} = g(q) - \delta K \qquad (11)$$

*Foreign Investors*

Foreign investors are modelled through the simple assumption that the return on direct investment in the home economy must equal $r$. Following recent literature (e.g., Turnovsky, 2002), we assume that there are frictions in international capital markets which lead the cost of domestic borrowing to be related to the total stock of borrowing (which, in our simplified modelling, equals the capital stock). Thus, we assume that:

$$r = r^* + \Phi(K) \qquad (12)$$

where $\Phi'(K) > 0$.

*Equilibrium*

Equations (8)-(12), in combination with the labour market clearing equation $\ell_1 = L$ give the full equilibrium for the economy. We can then solve for $w_1$, $q$, $r$, $K$ and $L$. We simplify the system by putting Equations (7) and (8) together to obtain the implicit function $L = L(K, \Theta, A)$. This function satisfies $L_1 > 0$, $L_2 > 0$ and $L_3 > 0$. Using this in Equation (9), and combining Equations (10) and (11), gives us a dynamic system in $q$ and $K$ which satisfies:

$$\dot{q} = (r^* + \Phi(K) + \delta)q - AF_K(K, L(K, \Theta, A)), \qquad (13)$$

$$\dot{K} = g(q) - \delta K. \qquad (14)$$

The behaviour of the economy is illustrated in Figure 2. The $\dot{q} = 0$ schedule represents the arbitrage equation determining the optimal capital stock, and is downward sloping. The $\dot{K} = 0$ schedule is upward sloping. If the economy begins with a relatively low capital stock, the price of capital is above its steady state. This leads to positive net investment, and the economy converges along the saddle path SS towards its steady state, characterised by

$$q = 1 \qquad (15)$$

$$(r^* + \Phi(\bar{K}) + \delta) = AF_K(\bar{K}, L(\bar{K}, \Theta, A)) \qquad (16)$$

Figure 2: *Dynamics*
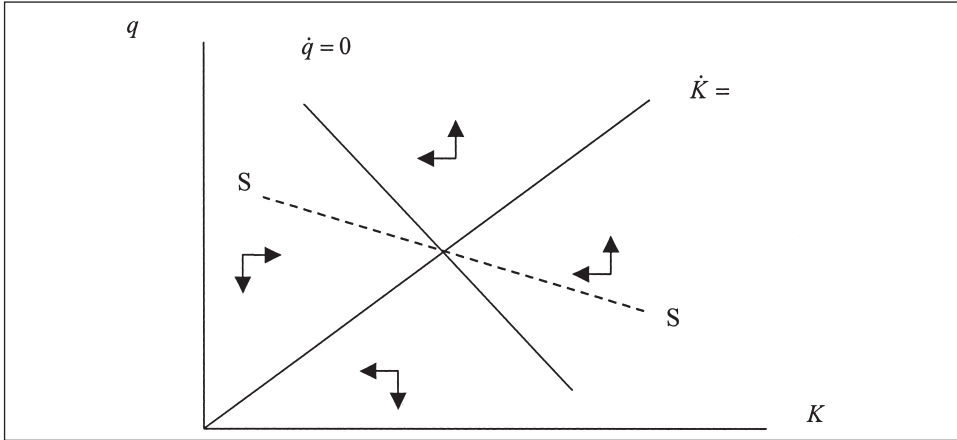


## Sources of Growth

Since we are abstracting from long-run growth in GDP per capita, we can think of all growth in this model as 'catch-up', or the convergence that occurs as GDP moves to a higher steady state. In a model where we properly accounted for steady state growth in GDP per capita, the interpretation would be that GDP grows temporarily at a rate higher than the steady state growth rate.

The steady state can be illustrated in Figure 3. The KK schedule describes the capital market equilibrium as given by the steady state equation:

$$(r^* + \Phi(\bar{K}) + \delta) = AF_K(\bar{K}, \bar{L})$$

Figure 3: *The Steady State*
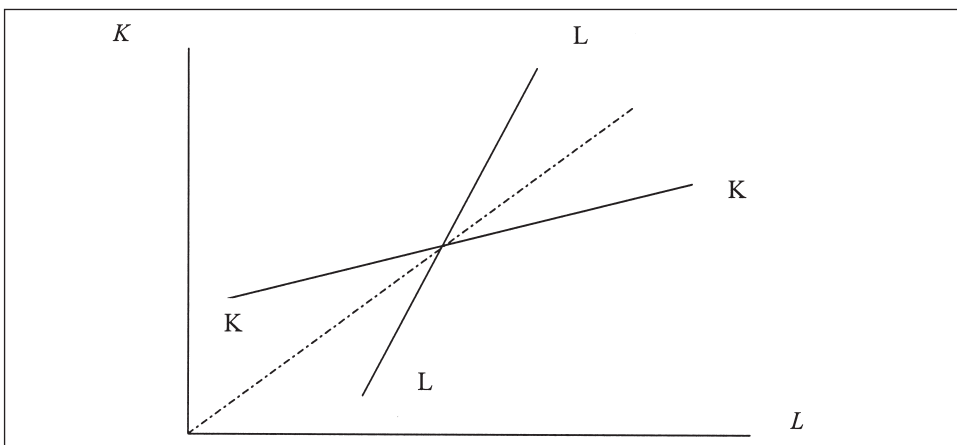
This schedule is upward sloping in K-L space, but cuts the 45-degree line from above. A rise in total factor productivity A or a fall in r* (capturing a fall in the external risk premium) will shift the KK schedule up and to the left. The LL schedule describes labour market equilibrium and is given by:

$$AF_L(\bar{K}, \bar{L}) = w_1 \left( \frac{\bar{L}}{\Theta} \right)$$

where the right hand side comes from inverting the labour supply function (8). The implicit assumption here is that an improvement in labour market institutions leads to an increase in total labour supply at a given real wage, but does not alter the elasticity of labour supply to changes in the home real wage. The LL curve is also upward sloping, but intersects the 45-degree line from below. A rise in $\Theta$ or a rise in A shifts the LL curve to the right.

Our model thus captures three sources of growth – a reduction in the cost of borrowing, changes in labour market institutions, or changes in total factor productivity. In the first case, a fall in the external risk premium will shift the KK curve up, and increase the capital labour ratio. This implies that long-run output rises more than employment. An improvement in labour market institutions however will have the opposite effect, reducing the capital labour ratio, so long-run GDP rises by less than employment. Finally, a rise in total factor productivity may increase or reduce the capital labour ratio, depending on the elasticity of labour supply and the importance of the endogenous external risk premium in foreign borrowing.

## IV GROWTH DYNAMICS

The critical features of the model are the openness of the labour and capital markets. To illustrate this we simulate the quantitative response of the model in a series of cases. We solve and simulate the model by linear approximation around an initial steady state. In order to do this we are required to choose numerical values for a number of key parameters. We assume that the production function is Cobb-Douglas, and assume a capital share equal to 0.36. The rate of capital depreciation is set at 10 per cent, so that $\delta = 0.1$. We assume that the implicit labour supply function (3) has a wage elasticity equal to unity (see below for discussion). A critical factor in the calibration is the magnitude of adjustment costs in investment. A low elasticity of investment with respect to the price of capital implies higher adjustment costs and slower convergence. We follow previous literature (see Bernanke, Gertler and Gilchrist, 1999) in assuming an elasticity of the price

of capital with respect to investment of 0.3. Finally, we set $r^* = 0.05$ and using evidence on the sensitivity of interest rates to external debt from Lane and Milesi-Ferretti (2001), we assume that (a) the elasticity of $\Phi(K)$ is equal to .01 and (b) the debt related risk premium is 2 per cent.

Figure 4 illustrates the role of labour market openness in the growth process. In the Figure, we compare two alternative convergence processes, where in one case, the labour force is constant throughout, and in the second case, employment responds endogenously to capital accumulation through the process described in Equation (8). In both cases, we have set the initial capital stock equal to 30 per cent of its steady state level, so that initial GDP is below steady state GDP.[13] As we can see from the Figure, the channel of endogenous employment expansion during the growth process implies a higher steady state GDP and a much higher growth rate during the convergence, beginning from an initial low level of GDP. As capital accumulation takes place, beginning from an initial low capital stock, the real wage in the home economy rises, drawing in labour from outside, magnifying the process of accumulation itself.
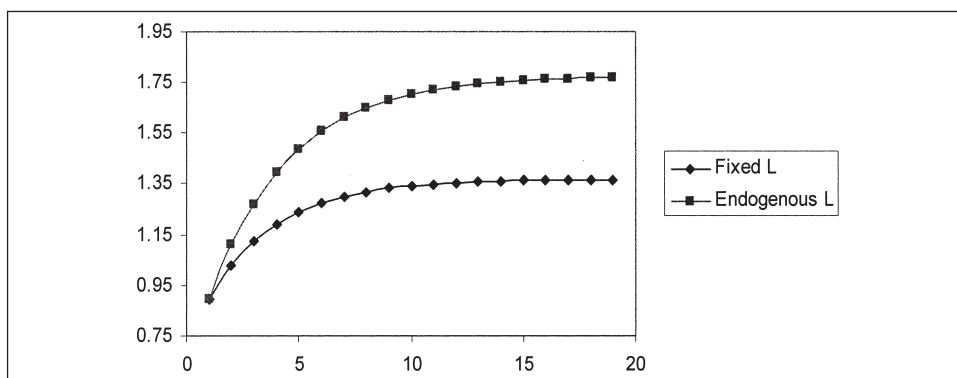
Figure 4: *Labour-Market Openness and Growth*



Figure 5 illustrates the role of international capital markets. The Figure again shows the convergence process, beginning from an initial capital stock equal to 30 per cent of steady state capital, but now contrasting the baseline calibration against a case where the opportunity cost of borrowing is sharply rising in foreign debt – we set the elasticity of the function $\Phi(K)$ equal to unity. This implies a much higher degree of restrictiveness of international capital markets. Again we see that capital market openness is a critical feature of the convergence process, in the same way as is labour market openness. With

[13]Figures 4 and 5 have time in years on the horizontal axis and an index of GDP on the vertical.

more restrictive capital markets, steady state output is significantly lower, and the growth rate during convergence is much lower.

Figure 5: *Capital-Market Openness and Growth*
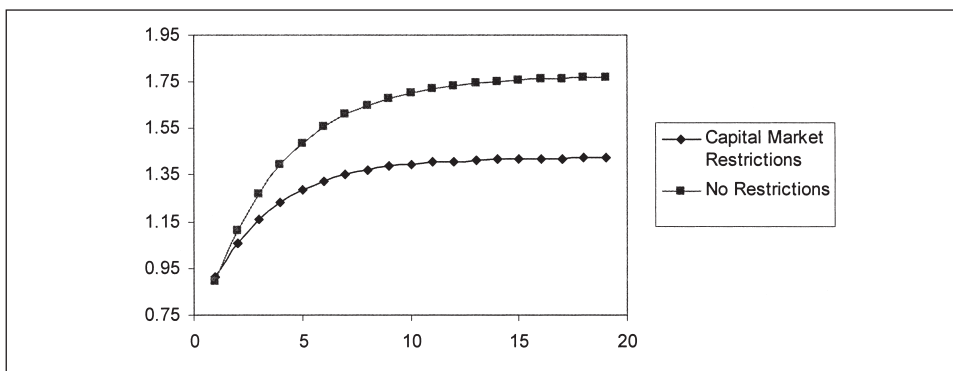


*Quantitative Application*

We now apply the model to the Irish growth experience. As is well known, Ireland experienced a major increase in its growth rate during the 1990s. Figure 6 displays GDP growth between 1970 and 2004. The average annual growth rate of GDP from 1981-1990 was 3.8 per cent. In the 1991-2000 decade this almost doubled to 7 per cent. Especially after 1995, growth rates rose dramatically. From 2001-2004, GDP growth had returned close to the average rates of the late 1980s.

Figure 6: *GDP Growth, 1970–2004*
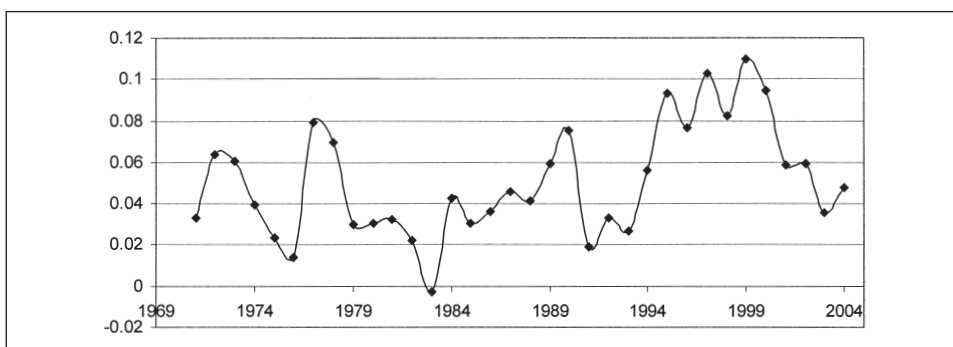


The full accounting for the sources of Ireland's growth success is beyond the scope of this paper. However, the large increase in growth rates during the 1990s suggests that important structural changes took place in the late 1980s

or early 1990s that raised the long-run path of Irish GDP per capita. According to the neo-classical growth model, this would lead to a rise in growth rates as the economy converged to the higher growth path. While the long run growth rate would be unchanged, the level of GDP per capita would be permanently higher at all dates. At the same time, total employment, as illustrated in Figure 7, increased dramatically. Between 1986 and 2004 employment increased by 72 per cent (from around 1.1 million to 1.8 million). This was of course the result of many factors; increased labour force participation, net in-migration, and a collapse in unemployment.

Figure 7: *Employment (thousands)*
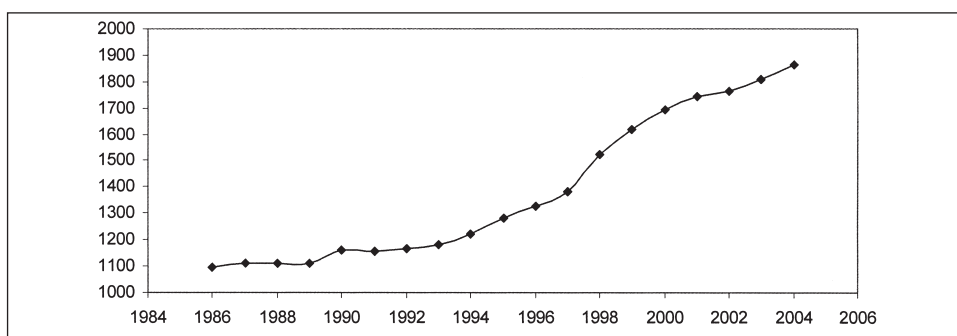


Can our model assist in the interpretation of the Irish growth experience? We have discussed three sources of growth shocks. How important could each shock be in explaining the historical growth record? Table 1 gives some indication of this. It documents the impact on GDP and employment of a fall in the external risk premium, a shift in aggregate labour supply (due to labour market reform), and a rise in total factor productivity. A fall in the risk premium leads to an increase in long run GDP and employment. But the

Table 1: *Steady State Effects of Shocks*

|  | $r^*$ | $\Theta$ | $A$ | $A(1)$ | $A(2)$ | $A(3)$ |
|---|---|---|---|---|---|---|
|  | % | % | % | % | % | % |
| Output | 15 | 14 | 33 | 200 | 77 | 194 |
| Employment | 7 | 14 | 14 | 70 | 0 | 68 |

*Notes:* r* indicates a shock that cuts the external real interest rate by half. $\Theta$ represents a labour market shock that directly increases employment by 10 per cent. A represents a 10 per cent increase in total factor productivity. A(1) represents a shock that raises GDP by 200 per cent and increases employment by 70 per cent, as in the data. A(2) represents the same shock when there is no endogenous labour supply. A(3) represents the same shock when the debt elasticity of external interest rates is increased from .01 to .1.

impact is quite small. Even a halving of r*, from .05 to .025, increases long run GDP by only 15 per cent. Since the share of capital in output is relatively small, the interest elasticity of steady state output is quite small. As a result, the reduction in the required rate of return on capital cannot account for the scale of the growth, at least given the current calibration of the model.

The second shock in the Table is an increase in labour supply resulting from a rise in Θ, where we arbitrarily set the increase in Θ to 10 per cent. But this has the counterfactual implication that the rise in GDP is less than the increase in labour supply itself (although the difference between the two are very small). In fact, GDP grew much faster than employment.

Finally, a 10 per cent rise in total factor productivity raises long run GDP by more than 30 per cent, while increasing employment by about 15 per cent. Thus, shocks to total factor productivity differ from the other shocks in having the potential to dramatically raise both GDP and employment while raising the former more than the latter.

How big a role did labour market openness play in the Irish growth experience? To investigate this, we conduct the following experiment. Assume that structural changes in the economy in the mid-1980s raised the long-run path of GDP. We set this shock as an exogenous rise in total factor productivity, although it may be attributed to various alternative factors, as discussed above. We choose the size of the shock so that, given the other parameter values, GDP trebles in a twenty year period, to conform with the Irish experience. Simultaneously, we pick the elasticity of the labour supply function (7) so that employment rises 70 per cent during the growth process. This implies an elasticity of approximately unity. We then ask, how much would GDP have risen, for the same shock, in the absence of labour market openness? That is, if employment had not risen endogenously in response to the rise in total factor productivity, how much would output have risen? We find that labour market openness played a highly significant role. As shown in Table 1, the implied increase in GDP in the absence of labour market openness would have been 77 per cent, as opposed to the 200 per cent increase that actually occurred. This translates to an average GDP growth of 3 per cent, as opposed to the actual growth of around 6 per cent.

We also investigate the role of capital market openness in the growth experience. We take the same total factor productivity shock as before, but now, assuming labour market openness, we increase the debt elasticity of external interest rates by a factor of 10, from 0.01 (as in Lane and Milesi-Ferretti's estimates) to 0.1. The results indicate that this would have had only a minor dampening effect on the growth of GDP and employment. GDP still rises by 194 per cent, and employment by 68 per cent. In fact even if we increase the elasticity 50-fold, to 0.5, we find that GDP and employment would

still rise by 160 per cent and 59 per cent, respectively. Hence, a tentative conclusion we may draw from our model is that of the two channels of openness that were emphasised in Blanchard's discussion, the labour market channel was by far the most important for magnifying the rate of economic growth in Ireland.

## V  CONCLUSIONS

This paper has explored the consequence of capital and labour-market openness for the response of an economy to the kinds of shocks that are widely recognised to have been of importance in driving the Irish boom. We explored three shocks: (i) an increase in the economy's attractiveness to foreign capital, (ii) a reduction in labour-market distortions, and (iii) an increase in total factor productivity. Our findings show, at the theoretical level, that the effects on GNP of all three shocks are magnified by the openness of factor markets. Quantitatively, however, labour-market openness appears to be vastly more significant for growth than capital-market openness, as proxied by the elasticity of the risk premium with respect to foreign borrowing.

Of the three shocks considered, only the TFP shock appears capable of generating an output and employment response of the magnitude seen over the course of the Irish boom. Labour-market shocks generate as much growth in employment as in GDP, which rules them out as a monocausal explanation. Of course, all three shocks are likely to have occurred simultaneously. One channel which we have not explored but which is likely to have been of major importance concerns the relationship between TFP growth and the increased FDI inflows of the period. This means that our capital-market and TFP shocks would have been related in a way that we intend to explore in future work.

## REFERENCES

AHEARNE, A., F. KYDLAND and M. WYNNE, 2004. "Accounting for Ireland's Bust and Boom", unpublished ms.

BARRY, F., 2002a. "The Celtic Tiger Era: Delayed Convergence or Regional Boom?", *Quarterly Economic Commentary*, pp. 84-91, Dublin: The Economic and Social Research Institute.

BARRY, F., 2002b. "FDI, Infrastructure and the Welfare Effects of Labour Migration", *Manchester School*, Vol. 70, No. 3, pp. 364-379.

BARRY, F. and D. CURRAN, 2004. "Enlargement and the European Geography of the Information Technology Sector", *World Economy*, Vol. 27, No. 6, pp. 901-922.

BALDWIN, R. and P. KRUGMAN, 2004. Agglomeration, Integration and Tax Harmonisation, *European Economic Review*, Vol. 48, No. 1, pp. 1-23.

BERNANKE, B., M. GERTLER and S. GILCHRIST, 1999. "The Financial Accelerator in a Quantitative Business Cycle Framework" in J.B Taylor and M. Woodford (eds.), *Handbook of Macroeconomics*, Amsterdam: North-Holland.

BERTOLA, G. and A. DRAZEN, 1993. "Trigger Points and Budget Cuts: Explaining the Effects of Fiscal Austerity", *American Economic Review*, Vol. 83, pp. 11-26.

BLANCHARD, O., 2002. "Comment on Honohan and Walsh", *Brookings Papers on Economic Activity*.

BORCK, R. and M. PFLÜGER, 2004. "Agglomeration and Tax Competition", DP 1033, Bonn: IZA.

CALMFORS, L. and J. DRIFFILL, 1989. Bargaining Structure, Corporatism and Macroeconomic Performance, *Economic Policy*, Vol. 6, pp. 13-62.

CRAFTS, N., 2005. "Interpreting Ireland's Economic Growth", background paper for UNIDO Industrial Development Report, unpublished ms.

DASCHER, K., 2000. "Trade, FDI and Congestion: The Small and Very Open Economy", CEPR Working Paper No. 2526, available at: http://www.ucd.ie/ ~economic/workingpapers/2000.htm.

DE LA FUENTE, A. and X. VIVES, 1997. "The Sources of Irish Growth" in Alan Gray (ed.), *International Perspectives on the Irish Economy*, Indecon: Dublin, Ireland. Also available as CEPR Discussion Paper No. 1756.

DUNNING, J., 1997. "The European Internal Market Programme and Inbound Foreign Direct Investment, Parts 1 and 2", *Journal of Common Market Studies*, Vol. 35, No. 1, pp. 1-30 and 35, 2, pp. 189-223.

HONOHAN, P. and B. WALSH, 2002. "Catching up with the Leaders: the Irish Hare", *Brookings Papers on Economic Activity*, Vol. 1, pp. 157.

KRUGMAN, P., 1979. "A Model of Innovation, Technology Transfer and the World Distribution of Income", *Journal of Political Economy*, Vol. 87, No. 2, pp. 253-266.

KRUGMAN, P., 1997. "Good News from Ireland: A Geographical Perspective" in Alan Gray (ed.), *International Perspectives on the Irish Economy*, Dublin: Indecon.

LANE, P. and G. MILESI-FERETTI, 2001. "Long Term Capital Movements", NBER Macroeconomics Annual.

MacSHARRY, R. and P. WHITE, 2000. *The Making of the Celtic Tiger: the Inside Story of Ireland's Booming Economy*, Dublin, Ireland: Mercier Press.

MILLER, M., R. SKIDELSKY and P. WELLER, 1990. "Fear of Deficit Financing: Is it Rational?" in R. Dornbusch and M. Draghi (eds.), *Public Debt Management: Theory and History*, Cambridge, UK: Cambridge University Press.

OSWALD, A., 1985. "The Economic Theory of Trade Unions: An Introductory Survey", *Scandinavian Journal of Economics*, Vol. 87, No. 2, pp. 160-193.

SUTHERLAND, A., 1997. "Fiscal Crises and Aggregate Demand: Can High Public Debt Reverse the Effects of Fiscal Policy?", *Journal of Public Economics*, Vol. 65, pp. 147-162.

TURNOVSKY, S., 2002. "Growth in an Open Economy: Some Recent Developments" in J. Smets and M. Dombrecht (eds.), *How to Promote Growth in the Euro Area*, Edward Elgar.