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The celtic tiger faces the factor price frontier: Labour market adjustment in Ireland

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**The Celtic Tiger Faces
The Factor Price Frontier**

—

Labour Market Adjustment in Ireland

by

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Abstract

Labour market flexibility is the key to sustainable economic development in advanced economies. The factor price frontier is used to analyse labour market adjustment in Ireland from the sixties to the present. The theoretical and empirical analysis lend support to the wideheld belief that excessive wage increases due to the interaction of the bargaining system and institutional rigidities have been at the root of the Irish unemployment problem in the eighties.

JEL classification: E 24, F21

*Keywords: Factor Price Frontier, Labour Market
Adjustment, Ireland*

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1 Introduction

Labour market flexibility is the key for a sustainable and satisfactory economic performance in an advanced economy. The Irish experience provides empirical evidence for this hypothesis. The rise of the celtic tiger in the nineties is crucially related to labour market flexibility, just as its limping in the seventies and eighties is related to labour market rigidities. The factor price frontier offers a framework to analyse labour market adjustment theoretically and empirically. It defines a negative, convex relationship between the user costs of capital and the real wage rate.

It appears to be a consensus view in the literature that a combination of increased globalisation, technical change, the bargaining system, and institutional rigidities are at the root of Ireland's unemployment problem (e.g. OECD 1997a, Taylor 1996, O'Hagan 1995, and Tansey 1991). Since the sixties, Ireland's exposure to international competition has increased due to progressing trade liberalisation (e.g. Curtis and Fitz Gerald 1996: 322) and membership in the European Monetary System from 1978 (e.g. Ó Gráda and O'Rourke 1996: 403). At the same time, the unemployment rate ratcheted up from around 5 percent to over 17 percent in 1985 and 1986 (Figure A1).¹

Based on an estimate of the factor price frontier for Ireland, I argue that Ireland's bargaining system together with its institutional

¹ Problems associated with the measurement of the Irish unemployment rate are discussed in OECD (1997a: pp. 67). Also, the malfunctioning of the Irish labour market does not fully show in the unemployment rate, because of migration.

rigidities would have resulted in unemployment even in the absence of the adjustment pressures emanating from globalisation or technical change.² The wage bargaining system, the tax system, and the welfare system created an environment that allowed for excessive wage increases in the late seventies and early eighties. The necessary adjustment along the factor price frontier resulted in a stark increase in unemployment.

The remainder of the paper is organised as follows. Section 2 outlines the model and briefly describes labour market adjustment in the factor price frontier framework. Section 3 presents estimation results for Ireland and discusses the results in the light of economic development. Section 4 summarises the main findings.

2 The Model

The factor price frontier is derived from a firm's intertemporal profit maximization calculus. In period t , profits Π are given by

$$\Pi_t = p_t Y_t - w_t L_t - q_t I_t \quad (1)$$

where p is the price of the output Y , w is the wage rate, L is labour input, and q is the price of investment good I . For a constant discount rate r , the firm maximizes the present value of its profit stream PV .

$$PV = \int_0^{\infty} e^{-rt} \Pi_t dt \quad (2)$$

² The interaction of adjustment pressure and labour market rigidities is discussed, for example, in Siebert (1997) and Paqué (1996).

Maximization is subject to two constraints. First, the net change in the capital stock \dot{K} is investment I minus depreciation δK_t .

$$\dot{K}_t = I_t - \delta K_t \quad (3)$$

Second, the production technology is described by

$$Y_t = Y(K_t, L_t) \quad (4)$$

The production function is linear homogeneous in the two inputs labour and capital and exhibits positive, decreasing marginal returns. In particular, I assume a stochastic, linear homogeneous Cobb-Douglas function, with A denoting an efficiency parameter and λ the rate of technical change. u is a normally distributed, white noise error term.

$$Y_t = Y(A, t, K_t, L_t) = A e^{\lambda t + u_t} K_t^\alpha L_t^{1-\alpha} \quad (4')$$

with $0 < \alpha < 1$

Substituting the production function (4) into the objective function (2), the present value Hamiltonian H_c is given by

$$H_c = p_t Y(K_t, L_t) - w_t L_t - q_t I_t + m[I_t - \delta K_t] \quad (5)$$

Since there is no equation of motion for labour, the static first-order condition yields the demand for labour.³

$$\frac{\partial Y}{\partial L_t} = \frac{w_t}{p_t} \quad (6)$$

³ All second-order conditions hold; they are not presented for the sake of brevity.

The optimal capital stock and the associated investment demand are derived by applying the maximum principle (cf. Chiang 1992: pp. 210).

$$\frac{\partial H_c}{\partial I_t} = -q_t + m = 0 \quad (7a)$$

$$\dot{K}_t = I_t - \delta K_t \quad (7b)$$

$$\dot{m} = -p_t \frac{\partial Y}{\partial K_t} + m(r + \delta) \quad (7c)$$

Using (7a), (7c) can be rewritten as

$$\frac{\partial Y}{\partial K_t} = \frac{q_t(r + \delta) - \dot{q}_t}{p_t} = uc \quad (8)$$

where uc are the real user costs of capital.

The optimal capital stock K in period t is given from solving the differential equation (8). Given the optimal capital stock, investment demand can be derived from (7b). For the present purpose, (8) is sufficient, because it relates the real user costs of capital uc to the marginal productivity of labour. Just as in a static framework, the two marginal productivity conditions (6) and (8) have to hold at the firm's profit maximum in every period (cf. Jorgenson 1967).

Combining the production function (4') and the two first-order conditions (6) and (8), yields the stochastic factor price frontier.

$$\frac{w_t}{p_t} = \frac{Y_t}{L_t} - \frac{K_t}{L_t} uc_t = \frac{1-\alpha}{\alpha} (\alpha A)^{\frac{1}{1-\alpha}} e^{\frac{\lambda}{1-\alpha} t + u_t} uc_t^{\frac{-\alpha}{1-\alpha}} \quad (9)$$

The shape and location of the frontier in the factor price space is determined by the given production technology. The slope of the factor price frontier equals the negative capital intensity $k = K/L$. It can also be shown that the frontier is convex.

$$\frac{\partial \frac{w_t}{p_t}}{\partial uc_t} = -k_t = -(\alpha A)^{\frac{1}{1-\alpha}} e^{\frac{\lambda t + u_t}{1-\alpha}} uc^{\frac{-1}{1-\alpha}} < 0 \quad (10)$$

Hence, the capital intensity defines the position on the factor price frontier. Or, the other way around, an exogenously given factor price defines the position on the factor price frontier and the capital intensity.

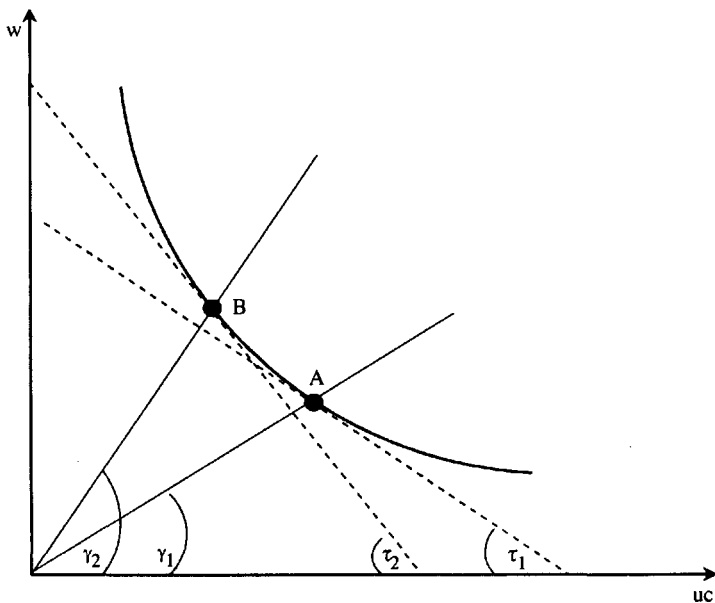
Holding all things constant, there is a trade-off between the wage rate and the user costs of capital. Technical change λt shifts the frontier out, allowing both factor prices to rise. This can be seen from taking the derivative of equation (9) with respect to λ .⁴

Labour market rigidities can lead to excessive wage increases, which in turn produce unemployment. Some aspects of this can be illustrated theoretically using the factor price frontier. In Figure 1, the economy is initially at point A with a factor price ratio $(w/uc)_1 = \tan \gamma_1$ and a capital intensity $k_1 = \tan \tau_1$. Any wage increase needs to be accompanied by a fall in the user costs of capital along the given factor price frontier.

⁴ Technical change can also be viewed as a change in the efficiency parameter A . This is appropriate, when technical change occurs as a shock.

Higher wages require a higher marginal productivity of labour at the profit maximum. Neglecting technical change, the marginal productivity of labour is increased by laying-off workers. For a constant capital stock, this leads to a rise in the capital intensity to $k_2 = \tan \tau_2$. The economy is now at B ; the factor price ratio has increased to $(w/uc)_2 = \tan \gamma_2$ with a higher wage rate and lower user costs of capital. If the frontier was shifted out by technical change or by an increase in average human capital, the fall in the user costs of capital would be smaller (cf. Hornung et al. 1998).

Figure 1 – A Theoretical Factor Price Frontier



For estimation purposes, the factor price frontier is written as:

$$\log\left(\frac{w_t}{p_t}\right) = \theta_0 + \theta_1 t + \theta_2 \log(uc_t) + \varepsilon_t \quad (9')$$

with

$$\theta_0 = \log\left[\frac{1-\alpha}{\alpha}(\alpha A)^{\frac{1}{1-\alpha}}\right], \quad \theta_1 = \frac{\lambda}{1-\alpha}, \quad \theta_2 = \frac{-\alpha}{1-\alpha},$$

and $\varepsilon_t = \frac{1}{1-\alpha} u_t$.

3 Empirical Results

All data for Ireland is taken from the OECD Business Sector Data Base (1997b, 1998a). The series are available from 1961 to 1994 on a quarterly basis and have been seasonally adjusted by the OECD. Table A1 contains descriptive statistics of the time series used for the wage rate and the user costs of capital. Figure 2 shows the time series.

The wage rate is approximated by the compensation per employee in the private sector. The user costs of capital are calculated according to (8). The long-term interest rate is used for the discount rate. The deflator for non-residential gross fixed investment in the business sector is used for the price of investment goods. Since no data on the actual depreciation rate was found, the business sector capital scrapping rate was used as a proxy. Both the compensation per employee and the user costs of capital were expressed in 1991 Irish pounds with the GDP deflator. A producer price index would have been preferable. However, the Business Sector Data Base contains no such index. Since the quarterly series were seasonally adjusted, I

chose to stay within the database instead of taking producer prices from some other source.

Both the compensation per employee and the user costs of capital are integrated of order one, as can be seen from the Augmented Dickey Fuller tests reported in Table A1. Therefore, the Johansen procedure is used to estimate a factor price frontier for Ireland.

The Johansen procedure initially assumes both variables to be endogenous to the system. The error-correction form of a general VAR is estimated.

$$\Delta z_t = \Pi z_{t-1} + \Gamma(L)\Delta z_t + \varepsilon_t, \quad (11)$$

where $\Gamma(L) = \Gamma_1 L^1 + \Gamma_2 L^2 + \dots + \Gamma_{k-1} L^{k-1}$; L is the lag operator. z_t is a 2×1 vector that contains the log compensation per employee and the log user costs of capital. The error term ε_t is *niid* $(0, \Sigma)$. Π can be decomposed according to $\Pi = \alpha\beta'$, where α is the matrix of loading coefficients that describe the speed of adjustment. β contains the cointegration vectors in its columns. The long-run factor price frontier given by equation (9') is described by $\beta' z_{t-1}$ in this dynamic specification.⁵

The AIC, the AAIC, the SC, and the HQ all point to an optimum lag length of one for the VAR. Although the time series are on a quarterly basis, this appears to be reasonable, as they have been seasonally

⁵ Johansen (1988, 1992, and 1995), Harris (1995), and Hansen and Juselius (1995) discuss the Johansen procedure. All estimates are carried out with CATS in RATS. I test at the 10 percent level of significance level for the cointegration rank of the system.

adjusted. In applying the Johansen procedure, the lag length is increased to two, to better control for autocorrelation.

Initial estimates for the whole sample period from 1961 to 1994 found no meaningful cointegration relationship between the user costs of capital and the compensation per employee.⁶ A quick glance at the data explains this finding (Figure 2 and A2). From the early sixties to the mid-seventies, the user costs of capital and the compensation per employee rose in a parallel fashion; a trade-off along a hypothetical factor price frontier is not recognisable in the data. Economic policy in this period, was directed to capital formation in agriculture and industry (cf. Ó Gráda and O'Rourke 1996: 402). Capital deepening in the form of introducing a modern capital stock followed. In other words, technical change allowed both factor prices to rise by shifting the factor price frontier outward.

Since there is not enough variation in the data to yield a factor price frontier-like relationship up to the mid-seventies, the sample period is shortened to 1973:1 to 1994:4. Unfortunately, therefore, adjustment in the sixties cannot be empirically investigated with the factor price frontier.

In the reduced sample, I first test for the cointegration rank of the system and the presence of a constant and a linear trend simultaneously according to the Pantula-principle. The system contains one cointegrating vector. There is a constant in the estimated

⁶ These test results are not presented due to space considerations. They are available from the author upon request. The same holds for all other results not documented.

cointegrating vector, but no linear trend, as the theoretical formulation of (9') suggested. This result is surprising, because it implies that Ireland experienced no technical change from the early seventies to the nineties. However, there is some evidence that technical change was actually low over this period (cf. Ó Gráda and O'Rourke 1996: pp. 391).

Comparing a hypothetical factor price frontier running through the factor price combination in 1974:1 to a hypothetical frontier running through the combination in 1994:4, there is an outward shift, reflecting technical change. Some of this is captured by the constant – the efficiency parameter A . Also, some of the technical change might be captured by the short-run dynamics of the system. The compensation per employee follows a linear trend (Figure A2) that could be interpreted as picking up the influence of technical change.

Next, I estimate an unconditional model to test for weak exogeneity of either variable (Table A2). The null hypothesis of weak exogeneity for the user costs of capital cannot be rejected at the 5 percent significance level; the LR statistic is $\chi^2(1) = 3.13$. Conversely, the null hypothesis of weak exogeneity for the compensation per employee is rejected at the 5 percent level; the LR statistic is $\chi^2(1) = 10.23$. For estimation purposes, this result implies that the model can be conditioned on the user costs of capital.

In terms of the factor price frontier, this result implies that the compensation per employee adjusts to changes of the user costs of capital. Although labour market rigidities appear to be responsible for the unemployment record in the seventies and eighties, they have not

made the wage rate completely exogenous to labour market conditions. This is especially true after 1987, when wages have been set with the aim of reducing unemployment. Also, weak exogeneity is a statistical concept that may be regarded as an indicator, but by no means as a proof of economic causality. Hence, the finding of weak exogeneity does not contradict the hypothesis that wages were at the root of the Irish unemployment problem.

Finally, I estimate a conditional model to come up with an empirical factor price frontier for Ireland (Table A3). The user costs of capital are treated as an exogenous variable, so that the two dimensional VAR reduces to a one dimensional VAR that contains the compensation per employee as the only remaining endogenous variable. In the specification of (9') the estimated long-run factor price frontier is:

$$\log \text{ real compensation per employee} = 10.89 - 0.47 * \log \text{ real user costs of capital} \quad (9'')$$

A one percent increase in the user costs of capital leads to a 0.47 percent decrease in the compensation per employee. From (9''), the estimated parameters of the production function (4') can be recovered.

efficiency parameter	A	=	3155.94
exogenous technical progress	λ	=	0.00
output elasticity of capital	α	=	0.32

The estimate for α translates into a wage share in the private business sector of 68 percent. The average wage share from 1973 to 1994 as the ratio of compensation of employees to GDP is 53 percent. Considering the large agricultural sector of Ireland, the lower wage share in the economy at large is not surprising. The average capital

income share in the business sector is 22 percent over the same period and 30 percent in 1994.⁷ Therefore, the estimates presented here are in line with the development in Ireland.

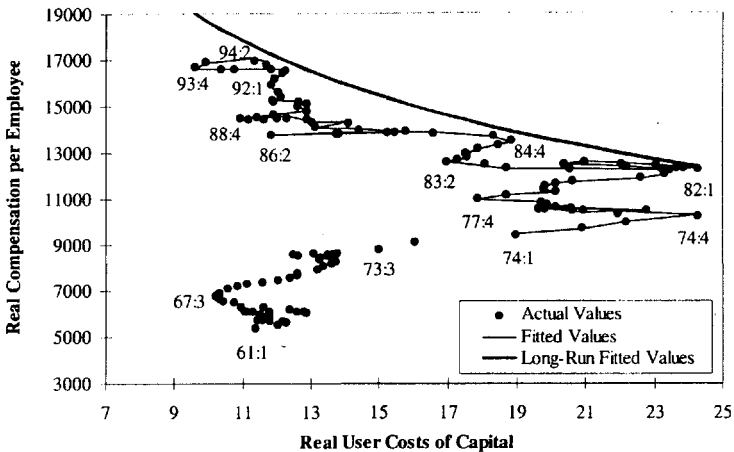
Figure 2 shows the actual factor price combinations along with the estimated short-run and long-run factor price frontiers. The high R^2 of 0.80 in the error-correction formulation shows in the excellent fit of the short-run frontier's in-sample forecast. The estimated long-run frontier of equation (9'') is located just above the actual factor price combinations. Short-run adjustment occurs towards this level or takes place on the frontier itself.

The factor price frontier tells a simple story about labour market adjustment from the mid-seventies to the late eighties: Wages were allowed to rise excessively, and the user costs of capital fell along the factor price frontier. The necessary increase in the capital intensity was brought about by laying-off workers; unemployment rose sharply.

In 1969, wage bargaining was centralised to achieve industrial peace. Locally, wage increases above the centrally bargained rate, could be negotiated. This bargaining system resulted in excessive wage increases and unemployment.

⁷ Data taken from OECD (1998a); own calculations.

Figure 2 – The Empirical Factor Price Frontier



Source: OECD (1998a); own calculations.

In 1978, wage bargaining was somewhat decentralised (cf. Ó Gráda and O'Rourke: 1996: 415). Wage increases slowed down, but speeded up again soon. Two factors have contributed to this. First, unemployment benefits increased significantly after 1979 (OECD 1997a: 83). Second, the tax wedge increased significantly in the late seventies and early eighties (Tansey 1991: pp. 37). Taken together, these factors caused the reservation wage to rise. In particular, the incentive to work in a low-productivity job was reduced. Excessive wage increases and a further rise in unemployment followed.

After 1987, centralised bargaining returned: Employers, unions, and the government agreed on labour market reforms to fight unemployment (cf. Ó Gráda and O'Rourke: 1996: 415). Wage increases slowed down. Unemployment benefits as well as the tax wedge were reduced. As the reforms began to work, Ireland stopped

moving up the factor price frontier: The fall in the user costs of capital came to a halt. As per capita investment picked up again, employment began to grow. The unemployment rate started to fall.

In a small open economy, the development up to the late eighties is expected to trigger capital movements out of the domestic economy. For capital-scarce Ireland, this tendency shows in an insufficient level of domestic and foreign investment. Only after labour markets became more flexible, did investment levels rise and contribute to the current growth performance of the Irish economy. Figure A3 and A4 provide support for this view. Per capita investment fell dramatically in the late seventies and early eighties, while the capital intensity continued to increase.

4 Summary

The factor price frontier describes a negative, convex relationship between the user costs of capital and the wage rate. If one factor price is set exogeneously, the other has to adjust. Wage increases, for example, call for a fall in the user costs of capital. All other things constant, the adjustment process involves a rise in the unemployment rate.

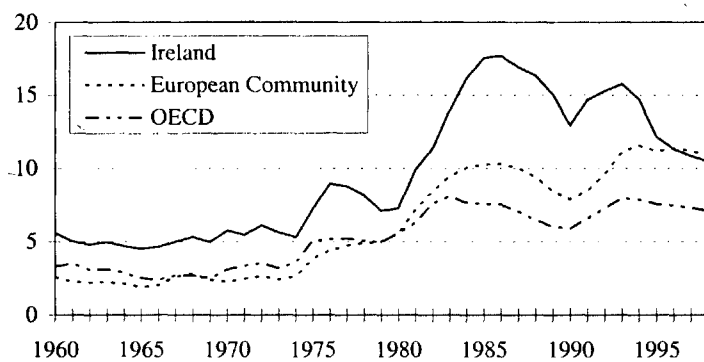
A factor price frontier was estimated for Ireland over the period from 1973 to 1994 that supported the theoretical model. Surprisingly, the estimated factor price frontier contained no linear trend, representing technical change. It was argued that the level of technical change was actually low in the sample. The compensation per employee, which follows a linear trend closely, captures the influence of this low level of technical change.

Adjustment pressures deriving from the openness of the Irish economy together with the wage bargaining system and institutional rigidities are often blamed for the employment performance in the eighties. Bruno (1984) and Hornung et al. (1998) have estimated factor price frontiers for several industrialised countries to study the effects of the first oil shock and globalisation. In their results, adjustment to exogenous shocks shows up as distinct shifts of the frontiers. None of this is visible in the Irish data after the mid-seventies. Instead, the Irish economy moved up a single factor price frontier. The user costs of capital fell, while the compensation of employees rose. This change in the factor price ratio was accompanied by an increase in the capital intensity due to laying-off workers. Hence, excessive wage increases as a result of the interaction of the bargaining system and institutional rigidities have been the dominant cause of rising unemployment.

During the late seventies and early eighties, the factor price frontier kept the celtic tiger caged. As of the nineties, Ireland appears to have learned its lesson: Even for a tiger it is impossible to jump over the factor price frontier by having excessive wage increases together with a good economic performance. Instead, through labour market flexibility and technical change, the frontier is to be pushed out, allowing both factor prices to rise. In turn, domestic and foreign investment have gained speed, and the economy performs well in terms of GDP and employment growth.

Appendix

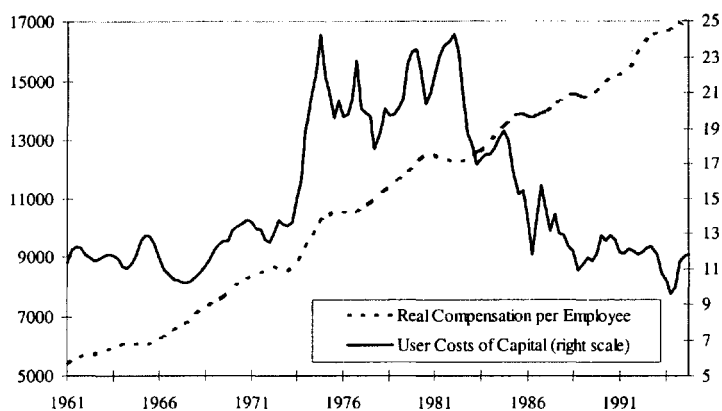
Figure A1 – The Irish Unemployment Rate in International Perspective^a (Percent)



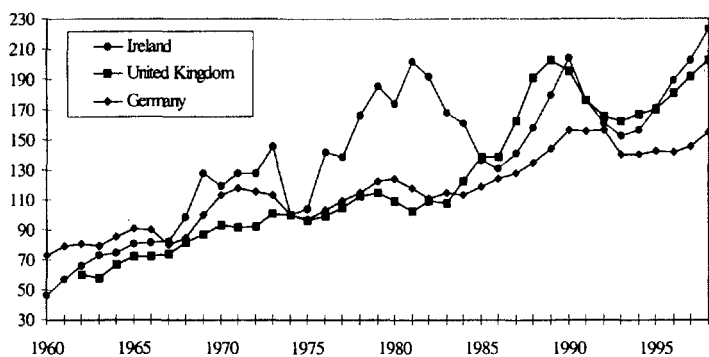
^aEuropean Community and OECD as of 1998.

Source: OECD (1998b).

Figure A2 – Real Compensation per Employee and User Costs of Capital in Ireland (1961 to 1994)

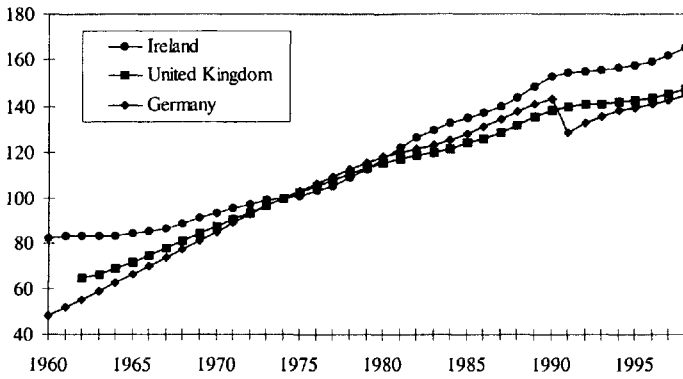


Source: OECD (1998a); own calculations (see text).

Figure A3 – Irish Per Capita Investment^a in International Perspective

^aRatio of gross fixed capital formation in the business sector (volume) to working-age population (15-64). 1974=100.

Source: OECD (1998b); own calculations.

Figure A4 – Irish Capital Intensity^a in International Perspective

^aRatio of the capital stock in the business sector (volume) to working-age population (15-64). There is a structural break in the German series in 1991 due to unification related changes in national accounting. 1974=100.

Source: OECD (1998b); own calculations.

Table A1 – Descriptive Statistics of the Time Series

	Log of Real Compensation per Employee	Log of Real User Costs of Capital
Sample Space	1961:1 – 1994:4	1961:1 – 1994:4
GDP Deflator	1990 = 100	1990 = 100
Mean	9.24	2.67
Standard Deviation	0.35	0.26
Minimum	8.59	2.26
Maximum	9.74	3.19
ADF-Test I(0) ^a	-0.52	-0.94
ADF-Test I(1) ^a	-5.41	-7.46
^a Augmented Dickey Fuller Test. The statistic is the t-value of $(\rho-1)$. Critical values are taken from Davidson, MacKinnon (1993). $\Delta y_t = (\rho-1)y_{t-1} + \mu + \beta t + \sum_{i=1}^p \gamma_i \Delta x_{t-i} + \varepsilon_t.$		

Source: OECD (1998a); own calculations.

Table A2 – Estimation Results for the Unconditional Model

<u>Sample period</u>		
Effective sample	1973:4 – 1994:4	
Observations	85	
Degrees of freedom	78	
<u>Cointegration rank</u>	$H_0: r = 0$	$H_0: r = 1$
Maximum Eigenvalue ^a	19.97 (10.29)	6.99 (7.50)
Trace ^a	26.96 (17.79)	6.99 (7.50)
<u>Residuals</u>		
AR(1), LM-Test	$\chi^2(4) = 2.13$	
AR(4), LM-Test	$\chi^2(4) = 0.97$	
Normality, Shenton-Bowman Test ^b	$\chi^2(4) = 2.62$	
ARCHC, LM-Test	$\chi^2(3) = 5.28$	$\chi^2(3) = 6.19$
<u>Test for Weak Exogeneity, LR-Test</u>		
Real User Costs of Capital	$\chi^2(1) = 3.13$	
Real Compensation per Employee	$\chi^2(1) = 10.23$	

^aCritical values at the 10 percent level in parentheses. — ^bMultivariate version of the Shenton-Bowman test for normality (cf. Hansen and Juselius 1995: 27).
— ^cThe first test refers to the equation determining the first difference of the user costs of capital, the second test refers to the equation determining the first difference of the real wage index.

Source: OECD (1998a); own calculations.

Table A3 – Estimation Results for the Conditional Model

<u>Sample period</u>	Effective sample	1973:1 – 1994:4
	Observations	85
	Degrees of freedom	77
<u>Cointegration rank</u> ($H_0: r = 0$)	Maximum Eigenvalue ^a	16.84 (7.50)
	Trace ^a	16.84 (7.50)
<u>Residuals</u>	AR(1), LM-Test	$\chi^2(1) = 0.94$
	AR(4), LM-Test	$\chi^2(1) = 0.69$
	Normality (Shenton-Bowman Test ^b)	$\chi^2(2) = 1.39$
	ARCH (LM-Test)	$\chi^2(3) = 6.17$
	R ²	0.80
<u>Loading coefficient</u>		-0.02
<u>Cointegration Vector β c,d</u>	Log Real Compensation per Employee {1}	1
	Log Real User Costs of Capital {1}	0.47
	Constant	-10.89
<u>First differences</u> (<u>short-run</u>) ^c	Log Real Compensation per Employee {1}	1.06
	Log Real Compensation per Employee {2}	-0.37
	Log Real User Costs of Capital {0}	0.00
	Log Real User Costs of Capital {1}	-0.01
	Log Real User Costs of Capital {2}	0.02
^a Critical values at the 10 percent level in parentheses. — ^b Multivariate version of the Shenton-Bowman test for normality (cf. Hansen and Juselius 1995: 27). — ^c The figures in curly brackets indicate the lag. — ^d β has been normalised. The sign of the estimates in β are opposite to the theoretical results because of the ECM formulation.		

Source: OECD (1998a); own calculations.

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