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Market Forces and the Continent's Growth Problem

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This paper has the objective of providing a summary of some of the explanations proposed for the disappointing economic performance of many continental European economies. These will then be tested using data for the OECD countries. While this paper presents several departures, which by themselves are of interest, the goal specific to this paper is to investigate the degree to which the growth problem that has become manifest on the Continent can be ascribed to market forces or perhaps endowments rather than to a hypothesized deficiency in the dynamism of its system of economic institutions or its economic culture. To reach that goal, however, it is necessary to imbed the hypothesised market forces in a model that at the same time gives expression to the alternative hypotheses of innovational disabilities, disincentives and barriers.

The picture of growth drawn here is one of genuine innovations taking place in leading firms in different countries and these innovations then spreading to other domestic and foreign firms. I depart from standard endogenous growth models in emphasising the generation of new business ideas and the adoption of ideas generated elsewhere. In doing so, I leave out technical inventions such as the discovery of new and better inputs. This is not meant to diminish the role of such inventions but to emphasise that ideas about new applications of existing knowledge – whether new or old – play a crucial role in economic growth. In contrast technological breakthroughs occur infrequently in discrete jumps while business ideas are generated continuously, some stillborn while others raise productivity and improve welfare. The ability to screen ideas and weed out bad ones is central to the functioning of a dynamic capitalist economy.

Another departure from the endogenous growth literature is to assume that genuinely original ideas may not require much input – in the form of labour or capital – on behalf of the entrepreneur. Instead, individuals have different intuitions about how the world works and which ideas are likely to generate profits. We can refer to this individual-specific attribute as "latent knowledge" reflecting the accumulated experience, education, and lessons learned by individuals, as well as personal attributes and the quality and perspectives of his or her social circles. It follows that the generation of new ideas cannot be described by a production function with fixed and known probabilities of success. Instead, ideas sometimes come without much effort and most often have an unknown probability of success; carry uncertainty in the Knightian sense. In contrast, the adoption of ideas is less risky but may require individuals with certain skills, education and aptitudes for taking on the new ideas.

I start by describing the adoption of existing ideas and then turn to genuine entrepreneurship.

1. Imitation

Let B^* denote the number of successful world innovations, B_j the number of innovations transferred (adopted) and implemented by the leading local firm and A_i the number of innovations adopted and implemented by follower firms, indexed by the letter i, $i \neq 1$. By assumption innovations are carried out by entrepreneurs while managers alone are involved with the adoption and implementation of existing business ideas.

Assume that each firm is owned and operated by a manager who lives for two periods, works in the first period, consumes and saves and then retires and consumes when old. Moreover, assume that his utility is of the CRRA type with coefficient of relative risk aversion ρ.

1.1 Production

During the first period of the manager's two-period life he combines business knowledge A with his education E and inputs X – which could be labour or, alternatively, intermediate inputs such as oil – in producing output Y. For simplicity, we abstract from physical capital. The problem facing the manager is to choose the fraction of time η he spends on actual production using, existing knowledge A and his education, and the fraction 1-η spent studying, evaluating and adopting new ideas in order to maximise his lifetime consumption. The production function for firm i ($i \neq 1$), located in country j, has the Cobb-Douglas form and knowledge is Harrod neutral

$$Y_{ijt} = \left(\eta_{ijt} E_{ij} A_{ijt}\right)^{1-\alpha} X_{ijt}^{\alpha}. \tag{1}$$

Profits P can then be written as follows

$$P_{ijt} = \left(\eta_{ijt} E_{ij} A_{ijt}\right)^{1-\alpha} X_{ijt}^{\alpha} - w_x X_{ijt} \tag{2}$$

where w_x denotes the (real) price of the input. Profit maximisation yields the following first-order-conditions with respect to the use of inputs X

$$\alpha\left(\eta_{ijt} E_{ij} A_{ijt}\right)^{1-\alpha} X_{ijt}^{\alpha-1} = w_x \tag{3}$$

which gives a demand function for inputs:

$$X_{ijt} = \alpha^{\frac{1}{1-\alpha}} \eta_{ijt} E_{ij} A_{ijt} w_x^{-\frac{1}{1-\alpha}} \tag{4}$$

Combining equations (2) and (4) gives,

$$P_{ijt} = \Omega \eta_{ijt} w_x^{-\frac{\alpha}{1-\alpha}} E_{ij} A_{ijt} \tag{5}$$

where $\Omega = \alpha^{\alpha/(1-\alpha)} - \alpha^{1/(1-\alpha)}$. Profits are increasing in the knowledge and the education of the manager and decreasing in the price of the inputs.

When not producing, a manager spends his time exploring, learning and adopting new ideas on how to produce more efficiently. There are B-A locally unexploited ideas that can potentially be adopted by managers. However, not all ideas can be adopted in any given period due to information frictions. The matching function (6) gives the number of successful adoptions of unexploited ideas. The efficiency of this matching process is captured by the parameter Λ while education E determines the ability of managers to understand new ideas as in Nelson and Phelps (1966)

$$A_{ijt} - A_{ijt-1} = \Lambda_j \left(\left(1-\eta_{ijt}\right) E_{ij}\right)^{\beta_{dom}} G_{ijt}^{1-\beta_{dom}} \tag{6}$$

where $G_{ijt} = B_{jt} - A_{ijt}$ and $0 \leq \beta_{dom} \leq 1$. Inserting (6) into (5) gives,

$$P_{ijt} = \Omega \eta_{ijt} E_{ij} \left[A_{ijt-1} + \Lambda_j \left(1-\eta_{ijt}\right)^{\beta_{dom}} E_{ij}^{\beta_{dom}} G_{ijt}^{1-\beta_{dom}} \right] w_x^{-\frac{\alpha}{1-\alpha}} \tag{7}$$

We can now address the problem of allocating time between the two tasks performed within the firm that is producing or learning about new technologies. The first-order condition for profit maximization with respect to η follows

$$P_{ijt}/d\eta_{ijt} = \Omega E_{ij}\left[A_{ijt-1} + \Lambda\left(1-\eta_{ijt}\right)^{\beta_{dom}} E_{ij}^{\beta_{dom}} G_{ijt}^{1-\beta_{dom}} - \eta_{ijt}\Lambda_j\left(1-\eta_{ijt}\right)^{\beta_{dom}-1} E_{ij}^{\beta_{dom}} G_{ijt}^{1-\beta_{dom}}\right] w_x^{-\frac{\alpha}{1-\alpha}} = 0 \qquad (8)$$

Taking logs gives the following expression defining $\hat{\eta}$, the fraction of a manager's time spent producing

$$\hat{\eta}_{ijt} = \frac{1}{1-\beta_{dom}}\left[\log A_{ijt-1} - \log\Lambda_j - \beta_{dom}\log E_{ij} - (1-\beta)\log G_{ijt} - \log\left\{(1+\beta)\hat{\eta}_{ijt} - 1\right\}\right] \qquad (9)$$

This fraction depends on the level of knowledge *A*, the manager's education *E* and the size of the knowledge gap *G*. Taking the total differential of equation (9) shows that the fraction of time spent working η is increasing in the level of productivity *A* and decreasing in the level of education *E*, the gap *G* and the efficiency of the matching function Λ. The manager spends more time studying new ideas the more he has to learn (higher G), the easier it is to access new ideas (higher Λ), and the more able he is (higher *E*). It follows that the effect of backwardness (high G) is an increasing function of 1-β_{dom} – the elasticity of learning with respect to G – while the effect of education is increasing in β_{dom}.

1.2 Consumption

The imitator's income from learning and producing during the working life is P_i. He has to decide how much of this income to consume when young and how much to save for retirement. We assume that there is a world capital market where entrepreneurs borrow money from financial intermediaries to finance their prospective innovations and managers and successful entrepreneurs invest their savings to provide for retirement consumption. The world rate of interest r^* makes the supply of savings equal to the collective demand for capital by the world's entrepreneurs.

Each individual faces the common world rate of interest r^* when making saving decisions. Let θ denote the rate of pure time preference. The following equation – remember that utility is CRRA – then gives consumption when young Q_t^1 and when old Q_{t+1}^2:

$$\frac{\left(Q_{ijt}^{1}\right)^{-\rho}}{\left(Q_{ijt+1}^{2}\right)^{-\rho}}=\frac{1+r^{*}}{1+\theta} \quad (10)$$

The equation then defines a saving equation

$$S_{ijt}=s\left(P_{ijt},r^{*};\rho\right)P_{i} \quad (11)$$

for individual i. Note that both r^* and ρ are exogenous. It follows that savings S_i are monotonically increasing in profits P_i.

2. Entrepreneurship

New innovations are introduced through transfers to the leading firm – owned and operated by an entrepreneur, indexed by the number 1, with education E_1 and creativity C_1 – from abroad as well as genuine innovations I. For simplicity we assume that there is only one leading firm in each country. Since Bj denotes the number of innovations made or adopted by the leading firm, it follows that $B_{jt}=A_{1jt}$; that is the number of innovations adopted or created in country j equal the number of innovations adopted or created by the leading firm. Their number grows over time because of both the adoption of ideas from abroad as well as from genuine innovations;

$$B_{jt}-B_{jt-1}=\Lambda_{j}\left(\left(1-\eta_{1jt}\right)E_{1j}\right)^{\beta_{for}}G_{1jt}^{*1-\beta_{for}}+\ I_{jt}^{\mu}B_{t-1}^{*\nu} \quad (12)$$

where $G_{1j}^{*}=B_{t}^{*}-B_{1jt}$ is the gap between the best domestic firm and best practice abroad – the ideas in the world that have not yet been exploited (that is adopted) by the best local firm. The first term of equation (12) captures the learning from abroad, while the last term of the equation describes genuine innovations in country j where I_j is a continuous variable that denotes the number of entrepreneurial ideas that are successful at getting finance and B^* denotes the world productivity frontier. The equation implies that new ideas have a greater impact on productivity B the larger is the stock of accumulated knowledge B^*. The parameter ν describes the strength of this effect.

Finally, the world frontier moves out when genuine innovations take place in different countries:

$$B_t^* - B_{t-1}^* = \sum_j I_{jt}^{\mu} B_{t-1}^{*\nu} \qquad (13)$$

The entrepreneurial firm is also engaged in production and equations (1)-(9) describe its decisions – with *B* now denoting productivity instead of *A* – when it comes to allocating time between producing and adopting ideas from abroad.

Let us now turn to genuine entrepreneurship that takes place in leading firms in different countries. Assume that local financial intermediaries – banks from now on – have the capacity to finance F_j entrepreneurial projects in the country *j* – assuming that they are sufficiently profitable – and that the potential number of such projects is related to the creativity of the entrepreneur C_{1j}. In particular, assume that there are C_{1j} entrepreneurial projects or potential innovations. Each potential innovation consists of a genuinely novel business idea and hence embodies a distinct view of the relevant markets.

The potential innovations differ along two dimensions. First, the probability of success differs between projects. Take the genuine innovations that take place in country *j* that we have denoted by I_j. These innovations can then be indexed by τ so that $\tau \in [0, I_j]$. We let the variable *b* denote the probability of failure and the expected probability of failure of project τ is then denoted by b_{τ}^{e}. Second, the projects give entrepreneurs non-pecuniary benefits that also differ between projects. Some ideas are more fun to carry out than others. As a result entrepreneurs may be willing to go ahead with projects that offer a low expected monetary return.[1] In particular, we let the variable *u* denote the non-pecuniary benefit so that u_{τ} denotes the benefit from idea τ.

[1] Schumpeter (1911) wrote extensively on the non-pecuniary benefits and costs. Recently, Phelps (2006) has shown the non-pecuniary benefits to be necessary for the existence of equilibrium in the market for innovations. Moskowitz and Vissing-Jörgensen (2002) provide empirical support. They find investment in private equity to be very concentrated so that households with entrepreneurial equity invest on average in excess of 70 percent of their assets in a single company where they have a management interest. However, they find that in spite of this lack of diversification, the average annual return to private equity is no higher than the market return on public equity. This finding suggests that there may be substantial non-pecuniary gains from investing in private equity, which often comes to entrepreneurship. Hamilton (2000) found similar results.

Financing of the different innovations is contingent on the entrepreneur finding a like-minded banker when it comes to the expectations about the probability of success of individual projects. The number of such matches *M* is given by the following equation

$$M_j = \Gamma_j C_{1j}^{\eta} F_j^{1-\eta} \tag{14}$$

where Γ is a measure of the efficiency of the financial system. However, it is not sufficient to find a like-minded banker, the expected return from the idea has to cover the required rate of return, determined by the exogenous world rate of interest. The value of a successful project to the entrepreneur – that is one that does not fail – stems from its expected contributions to profits, which analogous to equation (2) can be written as

$$P_{1jt} = \left[\eta E_{1j}\left(B_{1jt-1} + \Lambda_j\left(\left(1-\eta_{1jt}\right)E_{1j}\right)^{\beta_{for}} G_{1jt}^{*1-\beta_{for}} + \; I_{jt}^{\mu} B_t^{*\nu}\right)\right]^{1-\alpha} X_{1jt}^{\alpha} - w_x X_{1jt} \tag{15}$$

Solving for *X* and substituting back into (15) gives an equation that is analogous to (7);

$$P_{1jt} = \Omega \eta E_{1j}\left(B_{1jt-1} + \Lambda_j\left(1-\eta_{1jt}\right)^{\beta_{for}} E_{1j}{}^{\beta_{for}} G_{1jt}^{*1-\beta_{for}} + \; I_{jt}^{\mu} B_t^{*\nu}\right) w_x^{-\frac{\alpha}{1-\alpha}} \tag{15'}$$

From equation (15') it follows that the payoff to the entrepreneur from a successful innovation is measured by the derivative of (15')

$$dP_{1jt}/dI_{jt} = \mu \Omega \eta_{1jt} E_{1j} I_{jt}^{\mu-1} B_{t-1}^{*\nu} w_x^{-\frac{\alpha}{1-\alpha}} \tag{16}$$

The total return from a marginal project τ – if financed – can then be written as $dP_{1jt}/dI_{jt} + u_{\tau}$. The interest paid by the entrepreneur is innovation specific, in particular the bank receives r_{τ} if it finances a project τ. When the entrepreneur has found a like-minded banker who is potentially willing to finance his project, the two have to decide on the terms of their transaction. The interest payment is, by assumption, determined such that the surplus from a successful match between an entrepreneur and a bank is split evenly

$$V_{\tau}^{E} = V_{\tau}^{B} \tag{17}$$

where V_{τ}^{E} – how much the entrepreneur values the match – and V_{τ}^{B} – how much the bank values it – are given by equations (18) and (19) below

$$\left(1+r^*\right)V_{\tau}^{E} = \left(1-b_{\tau}^{e}\right)\left[P_I + u_{\tau} - r_{\tau}\right] \tag{18}$$

$$\left(1+r^*\right)V_{\tau}^{B} = \left(1-b_{\tau}^{e}\right)r_{\tau} \tag{19}$$

where r^* is the world rate of interest and b^e denotes the probability that he project fails.[2] This gives the following solution for the interest charged:

$$r_\tau = \frac{1}{2}\left[dP_{1jt}/dI_{jt} + u_\tau\right] \tag{20}$$

The number of projects financed is then determined by the condition

$$\left(1-b_\tau^e\right)r_\tau = \frac{1}{2}\left(1-b_\tau^e\right)\left(P_{1jt}/dI_{jt} + u_\tau\right) \geq 1 + r^* \tag{21}$$

which implies a lower bound on the sum of the pecuniary and the non-pecuniary benefit from a project to the entrepreneur:

$$P_{1jt}/dI_{jt} + u_\tau \geq 2\frac{1+r^*}{1-b_\tau^e} \tag{21'}$$

Denote the fraction of all entrepreneurial projects that fall below this critical level by $H\left(r^*, E_{1j}, w_x, B^*\right)$. It follows from (14) and (21) that the number of projects financed is

$$I_j = \left[1 - H\left(r^*, E_{1j}, w_x, B^*\right)\right]\Gamma_j C_{1j}^\eta F_j^{1-\eta} \tag{22}$$

The number of projects financed is increasing in the creativity of the entrepreneur C_{1j} – which determines the number of ideas that he has – increasing in the supply of loans by the banking system F_j, increasing in the efficiency of the matching process between banks and entrepreneurs Γ_j and, finally, increasing in the share of all entrepreneurial projects that offer pecuniary and non-pecuniary benefits above the critical level demanded by banks' required rate of return. From equation (16) and (21) it follows that this is increasing in the world frontier B^*; decreasing in the cost of the input w_x and the required rate of return r^*; and increasing in the level of education E_1. Finally, an equation analogous to equation (10) describes the entrepreneur's savings decision, which shows how he divides the income from producing, learning and inventing between his two periods.

3. Market forces and economic performance

The rate of productivity growth depends on a multitude of market and institutional variables. We can distinguish between domestic and world factors. Combining equations (6), (12) and (22) gives equation (23) below

[2] Dunne et al. (1988) used the Census of Manufacturers to calculate that on average 61.5 percent of firms disappear in their first five years and 79.6 percent in the first ten years.

$$A_{ijt} - A_{ijt-1} = \Lambda_j \left[\left(1 - \eta_{ijt}\right) E_{ij} \right]^{\beta_{dom}} \left\{ B_{jt-1} - A_{ijt-1} \right\}^{1-\beta_{dom}} \qquad (23)$$

where

$$B_{jt-1} = B_{jt-2} + \Lambda_j \left[\left(1 - \eta_{1jt-1}\right) E_{1j} \right]^{\beta_{for}} \left(B_{t-1}^{*} - B_{jt-1} \right)^{1-\beta_{for}} + \left(\left(1 - H\left(\bullet\right)\right) \Gamma_j C_{1j}^{\eta} F_j^{1-\eta} \right)^{\mu} B_{t-1}^{*\nu}$$

An improvement in the performance of domestic *financial institutions* – embodied in an increase in the value of the parameter Γ in equation (23) – will increase the number of matches between like-minded entrepreneurs and the suppliers of funds, which will raise the rate of growth of leading productivity in the country which then makes average productivity A grow. The impact on growth will then depend on the fraction of projects deemed sufficiently profitable or providing sufficient non-pecuniary benefits to receive financing by banks.

A positive domestic shock could also take the form of an improvement in the *expected profitability of innovations*; higher non-pecuniary benefits from embarking on new entrepreneurial projects; and an improvement in the creativity or the level of education of entrepreneurs. The effect of this change would then depend on the efficiency of financial institutions, embodied in the parameter Γ; only with financial institutions that are able to match entrepreneurs and like-minded financiers do these positive developments have an effect on growth.

The price of inputs w_x can measure factors such as the effect of labour unions, employment protection and other labour market regulation – i.e. all factors that raise the cost of labour as an input. Increased labour market rigidities can then be shown to have the effect of reducing the expected profitability of innovations with consequences described above; fewer entrepreneurial projects will be financed and carried out and growth of leading productivity will fall.

Education has a positive effect on productivity growth. General educational improvements facilitate learning from the best local firm, as well as learning by the leading firm from foreign firms. Finally, education raises the expected profitability of new entrepreneurial projects and hence has the effect of raising the proportion of projects that receive financing from the banks.

A rise in the price of oil could be modeled as a rise in the price of inputs w_x. An increase in this price will reduce the expected profitability of new technologies and lower the rate of productivity growth. The effect of an increase in *interest rates* r^* is somewhat more complicated. If world interest rates rise because of a fall in world savings, the consequence would be fewer projects receiving finance. If, in contrast, the increase was caused by a rise in the world level of entrepreneurial activity, then the effect would be more complex; the world theoretical level of productivity B^* would advance – increasing the rate of learning from abroad – but higher interest rates would mean some local entrepreneurs would have their projects turned down.

4. Empirical tests

4.1 The data

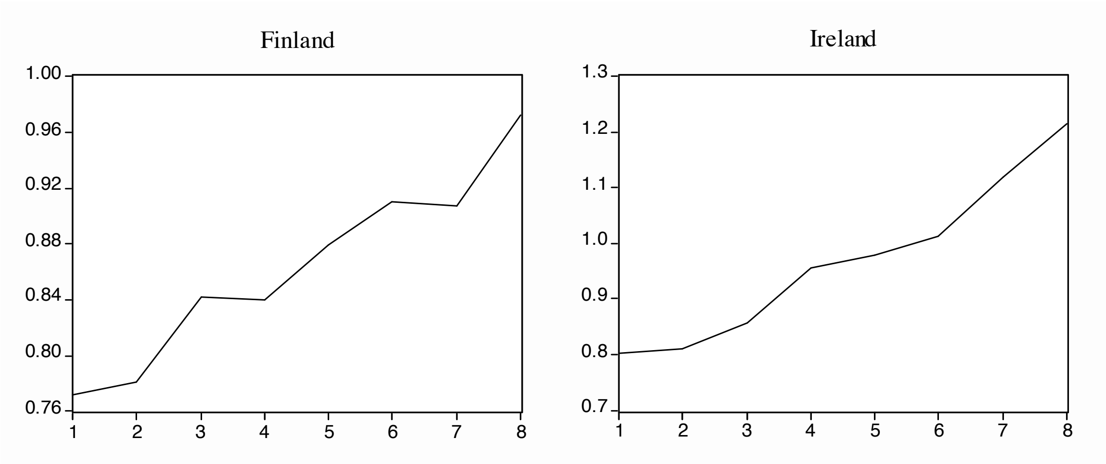
Productivity A is calculated as total factor productivity from a Cobb-Douglas production with capital and employed labour as factors of production.[3,4] I use five-year period averages in order to remove business cycle frequencies from the data. They are 1960-64, 1965-69, 1970-1974, 1975-1979, 1980-84, 1985-89, 1990-94 and 1995-1999.

The figure below shows our calculated productivity measure for the good performers Finland and Ireland. The horizontal axis has the eight periods, numbered from 1 to 8. The vertical axis shows the ratio of own TFP to the weighted average of TFP in the 18 countries in the sample (country GDP used as weights). In both cases we witness a dramatic catching up. This is the best consistent performance in our sample.

[3] Countries included are: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Greece, Ireland, Italy, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the U.K.

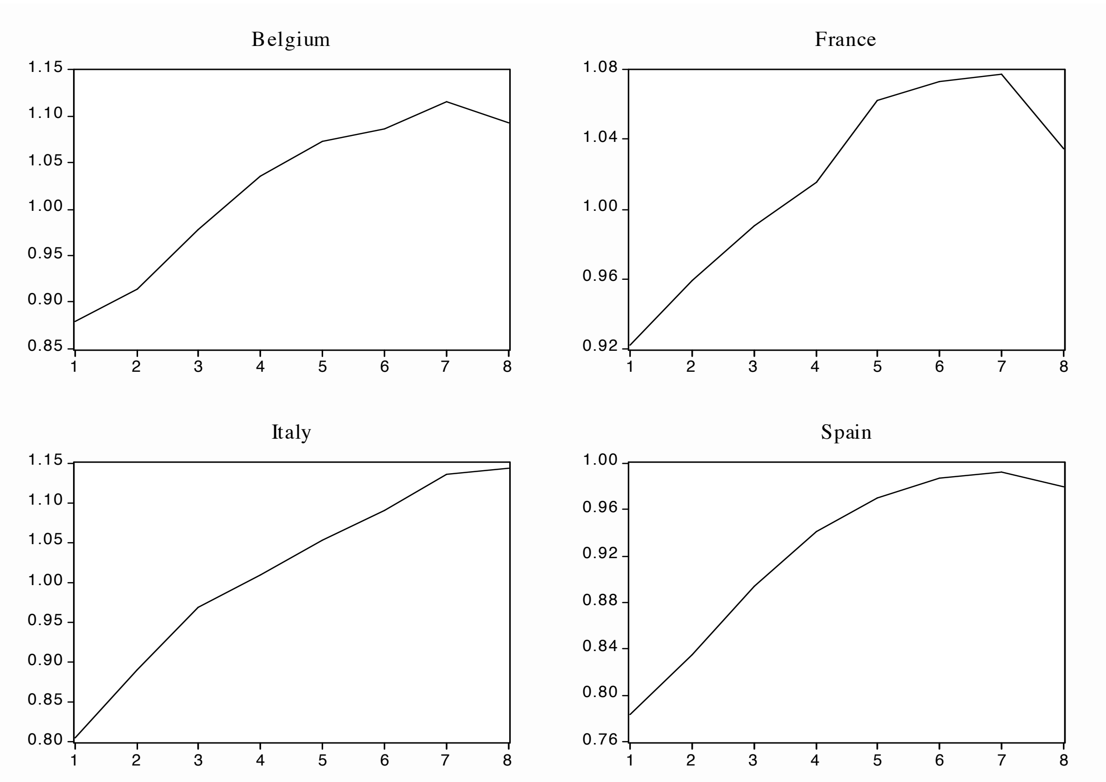
[4] The capital stock series is calculated using the perpetual inventory method assuming a 6% depreciation rate. The value of the stock of capital in year 1949 is first calculated by assuming a steady state in a neoclassical growth model with depreciation 6% and a growth rate that equals the average rate of growth of output between 1950 and 1960. The capital stock series 1951-2000 is then calculated using investment data and the assumed depreciation rate. Finally, the total factor productivity series are derived annually from 1960 to 2000 assuming that labour's share of output is 0.7.

Figure 1. Relative total factor productivity – star performers



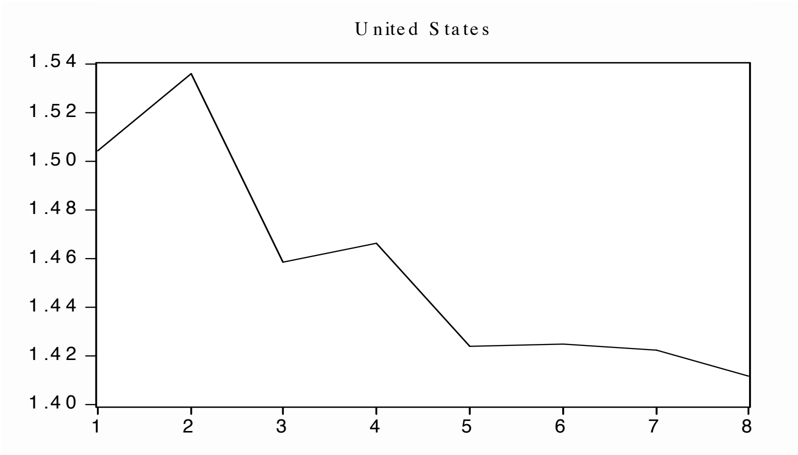
The Continental European economies did experience rapid productivity growth in the 1960s but this slowed down in the 1970s and 1980s and ended in the 1990s as shown in the figure below.

Figure 2. Relative total factor productivity – Continental Europe



The US experience, in contrast, involves falling relative productivity in the 1960s and 1970s while keeping its lead in the 1980s and 1990s.

Figure 3. The United States



We are interested in explaining the different productivity performances in light of the model of Sections 1 and 2. An equation will be estimated using observations for the eight periods, the first one being 1960-1964 and the last one 1995-1999.

The variables included in the equation are taken from Sections 1 and 2 above. They fall into four groups: demographic variables, labour market institutions, financial market institutions, and macroeconomic variables.[5]

The demographic variables include the fraction of the population with some tertiary education and the share of prime-aged adults of total population. Education determines the ability of managers to adopt new technologies and the ability of entrepreneurs to emulate the best overseas ideas. The size of the prime-aged workforce is also important in that the more people there are producing, imitating and innovating, the greater the rate of growth.

The labour market variables include an OECD index of employment protection, a measure of the coordination of unions and employers and union membership as a share of the labour force. Employment protection, union coordination and union membership can be thought of as affecting the cost of inputs w_x in the model in Sections 1 and 2. An increase in this variable reduces the profitability of new entrepreneurial projects and hence the number of innovations taking place. However, this does not affect the way managers share their time between production and

[5] See appendix for a description of variables and their sources.

imitation. Hence, these labour market rigidities would be expected to affect growth when we approach the productivity frontier A^* but less when we are far from it. The financial markets variables include deposits (commercial and savings) as a ratio to GDP; the number of listed companies per million inhabitants; and the amount of funds raised through public equity offerings by domestic companies as a ratio to gross fixed investment. The first enters through the supply of capital F in Section 2. More capital implies that more projects will be financed. The number of listed companies and the share of capital that is raised though the issuing of equity is meant to proxy for capital market development. This could be expected to affect the efficiency of the matching process, captured by the parameter Γ in the model above. In the model, financial market development and the supply of loans should become more important as we approach the frontier.

Finally, we have two macroeconomic variables: the real price of oil and the world real rate of interest (weighted real interest rates in G7). An increase in the price of oil would reduce profits through the w_x variable and hence the number of entrepreneurial innovations. An increase in world interest rates could be expected to raise the required rate of return r^* in the model, which would also lower the number of innovations. In the model these effects become more important the closer we get to the frontier B^*. However, the rise of r^* could be caused by an increase in worldwide entrepreneurial activity, which would affect the frontier and the rate of learning.

4.2 Regression analysis

Empirically we are not able to measure productivity in each country's leading firm separately from average productivity. We follow Vandenbussche, Aghion and Meghir (2004) in using average total factor productivity as a measure of country productivity A and then use US average total factor productivity as a measure of frontier productivity B^*. In terms of the equations in the model of Sections 1 and 2, the assumption that US average productivity – which we can label by A^* – is a good proxy for the world productivity frontier – is tantamount to assuming that all innovations take place in the US and/or that those innovations that take place elsewhere are instantly adopted by US firms. Assuming instant adoption by the US of world innovations and instant adoption internally from the local leader, equations (6) and

(13) can be rewritten so as to capture the growth of average productivity *A* in different countries;

$$A_{ijt} - A_{ijt-1} = \Lambda_j \left(\left(1-\eta_{jt}\right) E_j\right)^{\beta_{for}} \left(A_t^* - A_{jt}\right)^{1-\beta_{for}} + I_{jt}^{\mu} A_t^{*\nu} \qquad (6')$$

$$A_t^* - A_{t-1}^* = \sum_j I_{jt}^{\mu} A^{*\nu} \qquad (13')$$

where it is assumed that the education of the entrepreneur is equal to the education of a manager of the average firm and that both devote the same proportion of their time to production: E_i=E_l and η_l=η_l. The equations imply that some variables – as discussed in Section 4.1 – affect convergence to the frontier *A** while others have an effect independent of the distance from the frontier.

Instead of estimating the equations above directly, I will test for the convergence/innovation effect of different variables by interacting the many right-hand side variables with the productivity gap between each country and the United States.[6] Denote average productivity in country *j* by *A*, US – or frontier – productivity by *A** and then use *Z* to denote any of the variables that may have an effect on growth. The estimated equation will then take the following form:

$$\begin{aligned}\log A_{j,t} - \log A_{j,t-1} &= \alpha_{0,j} + \alpha_1 \left(\log A_{t-1}^* - \log A_{j,t-1}\right) \\ &\quad + \alpha_2 Z_{j,t-1} + \alpha_3 \left(\log A_{t-1}^* - \log A_{j,t-1}\right) Z_{j,t-1} + \varepsilon_{j,t}\end{aligned} \qquad (24)$$

Note that the estimated coefficients of *Z* in the equation will be a linear function of the productivity gap between country *j* and the US, which can be written as follows for element *x* of vector *Z*:

$$\hat{\alpha}_x = \hat{\alpha}_2 + \hat{\alpha}_3 \left(\log A_{t-1}^* - \log A_{j,t-1}\right)$$

It follows that the sign and significance of α_3 tells us whether the effect *Z* has on productivity growth becomes smaller or larger when the productivity gap is closed. In particular, a positive sign of α_3 tells us that the term is important when country *j* is far from the productivity frontier while a negative sign implies that its importance grows as we come closer to the frontier.[7]

[6] The empirical equation is similar to that of Vandenbussche, Aghion and Meghir (2004).

7 Philippe Aghion, in cooperation with several co-authors, has estimated an equation of this kind for a range ofl variables, such as tertiary education, the degree of competition, openness to trade and financial market development. They find that in the case of education α3<0, which implies that the

Estimating equation (24) imposes a restriction on the data, which is that the numerical value of the coefficient of own productivity is made to equal the coefficient of US productivity. Instead of imposing the restrictions to begin with, I estimate the unrestricted version and then test for the restriction and only impose it if it is not rejected. Thus, my estimated equation is the following:

$$\log A_{j,t} - \log A_{j,t-1} = \alpha_{0,j} + \alpha_1 \log A^*_{t-1} + \alpha_2 \log A_{j,t-1} + \alpha_3 Z_{j,t-1} + \alpha_4 \log A^*_{t-1} Z_{j,t-1} + \alpha_5 \log A_{j,t-1} Z_{j,t-1} + \varepsilon_{j,t} \qquad (25)$$

The (Wald) tests would then test the hypotheses $\alpha_1 = -\alpha_2$, $\alpha_4 = -\alpha_5$. We proceed by adding one variable at a time to the empirical equation. Each explanatory variable is first added in levels, and then as a product of A^* and A. In the first column we report results of the estimation when productivity growth is only explained by lagged own productivity (A) and lagged productivity in the US (A^*). We then add in column (2) the fraction of the population with some university education and in column (3) the share of the population between 15 and 64. In columns (4)-(6) we add the three labour-market variables; employment protection, coordination and unionization and then, finally, columns (7)-(9) have the capital market variables added; deposits (ratio to GDP) which provides a measure of the size of the banking system; the number of listed companies (per million inhabitants) which measures the development of the stock markets; and stock market capitalisation (as a share of GDP) which provides an alternative measure of the development of the stock market. Finally, we add the two global macroeconomic variables in columns (10) and (11). These are the world real rate of interest (average of real interest rates in the G7 countries) and the world real price of oil.

A time dummies is added in column (12) that takes the value 1 for the eighties and nineties and zero for the sixties and seventies. This turns out not to affect the results profoundly. The one notable change is the reversal of the sign of the interest rate

importance of education grows, as we get closer to the productivity education. Their hypothesis is that while imitation – what countries do far from the frontier – is intensive in less skilled labour, innovation – what countries have to do when they have closed the productivity gap – is intensive in skilled labour, i.e. individuals with university education. In contrast, financial market development is particularly important when a country finds itself far from the productivity frontier. In that case there are large gains to be expected from the adoption of new ideas. Financial market underdevelopment can slow down the rate of technological adoption while a technologically backward country that enjoys relatively developed financial markets can expect rapid growth and convergence.

coefficient. In column (13) we test for the equality of the numerical value of the terms multiplying A and A^*, i.e. whether it is only the gap in productivity that matters for the growth effect of the different variables or whether the levels of productivity matter as such. This homogeneity restriction is often rejected.

Unfortunately, Table 1 is characterized by a general lack of robustness for most variables. However, there are some significant, fairly robust, coefficient estimates. First and foremost, there is a significant positive effect of university education on growth.[8] The interaction term between education and US (frontier) productivity has a negative coefficient, which implies that the effect is decreasing in the level of frontier productivity. In contrast, the interaction term with own productivity has an insignificant coefficient.

Union density appears with a significantly negative coefficient. The interaction terms suggest that this effect becomes more pronounced the closer a country gets to the frontier. So unions lower the rate of productivity growth, both away as well as close to the frontier, but especially close to the frontier when innovations are needed. This is also consistent with the model above, in that stronger unions can increase costs, which reduces the profitability of innovations. Coordination of unions helps growth – which is taken to measure the extent to which they take the macroeconomic effect of their actions into account when bargaining – and the effect gets stronger the closer we approach the frontier.

Stock market capitalisation has a positive significant coefficient that becomes larger the higher is our own productivity. The same applies to the number of listed companies.[9] Higher oil prices appear to raise productivity growth, while higher interest rates reduce it. An anomaly is the negative coefficient of the share of the population between the ages of 15 and 64.

[8] The relationship between education and growth was described in Nelson and Phelps (1966). Recent contributions include Benhabib and Spiegel (1994) who find that the initial level of schooling affects subsequent growth in the poorest segment of the sample (non OECD!). In contrast, Temple (1999) finds support for the Lucas model when controlling for outliers. Engelbrecht (2001) finds support for both Lucas and Nelson-Phelps in OECD data when controlling for outliers. Vandenbussche, Aghion and Meghir (2004) find that education is better for innovation than imitation; its importance grows as a country approaches the productivity frontier.

[9] In this case we calculate the total effect by adding up the three estimates in the table, the level effect and the two interaction terms.

Table 1. Results from the estimation of equation (25)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	Wald
Constant	0.21	1.48**	6.28*	6.82**	6.80**	4.69*	10.62	13.43	35.74	35.06**	-53.30*	-766.89**	
	(0.45)	(2.42)	(1.83)	(2.31)	(2.36)	(1.98)	(1.11)	(1.31)	(2.45)	(3.12)	(1.73)	(2.95)	
A*	0.26**	0.01	-1.15	-1.42*	-1.51*	-1.07*	-2.48*	-1.88	-6.95	-3.90	8.64	106.00**	3.13*
	(2.19)	(0.07)	(1.25)	(1.74)	(1.84)	(1.66)	(1.85)	(0.80)	(2.20)	(1.30)	(1.52)	(2.89)	
A	-0.30**	-0.22**	0.34	0.56	0.64	0.48	1.10*	0.07	2.28	-0.81	-1.43	-2.33	
	(4.33)	(2.52)	(0.67)	(1.18)	(1.33)	(1.25)	(1.75)	(0.06)	(1.59)	(0.44)	(0.63)	(0.93)	
Schooling		-0.05	-0.04	-0.04	-0.05	-0.01	0.04	0.14	0.26	0.17*	0.23**	0.30**	
		(0.86)	(0.66)	(0.75)	(0.99)	(0.15)	(0.87)	(1.00)	(2.47)	(1.93)	(2.75)	(4.42)	
School.*A*		0.01	0.004	0.01	0.01*	0.01	-0.003	-0.02	-0.04	-0.02	-0.02*	-0.03**	8.18**
		(1.16)	(0.50)	(1.01)	(1.68)	(0.93)	(0.30)	(0.80)	(2.05)	(1.16)	(1.54)	(2.29)	
School.*A		-0.01**	0.001	-0.004	-0.01	-0.01**	-0.003	0.001	0.01	-0.004	-0.01	-0.01	
		(2.21)	(0.24)	(1.15)	(2.59)	(3.09)	(0.50)	(0.09)	(1.00)	(0.60)	(0.86)	(1.03)	
Prime age			-0.08	-0.09*	-0.07	-0.02	-0.13	-0.16	-0.60	-0.41*	-0.60**	-0.53**	
			(1.33)	(1.69)	(1.17)	(0.43)	(0.82)	(0.85)	(2.21)	(1.97)	(3.02)	(2.40)	
Prime*A*			0.02	0.02	0.01	0.004	0.03	0.03	0.14	0.06	0.07	0.05	10.45**
			(1.25)	(1.47)	(0.88)	(0.32)	(1.50)	(0.71)	(2.27)	(1.16)	(1.17)	(0.74)	
Prime*A			-0.01	-0.01	-0.004	-0.001	-0.02	-0.01	-0.06	-0.01	0.01	0.02	
			(1.13)	(1.18)	(0.54)	(0.18)	(1.36)	(0.45)	(2.19)	(0.17)	(0.18)	(0.45)	
EPL				0.27	0.40	-0.12	-1.27	-1.45**	-0.54	0.02	-0.22	0.28	
				(0.50)	(0.49)	(0.18)	(1.27)	(2.52)	(1.32)	(0.04)	(0.30)	(0.47)	
EPL*A*				0.07	0.07	0.07	0.16	-0.18	-0.31	-0.07	-0.14	-0.24	0.18
				(0.74)	(0.50)	(0.61)	(0.62)	(0.49)	(1.36)	(0.28)	(0.49)	(1.05)	
EPL*A				-0.12**	-0.14**	-0.06	0.01	0.40	0.41	0.07	0.18	0.21	
				(3.23)	(3.13)	(1.36)	(0.09)	(1.22)	(2.04)	(0.34)	(0.86)	(1.29)	

Table 1 continued.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	Wald
Coord					-0.75	1.01**	1.88*	3.36**	3.92	3.63**	3.39**	2.83**	
					(1.39)	(2.01)	(1.80)	(2.38)	(2.30)	(2.92)	(2.08)	(2.18)	
Coord*A*					0.23**	-0.10	-0.29	-0.70**	-1.01	-0.88**	-0.84**	-0.77**	
					(2.35)	(1.16)	(1.20)	(2.88)	(3.18)	(2.91)	(2.17)	(2.40)	4.40**
Coord*A					-0.14**	-0.04	0.03	0.26**	0.50	0.41**	0.40*	0.41**	
					(3.80)	(1.10)	(0.26)	(2.86)	(3.30)	(2.33)	(1.84)	(2.35)	
Density						-0.11**	-0.09**	-0.15**	-0.15	-0.10**	-0.11**	-0.11**	
						(4.88)	(3.22)	(3.89)	(3.61)	(2.73)	(2.77)	(3.42)	
Density*A*						0.02	0.02**	0.04**	0.03	0.02*	0.03**	0.03**	7.47**
						(5.28)	(2.40)	(3.81)	(2.92)	(1.87)	(2.56)	(3.80)	
Density*A						-0.01**	-0.01	-0.02**	-0.01	-0.01	-0.01*	-0.01**	
						(4.88)	(1.28)	(3.38)	(1.82)	(0.93)	(1.90)	(3.39)	
Deposits							-1.41	-1.80	1.27	-2.39	0.57	2.85	
							(0.96)	(0.57)	(0.47)	(1.69)	(0.30)	(1.64)	
Deposits *A*							0.35	0.52	0.07	0.57**	0.26	-0.12	
							(1.37)	(1.10)	(0.20)	(2.12)	(0.59)	(0.29)	0.12
Deposits *A							-0.16	-0.29**	-0.25	-0.26	-0.34*	-0.27	
							(1.36)	(2.44)	(1.27)	(1.50)	(1.61)	(1.25)	
Listed								-0.03*	-0.03	-0.02	-0.03**	-0.04**	
								(1.92)	(1.61)	(1.39)	(2.01)	(2.71)	
Listed*A*								-0.002	0.002	0.002	0.001	0.000	
								(0.35)	(0.64)	(0.31)	(0.27)	(0.25)	3.82*
Listed*A								0.01	0.000	0.001	0.004	0.004	
								(1.27)	(0.11)	(0.30)	(1.08)	(1.31)	

Table 1 continued.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	Wald
Smcap.									-1.46	0.34	-1.38	-2.20**	
									(1.16)	(0.48)	(1.28)	(2.06)	
Smcap..*A*									0.02	-0.20**	-0.02	0.10	1.65
									(0.09)	(2.42)	(0.13)	(0.66)	
Smcap..*A									0.182	0.15**	0.21	0.20**	
									(1.96)	(2.11)	(1.93)	(2.41)	
Oil										-27.57**	192.61**	1832.14**	
										(2.56)	(3.47)	(3.11)	
Oil*A*										3.47**	-26.28**	-248.00**	12.00**
										(2.28)	(3.48)	(3.11)	
Oil*A										0.27**	0.23**	0.22**	
										(3.10)	(4.58)	(3.63)	
Interest											1.24	-7.07**	
											(0.79)	(2.09)	
Interest*A*											-0.14	1.03	0.59
											(0.65)	(2.07)	
Interest*A											-0.02	-0.02	
											(0.89)	(0.62)	
R-squared	0.79	0.79	0.76	0.82	0.85	0.85	0.94	0.94	0.97	0.97	0.97	0.96	

Estimation method. Panel estimation with fixed (country) effects and White heteroskedasticity-consistent covariance matrix. t-statistics in parentheses. Two stars indicate significance at 5% level (rejection of homogeneity restriction in Wald test) and one star indicates significance at 10% level.

When looking for a culprit to explain the difference between the productivity performance of some of the good performers – such as Finland, Ireland and the US – and the bad performers on the Continent – Belgium, France, Italy and Spain – we are drawn to rely on differences in the level of university education, in the size and behavior of unions, and the development of the stock market

Table 2. Institutional differences (data applies to 1990)

	Schooling	Density	Coordination	Stock market capitalisation
	%	%	Index, 1-3	%
Good performers				
Finland	15.4	76	2.38	*
Ireland	14.6	51	2.75	*
U.S.	45.2	16	1	0.54
Bad performers				
Belgium	13.3	52	2	0.31
France	11.4	10	1.92	024
Italy	9.0	40	1.95	0.13
Spain	8.4	18	2	0.41

Union coverage is much higher in France and Spain than the density numbers would suggest.

In sum, university education, labour market flexibility and well-developed stock markets appear to be most conducive to productivity growth.

5. Concluding remarks

Business innovations play a fundamental role in economic growth. However, traditional models of endogenous growth emphasize technical innovations. This paper is an attempt to focus on the process of growth through business innovations and to study the role institutions play in this regard. Two aspects of a capitalist economy turned out to play a prominent role. First, the ability of managers to study, understand and adopt innovations already adopted by the local leader – and also the ability of the local leader to learn from foreign business practices – and, second, the creativity of local entrepreneurs and the ability of the local financial system to separate good from bad business ideas.

The empirical results are noteworthy for their lack of robustness. However they do suggest that tertiary education is important for productivity growth; that unions are detrimental to growth, especially when they are not coordinated; and that stock market development is good for growth. The laggard economies on the European continent tend to share the three attributes of having a comparatively small share of their population with university education, strong unions that do not take the macroeconomic effects of their actions sufficiently into account and less developed stock markets as measured by stock market capitalisation.

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Appendix

The Data

Productivity	TFP calculated using data on investment, labour force, participation and unemployment rate and assuming a factor share of 0.7 for labour.	Penn World Tables
Demographics		
Schooling	Fraction of population with some tertiary education (%).	Barro and Lee (2000)
Prime age	Prime aged adults as a share of total population (%).	OECD
Labour market institutions		
Employment protection	Index of employment protection (0-2).	OECD
Coordination	The coordination of union and employers (1-3).	OECD
Union density	Share of employed workers that belong to a labour union (%).	OECD
Financial markets institutions		
Deposits	The ratio of commercial and savings deposits to GDP	Rajan and Zingales (2001)
Stock market capitalization	Ratio to GDP.	Rajan and Zingales (2001)
Number of listed companies	Per million inhabitants.	Rajan and Zingales (2001)
Fraction of fixed capital formation raised via equity	Amount of funds raised through public equity offerings by domestic companies divided by gross fixed capital formation.	Rajan and Zingales (2001)
Macroeconomic variables		
Oil prices	The real price of oil	Andrew Oswald (webpage)
Real interest rates	The average real rate of interest in the G7 (GDP used as weights) (%).	IMF and Penn World Tables