A Primer on Innovation and Growth

Philippe Aghion (Harvard University and Bruegel)

October 2006

Introduction

Over the last ten years, the average annual growth of GDP per capita in the EU15 has been 0.4 percentage points below that of the US. The gap may not seem large, but cumulated over long periods, such small gaps end up producing large differences in income per capita. Furthermore, this gap indicates that, in sharp contrast with the previous decades where per capita GDP growth was much higher in Europe than in the US, in the last decade income per head in the EU has begun to decline in comparison to that of the US.

Against this background, the revival of growth and productivity has understandably become an overriding priority of European policymakers. But how can we explain this change of fortune and reverse the trend? Classical growth theories do not have much to tell us on this question. Indeed these theories emphasise capital accumulation and savings rates as the engines of growth. However, in spite of the US investment revival of the last fifteen years, both the capital-labour ratio and the investment rate are still higher in Europe than in the US. Europe may need to renew its capital stock, but it is hard to claim that its growth performance primarily results from underinvestment in physical capital.

An alternative explanation, which underlies the so-called Lisbon Agenda, is that Europe has not invested enough in research and development (R&D) nor in the knowledge economy. As a result, the region has not been able to take full advantage of recent technological revolutions, particularly in information and telecommunications. The Lisbon objectives in this respect are far from being met and high sustainable growth still remains a challenge for EU countries. But why is it that technology and R&D have suddenly become so important?

Another frequently mentioned possibility is that Europe has failed to reform overregulated labour and product markets. There is indeed a sharp contrast between the US and the EU countries in terms of product and labour markets regulation, but again, this contrast has been there for a long time – it was already apparent when Europe was growing much faster than the US.

Finally, macroeconomic policy is sometimes blamed for being too restrictive. But while there have been episodes of fiscal consolidation and monetary tightness, the overall policy has not been overly restrictive in recent years.

There is, therefore, a puzzle about the deterioration of Europe's growth performance. The purpose of this note is to identify the main reasons for this deterioration and to suggest ways to reverse it.

Why innovation has become a necessity for EU countries

In 1945, Europe's stock of physical capital had been largely destroyed and its technological knowledge, as reflected by its average level of per capita GDP, was far behind the per capita GDP in the US. So, at that time, what Europe needed to do to grow was essentially to accumulate capital and to imitate or adapt technological innovations made elsewhere. And this is what Europe did quite successfully during the *trente glorieuses*, with the support of economic institutions and policies that were adapted to those goals, in particular: limited competition in the product market; large firms financed by banks and by government subsidies; educational systems emphasising primary, secondary, and specialised undergraduate education; and rigid labour markets that favoured the accumulation of experience within firms over mobility across firms.

However, by the late 1980s, the advanced European countries had largely caught up with the world's best performers in terms of the capital-labour ratio and productivity levels: they were reaching the world technology frontier. This in turn implied that Europe had largely exhausted capital accumulation and technological imitation as its main sources of growth, and had to turn to an alternative source, namely innovation; that is, the ability for firms and workers to move rapidly into new activities or to improve production processes.

In the meantime, the IT revolution resulted in a revival of US growth in the late 1980s and early 1990s. Since Europe did not have the institutions and policies to benefit from this new technological revolution, the result was a reversal of Europe's approach to the frontier.

A first way to foster innovation is thus to invest more in R&D. As we all know, EU15 countries have been investing, on average, about 1.9% of their GDP in R&D in the last decade, against 2.6% in the US. That R&D investment becomes more essential when industries move closer to their technological frontier is evident when one analyzes the relationship between the distance to the frontier and R&D intensity at the industry level.

Some industries are evidently more R&D intensive than others. But, in fact, R&D intensity increases in *all* industries when an economy gets closer to the technological frontier, because the survival and growth of *all* industries in a high-cost, high-productivity economy depends on their ability to innovate. Thus, for example, pharmaceuticals are more R&D intensive than clothing, but both sectors are more R&D intensive in a developed economy than in a catching-up economy (Box 1).

BOX 1: Proximity to the technological frontier and R&D intensity at industry level

Let us define "proximity to the technological frontier" for an industry *i* in a given country at a given time – PTF – as the ratio of TFP (total factor productivity) in that industry and the highest TFP in industry *i* at time *t* among all countries. Proximity varies from zero (for very inefficient industries) to 1 (for the most efficient). We obtain estimates of the proximity to the frontier, as well as data on R&D intensity (R&D divided by sales), for the years 1974-1990[1].

Table 1 reports the correlation coefficients between the proximity to the frontier and R&D intensity. All columns show a significant positive correlation between these two measures: industries closer to their respective frontier are more R&D intensive. Moreover, as further empirical work shows, as an industry approaches the world technology frontier more rapidly than others, it becomes relatively more R&D intensive[2]. These results are consistent with the view that R&D gains in importance as industries or countries approach the world technology frontier.

TABLE 1: R&D intensity increases as industries get closer to the frontier

	Specifications		
	(1)	(2)	(3)
Proximity to the frontier	**0.031**	**0.018**	**0.009**
	(0.006)	(0.004)	(0.004)
Year dummies	YES	YES	YES
Country dummies	NO	YES	YES
Industry dummies	NO	YES	YES
Contry-industry dummies	NO	NO	YES
Number of observations	1801	1801	1801

Note: Standard errors are in parentheses. The dependent variable is the ratio of R&D to value added at the industry level.
Source: Daron Acemoglu, Philippe Aghion, Fabrizio Zilibotti (2006), "Distance to Frontier, Selection and Economic Growth". *Journal of the European Economic Association*, Vol. 4, No. 1: 37-74.

Thus, now that they have moved closer to the world technological frontier, EU countries should invest more in R&D – and within the EU, the most advanced countries should invest proportionally more as they benefit from a higher productivity of R&D.

However, it would be naive to assume that patent protection and R&D subsidies would be sufficient to foster innovation and productivity growth. It is not enough to invest more in R&D here and there to get the economy to grow faster. In the same way that R&D becomes essential when an economy develops, it becomes vital to create the micro and macro-economic conditions for innovation-based growth. In the remaining part of this note, we point at several such conditions: competition and entry, education, efficient

1 For more details, see Rachel Griffith, Stephen Redding, and John Van Reenen (2004), "Mapping the Two Faces of R&D: Productivity Growth in a Panel of OECD Industries". *The Review of Economics and Statistics*, 86 (4): 883 – 895.
2 More detailed empirical results are available from the author upon request.

labour markets, financial development, and the conduct of macroeconomic (particularly fiscal) policy over the business cycle. These are indirect ways to foster innovation and growth in maturing economies.

Four indirect ways to foster innovation and growth

1. Ensure competition and market entry

As stressed by the Sapir report[3], competition policy in Europe has emphasised competition among incumbent firms, but paid insufficient attention to entry. Entry, as well as exit and turnover of firms, are more important in the United States than Europe. For example, 50% of new pharmaceutical products are introduced by firms that are less than 10 years old in the United States, versus only 10% in Europe. Similarly, 12% of the largest US firms by market capitalisation at the end of the 1990s had been founded less than twenty years before, against only 4% in Europe, and the difference between US and European turnover rates is much bigger if one considers the top 500 firms[4].

The higher entry costs and lower degree of turnover in Europe compared to those in the US are an important part of the explanation for the differences in growth patterns between the two continents. While churning, (i.e. the replacement of old, less efficient firms by new, innovative ones) plays an important part in US productivity growth, most productivity gains in Europe take place within existing firms, as shown by Guiseppe Nicoletti and Stefano Scarpetta[5].

What frequently fails to be realised, however, is that the economic costs of less dynamic firm demographics actually *rises* as the economy gets closer to the technological frontier. This is shown in Figure 1, where we look at patenting rates within a panel of UK manufacturing firms over the period 1973-1992 as a function of the degree of competition in the industry.

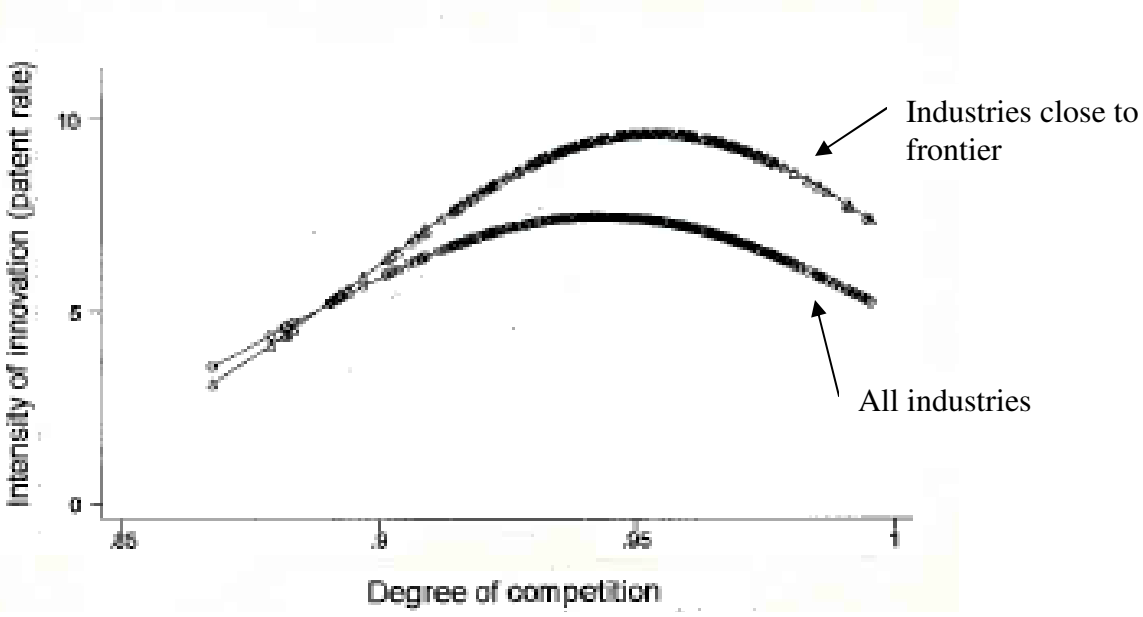
In general, there is an inverted-U relationship between competition and innovation: firms have little incentive to innovate if they are not stimulated by competition, but too much competition discourages innovation as firms are not able to reap the benefits of their efforts. There is, therefore, an optimal degree of competition.

What Figure 1 shows is that if we restrict the set of industries to those that are closer to their world technological frontier, the upward sloping part of the inverted-U relationship between competition and innovation is steeper than for the whole sample. Thus, the cost in terms of innovation, of having too little competition grows as the economy develops and gets closer to the frontier.

---

[3] Sapir, André et al. (2004). "An Agenda for a Growing Europe". Oxford University Press.
[4] Ibid.
[5] Giuseppe Nicolette, Stefano Scarpetta (2003), "Regulation, Productivity and Growth: OECD Evidence". *Economic Policy*, 18:36 9.

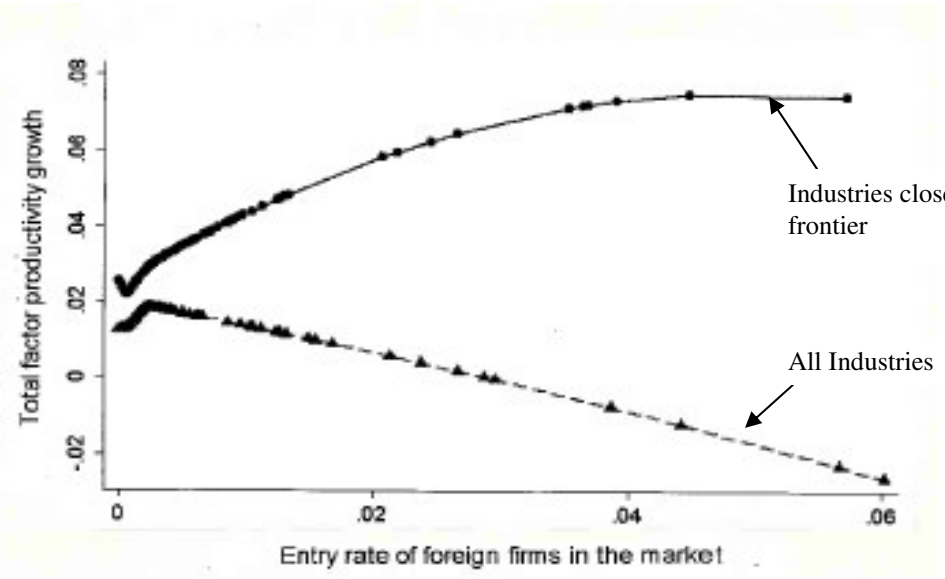
FIGURE 1: Competition is more beneficial in industries close to the frontier



Source: Philippe Aghion, Nick Bloom, Richard Blundell, Rachel Griffith, Peter Howitt (2005), "Competition and Innovation: An Inverted-U Relationship, , *Quarterly Journal of Economics*, Vol. 120, No. 2, pp. 701-728.

What is true for competition is also true for entry. Figure 2, again based on firm-level UK panel data over the period 1987-1993, shows that entry has a more positive effect on productivity growth in industries that are close to the technological frontier than in those that are not.

FIGURE 2: Entry is more beneficial in industries close to the frontier



Source: Philippe Aghion, Richard Blundell, Rachel Griffith, Peter Howitt, Susanne Prantl (2006), "The Effects of Entry on Incumbent Innovation and Productivity". NBER Working Paper 12027.

During the immediate Post-war period, the European (or Japanese and Korean) firms were predominantly technological laggards, whose catching-up could have been diminished by very intense competition. Thus, for some time, the relatively non-competitive nature of European markets was favourable to productivity growth in European firms. However, as Europe approached the global technological frontier, competition and entry have become increasingly important catalysts for innovation and productivity growth.

2. Invest in higher education

Is the European education system growth-maximizing? A first look at the US versus the EU in 2004 shows that 39% of the U.S. population aged 25-64 had attained tertiary education, against only 23% of the EU population. This educational attainment comparison is mirrored by that of tertiary education expenditure, with the US devoting 2.3% of its GDP to tertiary education versus only 1.3% in the EU (2003)[6].

Is this European deficit in tertiary education investment a big deal for growth? The answer is a clear 'yes' if one takes the view that higher education investment increases a country's ability to make leading-edge innovations, whereas primary and secondary education are more likely to make a difference in terms of the country's ability to implement existing technologies (Box 2). Thus, as Europe has moved closer to the world technological frontier, it should invest more in tertiary education in order to increase its innovative potential.

Box 2: Education, development and growth

Figure 3 shows that not investing in higher education is more damaging to growth, the closer a country is to the world technology frontier.

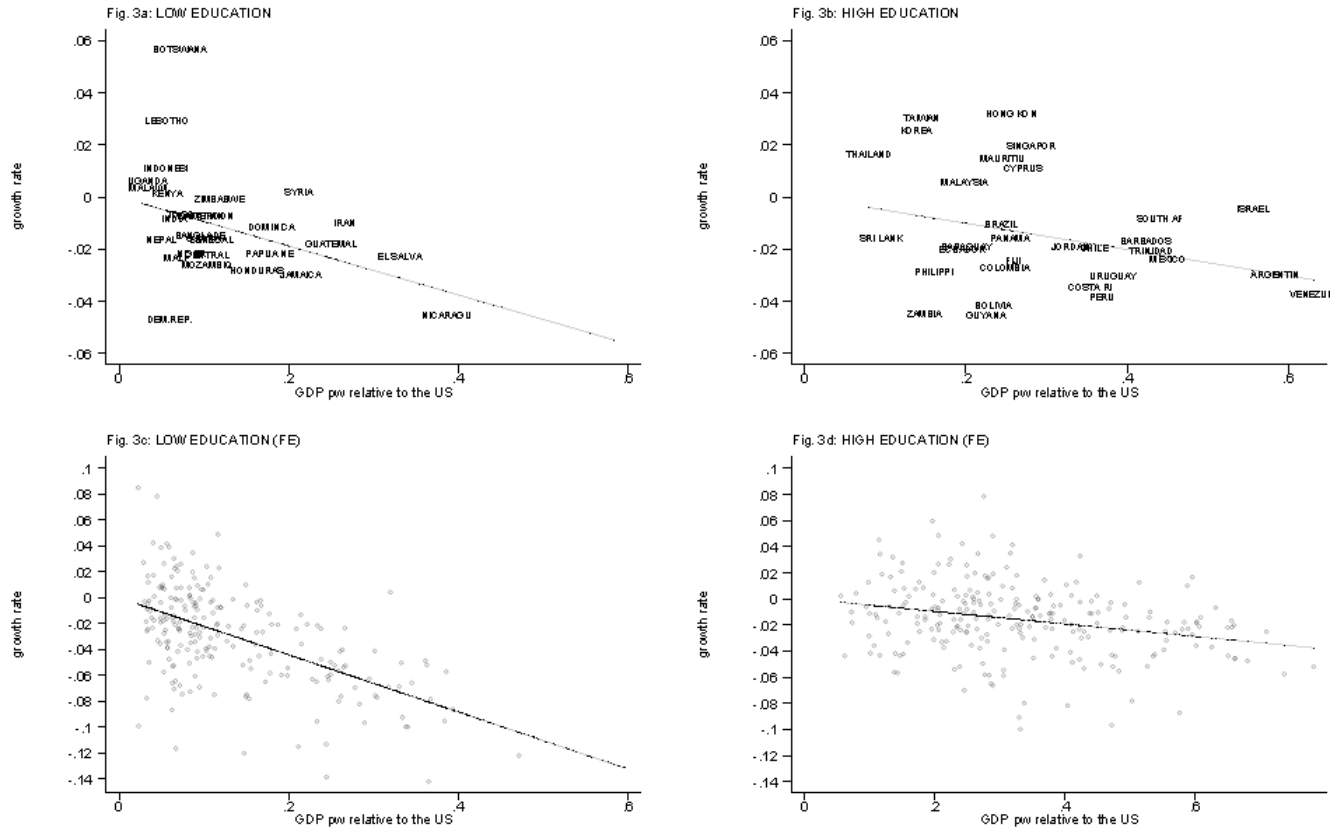
The upper part of the figure (Figures 3a and 3b) represents average growth in GDP per capita over the period 1960-2000 as a function of a country's proximity to the world technology frontier in 1960 (measured as the ratio of the country's GDP to that of the US). Figure 3a considers those countries with lower than median investment in higher education, whereas Figure 3b considers those countries with higher than median investment in higher education. In the lower part of the figure (Figures 3c and 3d), we decompose the 1960-2000 period in five-year sub-periods and look at how the average growth rate over the five year sub period depends upon the country's proximity to the world frontier at the beginning of the sub-period. Again, Figure 3c includes the results for countries with lower than median investment in higher education and Figure 3d includes those for countries with higher than median investment in higher education.

These figures show that there is a more negative relationship between growth and distance to the frontier for low-human capital countries than for high-human capital ones.

[6] OECD (2006), "Education at a Glance".

That is, under-investing in higher education impairs growth much more when the economy is close to the frontier than when it is far from it.

Figure 3: Investment in higher education is more beneficial in countries close to the frontier



Source: Daron Acemoglu, Philippe Aghion, and Fabrizio Zilibotti (2006), "Appropriate Institutions for Economic Growth".

What is true among countries is also true for regions within a country. For example, it has been shown that an additional $1000 per person in research education spending raises a US state's productivity growth rate by one-quarter percentage point if the state is at the frontier, whereas it raises it by only a tenth of a percentage point if the state is far from the frontier[7].

For Europe, to put the emphasis on primary/secondary education was fine as long as the continent was technologically far from the US and therefore relying more on imitation as a main source of growth; but now that the growth potential of imitation is wearing out, it becomes more urgent to invest more in higher education in order to foster innovation. Evidence actually shows that the IT and globalisation waves of the 1980s have further increased the growth potential of higher education investment in all OECD countries.

[7] Philippe Aghion, Leah Boustan, Caroline Hoxby and Jerome Vandenbussche (2005), "Exploiting State's Mistakes to Identify the Causal Impact of Higher Education on Growth". Mimeo Harvard University.

3. Reform credit markets, not only labour markets

Both credit constraints and labour market rigidities are likely to act as barriers to entry and innovation. Credit constrained firms may not be able to pay the required fixed costs to enter new markets or introduce new production technology. And labour market rigidities should make it harder for a firm to move to a new activity, as it will be more costly to find new workers adapted to that activity and to reduce employment in the old activity.

As it turns out, labour market rigidities are often presented as the main impediment to firms' entry, mobility and post-entry growth, whereas financial constraints are considered to be less important. A recent study by Aghion, Fally and Scarpetta (2006)[8] provides the opposite picture, however. This latter work looks at firms from 14 OECD countries over the 1990s, and examines how the entry of new firms and their post-entry growth are affected by three factors: 1) rinancial development; 2) regulations affecting start-up costs; and 3) regulations on the hiring and firing of workers.

Financial development is measured either by the ratio of private credit to GDP or the ratio of stock market capitalisation to GDP. Start-up costs and restrictions on firing are measured by the corresponding OECD indicators.[9] The main finding from this research is that financial development facilitates the entry of small firms especially in sectors which in the US rely more on external finance. In these sectors, however, labour market regulations do not inhibit the entry of smaller firms (although they do for larger firms).

Table 2 summarizes the relative impacts of financial development and labour market regulations on the growth of a new firm in its first years of existence (post-entry growth). In the table, financial development is interacted with the sector's dependence on external financing; and employment protection legislation is interacted with the sector's labour intensity (measured by the labour-capital ratio). Financial development is further decomposed into private credit and stock market capitalisation.

TABLE 2: Financial development favours entry

Impact of selected interactions on post-entry growth	
Financial development x dependence on external financing	POSITIVE
Credit Development x external financing	POSITIVE
Stock market development x external financing	POSITIVE
Employment protection legislation x labour intensity	INSIGNIFICANT*

Note: * Negative but statistically insignificant
Source: Philippe Aghion, Thibault Fally, and Stefano Scarpetta (2006), "Credit Constraints as a Barrier to the Entry and Post-Entry Growth of Firms: Lessons from Firm-Level Cross Country Panel Data" .

[8] Philippe Aghion, Thibault Fally, Stefano Scarpetta (2006), "Credit Constraints as a Barrier to the Entry and Post-Entry Growth of Firms: Lessons from Firm-Level Cross Country Panel Data".
[9] To minimize the scope for endogeneity problems, AFS uses industry-level indicators (the dependence on external finance of the corresponding sector in the US or the capital labour ratio in the sector) to differentiate the effect of credit constraints on entry and the post-entry growth of firms after six years into the market, across industries.

Table 2 shows that financial development facilitates the post entry growth of firms in sectors which are intrinsically more dependent upon external financing. In contrast, labour market regulations do not seem to be significantly correlated with post-entry growth of firms. These results suggest that political reformers in the EU should go beyond labour regulations and also emphasise financial development: on average, the ratio of private credit to GDP is far lower in the EU (0.76) than in the US (1.32), and this gap is even bigger if we look at stock market capitalisation indexes or at venture capital indicators.

4. Manage the economic cycle

There is currently a debate about the conduct of macroeconomic policy in the euro area. It has been noticed that structural budget deficits and short-term interest rates fluctuate much less over the cycle in the EMU zone than in the US and UK, and some policy makers have raised the concern that this in turn may inhibit growth in the euro area. Are these concerns at all justified?

This depends on whether firms can borrow enough funds to maintain their R&D investments during bad times and, therefore, throughout the cycle. If they can, the best would be, at least from a growth perspective, to recommend that governments do not intervene over the business cycle, and instead let markets operate.

However, the prescription might be quite different when credit market imperfections prevent firms from borrowing enough in recessions. For example, suppose that the borrowing capacity of firms is proportional to their current earnings. In a recession, current earnings are reduced and so therefore is firms' ability to borrow in order to maintain R&D investments. In this case, a countercyclical policy will foster innovation and growth by reducing the negative consequences of a recession (or a bad aggregate shock) on firms' innovative investments. For example, the government may decide to increase the volume of its public investments, thereby fostering the demand for private firms' products. Or the government may choose to lower taxes on private enterprises, thereby increasing their liquidity holdings and thus making it easier for firms to face idiosyncratic liquidity shocks without having to sacrifice R&D or other types of longer-term growth-enhancing investments.

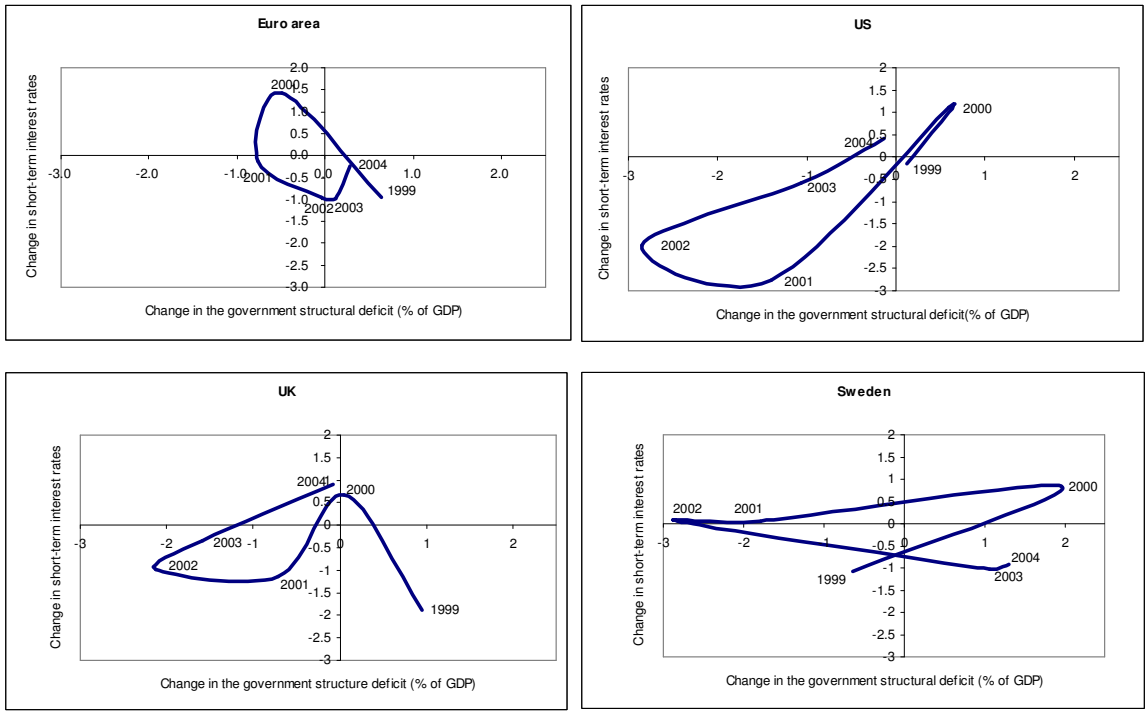
In a recent empirical study using annual data from 17 OECD countries, Aghion and Marinescu (2006)[10] show that the pro-cyclicality of fiscal policy is actually detrimental to growth; but they also show that the same degree of pro-cyclicality is *less* detrimental to growth in countries with a higher degree of financial development.

One can also show that if public debt growth in the EMU zone were to become as countercyclical as in the US, long-term growth in the euro zone could increase

[10] Philippe Aghion, and Iona Marinescu (2006), "Cyclical Budgetary policy and Economic Growth: What Do We Learn from OECD Panel Data? ".

significantly, possibly by the order of magnitude of half a percentage point[11]. Moreover, it is the investment part of government spending that appears to drive this positive effect of budget counter-cyclicality. Budgetary policies are currently far less countercyclical in the EU than in the US even though the US is more financially developed than the EU. As shown in Figure 4 below, both the structural deficit and the real interest rates vary much less over time in the euro area than in the US. Our discussion suggests that the absence of an active (or reactive) macroeconomic policy in the euro area is, therefore, a potential source of the growth deficit in the region.

FIGURE 4: A distinctively less activist policy-mix in the euro area



Source: OECD

Conclusions

Four main lessons can be drawn from this discussion as to how one could best stimulate innovation and growth in the EU area.

The first lesson is that one must go beyond the obvious recommendation of increasing state spending on, or subsidies to, R&D, and protecting intellectual property rights, and also consider indirect channels whereby innovation can be fostered.

The second lesson is that innovation-based growth requires coherence. We have emphasised here the necessary coherence between R&D and structural reforms and

[11] Ibid.

policies such as competition, higher education, labour market flexibility and financial market development. But the coherence must also be between structural and macroeconomic policies as they become more proactive over the business cycle. This coherence in policy design is lacking in Europe and this, more than particular failures here or there, is the main problem to address.

Third lesson: reforms entail winners and losers. For example, liberalising entry boosts innovation in sectors closer to the technological frontier but less so in sectors far below the frontier; this in turn points to the importance of complementary structural policies aimed at helping workers reallocate from lagging to more advanced sectors, and of policies aimed at compensating potential short-term losers from structural reforms. Failing to do so might result in further protracting the implementation of those reforms.

Fourth lesson: structural reforms need careful agenda-setting and prioritisation, based on a comparative cost-benefit analysis where the value of each reform would be measured by the ratio of its contribution to the overall growth potential of the country over the (social) cost of implementing the reform. This in turn would enable us to "rank" the reforms; that is, to get a more precise view as to what should be undertaken first, or as to which reforms should be implemented jointly because of complementarities in their growth impacts.