THE EU'S R&D DEFICIT & INNOVATION POLICY

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This report draws primarily on the written contributions and oral discussions of the members of the Expert Group on "Knowledge for Growth".

EXECUTIVE SUMMARY

The concept of a deficit in research and development expenditures (R&D) has recently served as a crucial focusing device for research and innovation policy in the European Union. With a view to better understanding the role that such a deficit ought to play for policy, the Expert Group conducted extensive discussions of what we know about the nature of this deficit, its causes, as well as its impact on economic and social outcomes.

Our general conclusion is that we need to be much more precise about what we mean about an R&D deficit and more careful about linking it to specific policy measures if it is to serve as a useful guide, even if that guide is largely exhortatory, for research and innovation policy in the EU. This is particularly important since, at least based on what we currently know, policy actions that directly address the causes of the R&D deficit fall largely outside of the ambit of current EU research and innovation policy. As a result, policy experience cannot substitute for a sound analytical basis for policy action and, in the opinion of the Expert Group, we still know too little about the characteristics, causes and impact of the EU R&D deficit to be sufficiently confident to prescribe specific policy actions to redress it. Yet, we do have a reasonably good grasp of what we do not know and, in this report, we seek to highlight not just the lacunae in our understanding but the ones that really matter to the prescription of policy actions for the EU.

The Expert Group believes that we need to be much more precise about what we mean when we speak of the EU as having a deficit in R&D spending. If we focus on the national economies of the EU and compare their R&D performance with a range of benchmarks it is hard to argue that these economies suffer from any general deficit in R&D expenditures. Instead, the concept of an EU R&D deficit takes on its most definite meaning when it is understood as a deficit of R&D expenditures in the EU economy relative to another benchmark economy of comparable complexity and size which is usually the United States.

The choice of whether it is appropriate to abstract from, or admit, national differences in R&D intensity for research and innovation policy largely depends on what one believes to be the scope and purpose of EU policy. The Expert Group took the view that EU research and innovation policy was about cutting across national boundaries to bring life to a European Research and Innovation Area. Therefore, it seemed appropriate to us to

downplay national differences in R&D expenditures for the purpose of thinking about the challenges and opportunities for innovation policy that confront the EU region.

Yet, even if we think that there is good reason to think about an R&D deficit as it manifests itself at the EU level, we also believe that there is much more to be done to understand its precise characteristics. Industrial structure is a crucial consideration since the EU's deficit in R&D expenditures vis-à-vis the United States is one that primarily reflects a shortfall in EU R&D spending in the production of IT goods and services. Furthermore, some scholars have suggested that the EU's R&D deficit in IT in turn reflects characteristics of its enterprise structure and dynamics, specifically the constraints on the rapid growth of new, technology-based entrants in the EU as compared with the US. They suggest that these constraints may also be an obstacle to EU success in other sectors, such as biotechnology, even if they do not as yet show up in statistics based on highly aggregated industrial classifications.

From this perspective, the R&D deficit is a symptom, rather than a cause, of a weakness in the EU's capacity to innovate; the cause is rooted in the structure and dynamics of industry and enterprise rather than in a deficiency of R&D spending *per se*. While the Expert Group found this line of reasoning to be provocative it also believed that it is, as yet, based on tentative evidence and needs firmer analytical foundations to form the basis for policy recommendations. Yet, if it is shown to be true, it will be of crucial importance to research and innovation policy. In particular, it suggests that policies to raise R&D expenditures across all types of industries and firms in the EU are not appropriate to redressing the deficit. To the contrary, policies that focus on overcoming the barriers to innovation for certain industries and certain types of firms are likely to be more effective.

To identify which barriers need to be overcome, we turned to a discussion of what we know about the causes of the EU's R&D deficit. What accounts for Europe's weakness, compared to the US, in the IT sector, and in other relatively new technology-based sectors like biotechnology? And what explains the apparently related problem of European firms' capacity to grow into large firms that generate substantial revenues, spend significant resources on R&D and employ large numbers of people?

Perhaps the most common explanation for these differences is a greater willingness on the part of the US financial markets to fund new sectors and new firms. In addition, the greater flexibility of the US labour market is often mentioned as an important factor in spurring the emergence of new industries and new firms. Finally, the fragmentation of product markets in the EU as well as the attitudes of EU consumers to new products have also been cited as potential barriers to innovation in the region compared with the United States.

However, some members of the Expert Group were concerned about the basic presumption that underlies these market-based explanations that R&D deficits occur only when markets fail. Instead they suggested that it may be more fruitful to think about the causes of R&D expenditures as the outcome of a systemic interaction among different elements in an innovation system. From this perspective, deficits of R&D reflect

systemic, rather than market, failures. Adopting this "systems of innovation" approach, it is more useful to look at interactions among, or interfaces between, various elements of that innovation system in seeking to locate the causes of the R&D deficit.

Several interfaces that may be particularly important were discussed by the experts. The public-private interface, that is, the relationship between elements of the public sector, such as the defence and health systems, and the industrial base received considerable attention in our discussions. This reflected a widespread awareness in the group of the long-standing and continued importance of the role of the US federal government, through procurement, R&D subsidies and other mechanisms, in the success of the IT, biotechnology and other dynamic, high-technology sectors. The interface between the university system (both publicly- and privately-funded institutions) and the industrial base was also discussed by the group and will be taken up at much greater length in our next report. Another interface that was highlighted for its potential significance in accounting for the R&D deficit was that between services and manufacturing. Finally, there was some discussion of the importance of thinking about firm entry and growth in terms of the relationship between incumbent and entrant firms and, more generally, in the context of an enterprise system.

Although there are plenty of ideas out there about the possible sources of US success, relative to the EU, in developing new industries like IT and biotechnology in the postwar period, it became clear over the course of our discussions that we are, as yet, a long way from being able to make strong statements about the way these causal interactions should be understood. The relative importance of different factors in explaining success remains obscure in many of these accounts as does the potential to abstract from the particular circumstances of time and place to generalize about the causes of success.

If the possible causes of the problem that policy makers sought to redress were familiar to them, if they were the usual list of issues at which research and innovation policy was directed, there might be an argument for embarking on a policy agenda with a view to learning by doing. However, this is not the case. Whichever policy direction one chooses from what is currently on offer, be it towards the greater flexibility in labour and financial markets that some commentators advocate or in the direction of industrial policy to encourage new industries that others would like to see, it will be strange, new ground for research and innovation policy in the EU. As a result, it is hard to fall back on experience as a substitute for analysis.

For advancing policy efforts, the Expert Group believes that we need not only an improved analysis of the causes of EU's R&D deficit but also of its consequences for the economic and social performance of the region. We already know that it will be a hard problem to redress so we ought to be cognizant of exactly what it is that we might expect to achieve in seeking to overcome it. Evidence of the contemporary sources of the productivity benefits that accrue from IT suggests that we ought not to assume that the presence of a strong IT-producing sector will generate these benefits. Most of these benefits have accrued through the use of IT, especially in services, so it is only if an

important interaction between user and producer industries is necessary to achieve these benefits, that this might be so.

Of course, to focus exclusively on the contemporary benefits that accrue to a strong IT-producing sector would be a mistake in evaluating the costs of the EU's lag, relative to the US, in emerging sectors. The IT sector is long past its emergent phase and there may well have been important costs of the EU's falling behind that are hard to see now. Even if a comprehensive analysis suggests that these costs were large, however, that does not imply that the EU should seek to redress its lag in the IT sector; it may well be that a window of reasonable opportunity as well as the likely benefits to be recouped by so doing have passed. Instead, a better understanding of what has been lost in IT would provide the context for understanding what might be lost again from falling behind in sectors that are only now emerging although the difficulties of extrapolating from one case to another are, as always, fraught with difficulty.

The Expert Group also emphasised that we ought not to focus only on economic outcomes in discussing the impact of the EU's lag in emerging technologies. Indeed, in cases such as biotechnology, nanotechnology and new materials as well as environmental technologies, the social implications of leads and lags seem just as important to us. Yet, as recent research on biotechnology suggests, we cannot assume that these technologies are panaceas in improving health care and other social policies. As for the economic realm, serious effort is required to evaluate the social costs and benefits of being leaders or laggards in these fields.

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1. INTRODUCTION

Contemporary concerns about the EU's innovative performance are often expressed with reference to a deficit in research and development (R&D) spending. In 2003, the EU's gross domestic expenditure on R&D amounted to 1.93 per cent of GDP. Its R&D intensity lagged well behind the US and Japan with comparable figures of 2.59 per cent and 3.15 per cent respectively. Although the EU's R&D intensity was well ahead of China's 1.31 per cent in 2003, the European Commission forecast that China would catch up with the EU before 2010 if recent trends continued (European Commission, 2005, pp. 24-5).

The EU's R&D deficit became a central focus of research policy with the articulation of a target for R&D expenditures as part of the Commission's Lisbon Strategy. In Barcelona in 2002 that target was set at 3 per cent of GDP to be reached by 2010. There is some debate about exactly what role the "3 per cent target" does and should play in research policy and performance for the EU and its Member States (MS). In particular, there are questions about whether it should be understood as a general exhortation to greater effort in research and innovation within the EU or as a specific target against which the EU and its MS should measure progress or regress in R&D and innovation. Notwithstanding these debates, there is no question that the idea of a European deficit in R&D serves as a crucial focussing device for research and innovation policy in the EU today.

Given its importance, the Expert Group decided to devote some time to thinking about the characteristics of this putative deficit and what it ought to mean for research and innovation policy in the EU. Although the R&D deficit is typically defined as the problem of a shortfall in total R&D spending, business expenditures on R&D (BERD) typically garner most attention and, in this report, most of what we say is with reference to them.

Since there is considerable ambiguity and controversy about what it means to speak of Europe as having a deficit in R&D, we begin with a discussion of what that might mean. Second, we discuss the variety of arguments that are typically made about the causes of this deficit and emphasise two main categories of explanation: market-based and systemic explanations. Third, we consider evidence on the impact of the R&D deficit on

economic and social goals to determine the policy importance that should be ascribed to it.

Our general conclusion is that we need to be much more precise about what we mean about an R&D deficit and more careful about linking it to specific policy measures if it is to serve as a useful guide, even if that guide is largely exhortatory, for research and innovation policy in the EU. This is particularly important since, at least based on what we currently know, policy actions that directly address the causes of the R&D deficit fall largely outside of the ambit of current EU research and innovation policy. As a result, policy experience cannot substitute for a sound analytical basis for policy action and, in the opinion of the Expert Group, we still know too little about the characteristics, causes and impact of the EU R&D deficit to be sufficiently confident to prescribe specific policy actions to redress it. Yet, we do have a reasonably good grasp of what we do not know and, in this report, we seek to highlight not just the lacunae in our understanding but the ones that really matter to the prescription of policy actions for the EU.

2. THE NATURE OF THE R&D DEFICIT

Concern with deficits in R&D spending both reflect and foster an interest in aggregate comparisons of R&D intensity across economies. As the R&D deficit has become a prominent focus of EU policy, a number of critics pointed out that qualitative variations across the economies that are being compared need to be taken into account for aggregate comparisons of R&D intensity to be useful. As Keith Smith put it: "[a] key problem in any benchmarking exercise is that quantitative comparisons usually have to assume that there is qualitative uniformity among the objects being compared or counted: like has to be compared with like (Smith, 2001, p. 268)." In particular, he argued that variations across economies, industries and firms needed to be considered to make sense of aggregate comparisons of R&D intensity (Smith, 2001, p. 269).

Over the last few years, there has been considerable research on these qualitative variations and their implications for the interpretation of aggregate comparisons of R&D intensities. There has been particular interest in the industry as a unit of analysis and the extent to which variations in the R&D intensities of particular economies reflect differences in the structural composition of their industrial sectors or differences in R&D intensities within particular sectors. One approach to this question is to decompose aggregate differences in R&D intensities into two components: a "structural" effect and an "intrinsic" effect.

Several recent studies have been undertaken by MS governments, the OECD and academics to quantify the importance of these two effects in determining differences in R&D intensities at the country level. One study by the Ministry of Economic Affairs for the Netherlands calculated the deficit or surplus in R&D intensity relative to the OECD average for 19 advanced countries of which 13 were EU member states (Netherlands Ministry of Economic Affairs, 2005). It found that nine of the 13 EU member states had an overall R&D intensity deficit and, in general, it seemed, these deficits were more strongly related to intrinsic, than to structural, effects. However, in some cases (Denmark,

Netherlands, Norway, Poland and Spain) the contribution to the deficit of a structural effect seemed to be rather big, meaning that these countries were specialized in industries that typically have low R&D intensities. In contrast, countries like Ireland and (to a much lesser extent) Germany experienced offsetting effects between a negative intrinsic effect and a positive structural effect.

Other country-level studies, however, suggest a stronger role for industrial structure in accounting for R&D deficits. For example, in its recent country report on the UK, the OECD estimated that structure accounts for 73 per cent of the country's R&D deficit relative to Germany. More generally, it found that most of the R&D intensity gap that the UK has, not only with Germany but also with France and Japan, can be attributed to industrial structure. In contrast, the OECD found that structure plays a small role in accounting for the UK's overall R&D deficit with the US.

The results of these studies suggest the difficulties of drawing general conclusions that are applicable across the Member States about the role of industrial structure in determining R&D deficits within the EU. One reason is the presence of methodological problems that make it difficult for scholars to converge on generally-accepted measures of structural and intrinsic effects. First, the results of de-composition analyses of the R&D deficit into these two components have been shown to be highly sensitive to the level of detail at which industries are compared. As Jaumotte and Pain (2005) put it: "[t]ypically, the proportion of the gap in R&D intensities explained by differences in industrial composition has been found to rise as the extent of disaggregation rises (p. 12)." Second, the de-composition of differences in aggregate R&D intensities into structural and intrinsic effects is highly sensitive to variations in the measured R&D for the services sector and the assignment of R&D expenditures to the services sector is subject to very different statistical norms across countries.

A second reason for the heterogeneity in the results of these studies lies in the choices that they make about how much qualitative variation to admit, not only across industries, but also in the economies whose R&D intensities are being compared. They focus on national economies and, therefore, treat member states of the EU, rather than the EU itself, as their primary units of analysis. As a result, they take full account of the heterogeneity in R&D intensities and industrial structures which continues to characterise the national economies of which the EU is comprised. They also admit additional variety by employing a number of benchmarks to evaluate national economies' relative R&D performance. The US economy is sometimes employed as a benchmark but so too are other EU economies as well as the average R&D intensity for OECD members.

If one admits such variation in the economies being compared, it makes little sense to talk of Europe as having a deficit in R&D. Instead, multiple R&D deficits and, in some cases, R&D surpluses can be identified. The characterisation of these deficits or surpluses varies with the identity of the economies that are the basis for bilateral comparisons of R&D intensity, that is, with the economy of focus (whether it is the UK, France, Ireland or Greece) and the economy with which it is being compared (Germany, Italy, the EU average, the OECD average or the US).

The Commission has recently pursued an alternative approach to characterising and understanding the relative R&D performance of the EU (European Commission, 2005). The most important differences in its approach, relative to the studies described above, are that 1) it defines the EU as a whole as the primary economy of interest and 2) it specifies the US economy as the main benchmark against which the EU's R&D performance is to be evaluated. Based on this approach, it becomes possible to give definite, albeit highly specific, meaning to the idea of an EU deficit in R&D spending.

The Commission has also taken a number of steps to redress the methodological problems described above. Instead of making a distinction between structural and intrinsic effects, the Commission opts for more approximate measures of the role of industrial structure in determining aggregate differences in R&D intensity which are reached based on simpler but, arguably, more transparent assumptions. Specifically, it re-calculated the EU's business R&D intensity based on the assumptions that the EU had the same industrial structure as the US in 2002 and that EU business R&D intensities remained unchanged at the sectoral level (European Commission, 2005, p. 70). The results of this exercise suggest the overwhelming importance of a small number of sectors in accounting for the deficit.

On the face of it, the most important distinction between the EU and US economies seems to lie in the large and highly R&D-intensive service sector of the US. On closer observation, this result appears to be a symptom of another methodological challenge described above: the presence of a large amount of R&D expenditures within services in the US reflects a peculiar classification system in the US. According to the National Science Foundation of the United States, much of the R&D that is characterised as occurring in the service sector more properly belongs in a small number of manufacturing sectors of which the most important is the IT sector. As a result, the Commission re-classified the various elements of services R&D in the US and added them to recorded R&D in the appropriate manufacturing sectors. Its revised estimates suggested a very clear conclusion: the IT sector was responsible for the bulk of the R&D deficit between the EU and the US (Commission analysis).

The clarity of the conclusion that the Commission's analysis generated contrasts sharply with the variegated findings from the cross-country studies cited above. It is perhaps appealing to some as the basis for policy making for that very reason. However, it seems advisable to appeal to some other criterion than tidiness for determining the evidence that ought to be the basis for policy making. In this regard, the legitimacy of the assumptions that generated the different empirical results is central. In essence, the question we confront is whether we should abstract from, or admit, national differences in R&D intensity in diagnosing the challenges that EU innovation policy seeks to overcome.

The answer to this question largely depends on what one believes the scope and purpose of EU innovation policy to be. The bulk of what is spent on innovation policy in the EU today is spent by national governments to address the challenges that their national economies confront. In terms of its scope, if EU innovation policy is seen as operating

primarily to facilitate these national policies, it is difficult to see why abstracting from national characteristics of R&D expenditure and industrial structure would be appropriate. If, on the other hand, one thinks of EU innovation policy as attempting to promote innovation in ways that cut across national boundaries, if it is about bringing life to a European Research and Innovation Area, then it seems more appropriate to abstract from national differences to think about the challenges and opportunities for innovation policy that arise at the European level.

The Expert Group favoured the latter approach largely since its ambition has the potential to stimulate new ideas in thinking about research and innovation policy for the EU. Precisely because so much spending on innovation policy is undertaken at the national level, many minds are preoccupied with the challenges of national variations in innovation spending, industrial structure and economic performance. To the extent that the Commission, given the limited resources at its disposal to promote innovation, is going to have an important impact, it seemed to us that defining its task as understanding and redressing European problems is a fruitful way to go forward.

The appropriate purpose of innovation policy is a more controversial issue. To apply the US economy, rather than some other national or regional economy, as the benchmark for evaluating EU R&D performance is essentially to state that the primary challenge for EU policy is to catch up with, and perhaps, surpass the US in this regard. Most of the arguments that provide implicit or explicit justification for such a purpose for EU innovation policy rely on the assumption of close links between R&D spending, and more particularly between strength in R&D in sectors such as IT, and recent US macroeconomic performance. Rather than engaging this issue now, we explore it later in this note when we discuss the impact of the R&D deficit in Section 4 below. For the moment, therefore, we opted to think of the EU's R&D deficit as an aggregate deficit for the EU economy vis-à-vis that of the US but to consider its importance as a guideline for research and innovation policy only when we have reviewed what we know about its impact on economic and social goals.

To the extent that we define the EU's R&D deficit as the shortfall in R&D spending relative to the US, the Commission analysis of Frascati BERD statistics makes it very clear that there is no general problem of a deficit in R&D spending across all sectors of the EU economy. To the contrary, some sectors are more R&D-intensive in the EU than in the US. The overall shortfall in R&D intensity between the two regions is generated primarily by one sector: IT.

Some researchers have linked this sectoral outcome to different patterns in the structure and dynamics of the enterprise sectors in the two regions. Based on an analysis of the top 1,000 global firms in terms of market capitalisation which were listed in Business Week in 1999, Cohen and Lorenzi argued that the US economy is a more hospitable environment than the EU for new firms to grow large. They show that, of the 355 US firms included in this list, 120 of them (33 per cent) were created after 1950 and 64 of them (18 per cent) were founded after 1980. [1] In contrast, of the 181 firms EU firms in the

[1] These numbers refer to creations from scratch or *ex nihilo*.

list, 64 were created after 1950 (1 4 per cent) and 9 were established after 1980 (5 per cent).

The greater importance of new firms in the ranks of the largest companies in the US is found across most sectors. However, IT was by far the most important sector in determining the difference in the total number of new giants between the two regions. It accounted for more than 70 per cent of the new giants created in the US in both time periods as well as over 70 per cent of the difference between the two geographical regions in this regard (Cohen and Lorenzi, 2000, p. 125).

This explanation seems consistent with the findings of the 2005 EU Industrial R&D Investment Scoreboard, which is based on firm-level data for companies with R&D investment of more than €35 million. The Scoreboard analysis confirms that the major source of the difference in R&D intensity between the EU and the US is in the sectoral composition of industry and, in particular, the greater specialisation of US companies in the production of information technology, both hardware and software.[2] However, the main reason for this difference is not that existing EU players in these industries have a lower R&D intensity than their US counterparts. If one controls for sector, the largest EU firms have similar R&D intensities to those of their US counterparts. However, relatively few EU companies are found in highly R&D intensive sectors and, especially in the IT sectors, the cluster of medium-sized, highly R&D-intensive firms found in the US is missing in the EU (Ciupagea & Moncada Paternò Castello, 2005).

Cohen and Lorenzi argue that Europe's difficulty in turning young companies into giants is also a problem in other rapidly-growing new sectors of the economy. To support this claim, they invoke evidence of the relative weakness of the European biotechnology industry as compared with its US counterpart. They note that, in 1997, there were 1,274 biotechnology companies in the US compared with 1,036 in Europe and they generated $15.9 billion in revenues and employed 140,000 people compared with $2.7 billion and 39,045 respectively for their European counterparts (Cohen and Lorenzi, 2000, p. 126).

The Expert Group found this line of interpretation of the EU's weaknesses relative to the US to be provocative. However, it also seemed to us to be, as yet, far from definitive since the evidence on which it is based is rather preliminary. Certainly questions can be raised about whether the list of the Business Week 1000 generates representative samples of US and EU firms and, therefore, credible results. The list is heavily skewed towards US firms, which for a long time have ranked as the largest firms in the world. Therefore, the sample of US firms derived from this source is much larger than its European equivalent. If we expect the very largest of a region's firms to be the least likely to be new firms then this approach biases the European sample towards older rather than younger firms.

[2] However, echoing our earlier discussion of national economies as compared with the EU economy, the report also shows that specialization in IT differs considerably across national economies within the EU (see p. 67).

The period of focus of the analysis also matters. For example, if we compare Europe's biotechnology industry with its US counterpart based on the most recent data available, the comparison is much more favourable to Europe than it was in 1997. In 2004, the European industry was comprised of 2,163 firms, more than the 1,991 firms that were active in biotechnology in the US. Moreover, and despite continued growth by the US industry, the European industry reached about half of its size in revenues and employment by 2004 generating €21.5 billion in sales and employing about 96,500 people compared with €41.5 billion and 190,500 people for its US counterpart (Critical 1), 2006). Nevertheless, some of the weaknesses that Cohen and Lorenzi highlighted, notably the fact that European biotechnology firms grow much more slowly than their counterparts in the US, have endured.

In summary, it seemed to the Expert Group that we need to be much more precise about what we mean when we speak of the EU as having a deficit in R&D spending. If we focus on the national economies of the EU and compare their R&D performance with a range of reasonable benchmarks it is hard to argue that these economies suffer from any general deficit in R&D expenditures. If we focus on the EU economy as a whole, and take the US economy as the appropriate benchmark, then we are really talking about a deficit that primarily manifests itself, at least at the industry level, in the production of IT goods and services. In terms of firm behaviour, based on the limited evidence available, the deficit in IT may reflect constraints on the rapid growth of new, technology-based entrants in the EU as compared with the US. These problems may also be an obstacle to EU success in other sectors, such as biotechnology, even if they do not as yet show up in statistics based on highly aggregated industrial classifications. We continue to use the terminology of R&D deficit in the rest of this note but when we do we mean it in the specific sense in which we have summarised the problem in this paragraph.

3. THE CAUSES OF THE R&D DEFICIT

In an ideal world, discussions of the possible causes of the EU's R&D deficit with the US would be linked to a precise understanding of the nature of that deficit. However, most of the causes that have been suggested seem more appropriate to explaining perceived general deficiencies in European research and innovation than the more specific challenges that the previous section highlights. What we really need are explanations that shed light on 1) Europe's weakness, compared to the US, in the IT sector, and in other relatively new technology-based sectors like biotechnology and 2) the apparently related problem of European firms' capacity to grow into large firms that generate substantial revenues, spend significant resources on R&D and employ large numbers of people. In this section we discuss the various possible causes that the group considered but we also highlight the limits to the evidence for linking these causes to the effects that we are interested in explaining.

A simple way to organise the arguments that have been made is to distinguish between two types of explanation of the EU R&D deficit: market-based and systemic explanations. As far as market-based explanations are concerned, the most common explanation for differences between the EU and the US in the emergence of new sectors

and new players within them is undoubtedly the greater willingness of the US financial markets to fund new sectors and new firms. In addition, the greater flexibility of the US labour market is often mentioned as an important factor in spurring the emergence of new industries and new firms. Some commentators believe it to be an important factor in encouraging entrepreneurs to start their own firms. Perhaps more importantly, in light of evidence on the apparent limits to the rapid growth of European firms, labour market characteristics are often cited as restraints on firms' willingness to expand employment when opportunities present themselves, especially in new industries where uncertainty may be particularly high. Finally, some commentators point to the fragmentation of European product markets, to the attitudes of EU consumers to new products as well as to differences in the role of public procurement, as explanations for the region's lag relative to the US in emerging sectors.

However, some members of the Expert Group were concerned about a basic presumption that underlies the idea that R&D strength or weakness is ultimately a response to a market-mediated interaction between the demand for, and supply of, R&D. From this perspective, R&D deficits occur when markets fail. In contrast to this approach, they suggested that it may be more fruitful to think about the causes of R&D expenditures as the outcome of a systemic interaction among different elements in an innovation system. From this perspective, deficits of R&D reflect systemic, rather than market, failures. Adopting this "systems of innovation" approach, it is more useful to look at interactions among, or interfaces between, various elements of that innovation system in seeking to locate the causes of the R&D deficit.

Several interfaces that may be particularly important were discussed by the experts. The public-private interface, that is, the relationship between elements of the public sector, such as the defence and health systems, and the industrial base received considerable attention in our discussions. This reflected a widespread awareness in the group of the long-standing and continued importance of the US federal government, through procurement, R&D subsidies and other mechanisms, in the success of the IT, biotechnology and other dynamic, high-technology sectors.

For understanding how the government played its role, most commentators emphasise that the issue is not simply or even primarily one of the amount of public support that was committed to technological development through R&D subsidies and public procurement. In most of the literature on the subject, the process through which the US government was involved in technology development is emphasized as being as or more important. The US federal government did not pick winners in terms of specific technologies or firms in contrast to the practice that prevailed in other countries, like France, where the government was also a prominent supporter of technological development. Moreover, the policy of "second sourcing" pursued by the US military is often seen as playing an important role in contributing to the diffusion of technology in the formative stages of the US semiconductor industry and other lead industries in the IT sector.

The interface between the university system (both publicly - and privately-funded institutions) and the industrial base was also discussed by the group and will be taken up at much greater length in our next discussion. Here the importance of relationships that operate through the research and educational activities of universities were emphasized. Some members of the group were concerned about general weaknesses of the higher education system in the EU. The smaller proportion of the working -age population in tertiary education in the EU compared with the US, the lower levels of funding allocated to education, as well as the limited attractiveness for foreign scholars and researchers to study and work in the EU have all been cited as potential problems. It was also suggested that certain characteristics of the governance of universities and research centres may limit their innovative impact . A lack of professional management in European universities as compared with their US counterparts may constrain their contribution to R&D. The persistence of rigid hierarchical structures in academia in certain European countries may also be an issue and some have suggested a more general problem with the structure of rewards and responsibilities in European universities as barriers to R& D spending in the EU. However, other members of the group argued that some of the features of universities that are seen as egregious by critics are not common throughout the EU. Moreover, the cross-national patterns that they exhibit do not seem to line up, at least in any straightforward way with weaknesses in R&D spending.

Another interface that was highlighted for its potential significance in accounting for the R&D deficit was that between services and manufacturing . The health care sector serves as an interesting illustration. Innovation in the medical devices industry may be importantly influenced by what happens in hospital -based health care delivery systems. Hospitals often have to innovate to make effective use of new medical devices and, as a result, their resources, capabilities and motivations, as well as the extent to which these characteristics are known to, and understood by, the medical devices industry may have an important impact on the extent and quality of R&D investment in developing and improving medical devices.

Finally, there was some discussion of the importance of thinking about firm entry and growth in the context of a broader enterprise system. To the extent that the innovative success of entrants is attributable to their origins and, in particular, to their relationship to existing successful firms, as some recent research suggests (see, for example, Klepper, 2001**)**, the characteristics of incumbent enterprises are likely to be an important factor in determining future, as well as current, innovative performance.

A related observation that was raised in this general discussion of the causes of the R&D deficit was the need to take account of historical processes. In this regard, the importance of first-mover advantages early in an industry's development is salient. More generally, the possibility of cumulative processes of innovation which make contemporary industrial capabilities dependent on historical trajectories may well be an important factor in explaining the EU's R&D deficit.

There seems little question that there are plenty of ideas available about the possible reasons for the success of the US, relative to the EU, in developing new industries like IT

and biotechnology in the postwar period. While the various types of accounts that we have discussed are not necessarily mutually exclusive, the causal interactions that they envisage are very different and this is of crucial importance for policy setting. For example, while an active venture capital industry and a vibrant market for technology stocks could be a cause of success in emerging industries, these characteristics of the US financial markets could also be seen, at least in part, as an outcome of the US having a greater propensity, for other reasons, to generate new companies in these industries in the first place.

We are, as yet, a long way from being able to make strong statements about the way these causal interactions should be understood. Much of the detailed work that has been done on the evolution of these industries was not undertaken to address the questions that EU policy makers need to have answered. The relative importance of different factors in explaining success remains obscure in many of these accounts as does the potential to abstract from the particular circumstances of time and place to generalize about the causes of success. In contrast, many of the general explanations that have been suggested seek to persuade on the basis of their theoretical plausibility but often lack solid empirical evidence to support their claims.

If the possible causes of the problem that policy makers sought to redress were familiar to them, if they were the usual list of issues at which research and innovation policy was directed, there might be an argument for embarking on a policy agenda in the hope of learning by doing. However, this is not the case. Whichever policy direction one chooses from what is currently on offer, be it towards the greater flexibility in labour and financial markets that some commentators advocate (see, for example, the Aho Report) or in the direction of industrial policy to encourage new industries that others would like to see (Cohen and Lorenzi, 2000; for a discussion, see Maincent and Navarro, 2006), it will be strange, new ground for research and innovation policy in the EU. As a result, it is hard to fall back on experience as a substitute for analysis.

4. THE IMPACT OF THE R&D DEFICIT

The discussion so far, in focussing on the nature and causes of the R&D deficit, makes the implicit assumption that this deficit is important. In this section, we subject this assumption to explicit scrutiny by asking not so much whether the deficit is important but how important it is. Addressing this issue seems vital to determining how concerned European policy makers should be about it and what priority they should give to redressing it in the allocation of the time and resources available for research and innovation policy.

There is certainly a widespread presumption that investments in R&D bear some systematic relationship to the process of innovation and, relatedly, that they are important to economic growth. As the Commission put it in the introduction to its "Key Figures 2005":

> It is widely recognised that productivity gains, sustained economic growth and employment are largely determined by technological progress, innovation and human capital. These factors are in turn largely dependent on investments in knowledge (e.g. investments in education and R&D) and their outcomes. (European Commission, 2005, p. 8).

Considerable evidence of the private and social returns to R&D expenditures supports this view. Nevertheless, the identification of a macroeconomic relationship between R&D intensity and economic prosperity has proven elusive. As Temple (1999) points out, there is an ongoing debate about the extent to which comparative patterns in economic growth are explicable, even in part, by changes in R&D intensity. When we look to historical evidence, we also find the relationship between R&D investments and growth to be a rather murky one. For example, as Jones (1995, 2005) observed, it is difficult to see the impact of the large secular increase in US business R&D intensity in a corresponding rise in either per capita income growth or labour productivity growth (Jones, 1995, 2005).

In light of the ambiguity in the relationship between R&D expenditures and economic growth, some commentators have argued that there is an excessive focus on R&D spending in EU policy on research and innovation. On the one hand, the amount of investment in R&D captures only one dimension of what makes the R&D process successful in stimulating innovation. The quality of inputs that go into the R&D process, the allocation of effort to different activities within it and, in general, the productivity of the process that produces new products and processes would also seem to be important but these aspects of the R&D process are only beginning to be subject to systematic scrutiny by scholars and policy makers.

Moreover, the innovation process is not reducible either to R&D expenditures or even to the R&D process as a whole. One important insight of the systems-based approach to technical change and innovation (developed in the *Maastricht Memorandum on European Innovation Policy, Soete and Arundel, 1993*) is that innovation and knowledge generation are based on systemic relations involving many important "nodes". From this perspective, R&D is only one node in the whole system although it may be an important node. Complementary resources and activities at various different levels in the economy -- the EU, the nation, the region, the industry and the firm – are also required for R&D to "work".

Finally, for some industries and types of firms, R&D is not the primary locus of new products and processes. In many service industries, for example, R&D may be unimportant and even irrelevant to innovation performance. And for certain types of firms, such as small enterprises, their innovative efforts may not show up in the form of R&D expenditures.

For all of these reasons, it is misguided to think of R&D expenditures as a magic pill for boosting economic performance. However, to the extent that we define Europe's R&D deficit as reflecting a weakness in IT and other new industries relative to the US, our task goes beyond a discussion of the general relationship between R&D and economic growth

to an evaluation of the specific costs for the EU of lags in these industries. In discussing what we know on this subject, we shall focus mainly on the IT sector because a substantial amount of research has been undertaken to identify the productivity advantages for the US of its leadership in IT and the related disadvantages to the EU of being a follower.

Most of this research is focussed on the late 1990s since it was during this period that the US performed especially well in macroeconomic terms both in historical perspective and relative to the EU region.[3] There are now a large number of empirical studies that link rapid productivity growth in the US, and Europe's less impressive overall performance, to differences in the role of IT in these economies (see, for example, Jorgenson, Ho and Stiroh, 2003; Jorgenson, 2001; Stiroh, 2002; Oliner and Sichel, 2000; Van Ark, Inklaar and McGuckin, 2003). In the summary that follows, we rely primarily on one of these studies by Van Ark, Inklaar and McGuckin (2003) which is a direct comparison of the relationship between IT and productivity in the EU and the US on the basis of a detailed decomposition analysis at the industry level.

So far in this note, in speaking of IT we have been concerned with the IT-producing industries, the manufacturing and services industries that generate new IT products and services, since it is in these industries that the evidence that the EU lags the US is to be found. The relative performance of these industries in the two regions does seem to explain some of the divergence in their overall productivity performance in the late 1990s. From 1995 to 2000 IT producing industries accounted for about 36 per cent of the US lead in aggregate productivity compared with the EU (Van Ark, Inklaar and McGuckin, 2003, p. 9).

However, the most important source of difference in aggregate productivity between the two regions lies elsewhere. It stemmed from the relative performance of IT-using industries which accounted for 73 per cent of the US lead over the EU in aggregate productivity from 1995 to 2000. All of this difference stemmed from the higher productivity growth of IT-using service industries, especially wholesale and retail trade and the financial services industry. IT-using manufacturing industries were actually a drag on overall US productivity performance relative to the EU (Van Ark, Inklaar and McGuckin, 2003, p. 9).[4]

The importance of the IT-using industries, especially the IT-using services industries, to the greater productivity gains from IT that accrued to the US raises one very important question: was the US advantage in this regard related to the presence of a strong group of IT-producing industries? Are there important producer-user interactions at work in IT that increase the motivations and capabilities of IT-using industries in the US to employ the technology to improve their productivity? If so, then this would count as a cost to the

[3] Although, once again, if national variations in macroeconomic performance are taken into account, no such general conclusion can be reached.

[4] In contrast to the IT-producing industries, most of the difference between the US and the EU in the IT-using industries stemmed from higher productivity growth in IT-using services rather than their larger employment share in the economy (Van Ark, Inklaar and McGuckin, 2003, p. 9).

EU of having a weaker IT-producing sector. Alternatively, if the apparent advantage of the US in IT-using sectors is related to other factors, then it should not be seen as a benefit of the US lead in the production of IT nor will the gap be closed by the EU's efforts to increase the strength of its IT producing industries.

Important as this point may be, an undue focus on the contemporary IT sector for evaluating the costs of the EU's lag, relative to the US, in emerging sectors would be unwise. The IT sector is long past its emergent phase and there may well have been important costs of the EU's falling behind in the set of technologies and markets that comprise it that are hard to see now. A wholistic analysis of the costs to the EU of being late in the development of IT would need to take account not only of the current costs of lagging the US but also of the earlier costs, if they can be identified, of doing so. If such an analysis suggests that these costs were large, that does not imply that the EU should seek to redress its lag in the IT sector; it may well be that a window of reasonable opportunity as well as the likely benefits to be recouped by so doing have passed. Instead, a better understanding of what has been lost in IT would provide the context for understanding what might be lost again from falling behind in sectors that are only now emerging although the difficulties of extrapolating from one case to another are, as always, fraught with difficulty.

The Expert Group did raise the question of whether we should focus only on economic outcomes in discussing the implications of the relative positions of the EU and the US in new technology-based sectors. It does seem ironic to be preoccupied with productivity and other economic indicators when the benchmark for success is a country where there has long been a strong emphasis on social goals from national defence to the "war on cancer" as a justification for the country's public policies towards R&D and innovation. Besides the embarrassment of irony, there did seem to us to be good reasons for the EU to become more self-conscious and explicit in evaluating the effectiveness of R&D and innovation, and strength in new technology-based industries in particular, in achieving social goals.

Recent research on the implications for health care of the development of biotechnology suggests that we should not take this effectiveness for granted. In fact, reading the following paragraph from the recent report on Innovation or Stagnation : Challenge and Opportunity in the Critical Path to New Medicinal Products by the US Food and Drugs Administration makes it clear that biomedical research has not been a panacea for, US health care (for a more general discussion of the fruits of biomedical research, see Nightingale and Martin, 2004):

> Today's revolution in biomedical science has raised new hope for the prevention, treatment, and cure of serious illnesses. However, there is growing concern that many of the new basic science discoveries made in recent years may not quickly yield more effective, more affordable, and safe medical products for patients. This is because the current medical product development path is becoming increasingly challenging, inefficient, and costly. During the last several years, the number of new

> drug and biologic applications submitted to FDA has declined significantly; the number of innovative medical device applications has also decreased. In contrast, the costs of product development have soared over the last decade. Because of rising costs, innovators often concentrate their efforts on products with potentially high market return. Developing products targeted for important public health needs (e.g., counterterrorism), less common diseases, prevalent third world diseases, prevention indications, or individualized therapy is becoming increasingly challenging. In fact, with rising health care costs, there is now concern about how the nation can continue to pay even for existing therapies. If the costs and difficulties of medical product development continue to grow, innovation will continue to stagnate or decline, and the biomedical revolution may not deliver on its promise of better health.

Clearly there is more work to be done to understand the costs to the EU of falling behind, relative to the US, in the production of IT, biotechnology and other emerging technologies. What we know so far suggests that EU policy makers need to be very clear about what it is they hope to gain from attempting to redress the EU's lag in sectors such as IT, biotechnology and other new industries. Especially to the extent that policies to overcome these lags are broader in scope and impact than the norm for contemporary research and innovation policy, it seemed crucial to us that we be clear that the benefits merit the costs involved.

5. CONCLUSION

Throughout this note, we have emphasised the importance of being very clear about what we mean in speaking of Europe as having a deficit in R&D. If we are primarily interested in designing research and innovation policies for national economies, then the R&D deficit makes little sense as a guide since it is impossible to identify a general deficit that applies across the MS. If, instead, we focus on the EU as a whole, and the Expert Group believed that it was possible to make a good case for doing so, then the idea of a deficit does have meaning, at least if the US is the appropriate benchmark for evaluating its R&D efforts. However, this deficit has a very specific location. It is concentrated in IT and, perhaps, in other new industries and it seems to be related to the challenges that confront certain types of firms – new firms that seek to grow large – more than Europe's leading firms.

Our discussion of the nature of the deficit suggests the need for a much sharper distinction between research and innovation policy for the EU and for the MS. It may well be that it is appropriate to define EU policy to target specific problems in research and innovation that cut across the MS and to design policies to redress them. However, these EU policies should not be mechanically transposed to the MS to the extent that the national characteristics and challenges of their research and innovative efforts have not been taken into account in the formulation of EU targets and policy.

Relatedly, one would do well to ask whether the very specific challenges that we have described for the EU economy should be discussed in terms of a n R&D deficit. The language of a European R&D deficit certainly seems to connote a general problem of deficient R&D expenditures throughout the EU. This is clearly misleading not only because it does not apply across MS but also given how sectorally concentrated the deficit seems to be. In addition, to the extent that the problem can be traced to the difficulties that entrants to new industries confront in growing to become major players, their deficient R&D expenditures are as much an outcome as they are a cause of that problem. The real challenge would seem to be better described as a deficit in enterprise dynamics in new sectors even if, for want of a less unwieldy term, we have continued to speak in the more concise terms of a deficit or an R&D deficit.

Our discussion of the causes of the EU-level deficit, as we have summarised it above, highlights the importance of a wide range of factors from the structure of capital and labour markets to the role of government in stimulating and subsidising technological development. However, we emphasised that although ideas abound about the causes of the deficit most of them have not been tied in a rigorous way to the outcomes that they seek to explain. Moreover, many of the explanations seem more consistent with general shortcomings in R&D in Europe rather than the very specific problems that we have highlighted for particular industries and types of firms. There seems little question that more work needs to be done to identify the general causal interactions and dynamics involved in the emergence of new industries if policy making in this area is to be systematic. This is particularly important since whichever causes are found to be the most salient, they will force research and innovation policy out of its normal realm if it seeks to redress them.

That should also motivate policy makers to be very clear about what benefits they expect to derive from their efforts to overcome the EU's lag in new industries. We already know that it will be a hard problem to redress so we ought to be cognizant of exactly what it is that we might expect to achieve in seeking to overcome it. Evidence of the contemporary sources of the productivity benefits that accrue from IT suggests that we ought not to assume that the presence of a strong IT-producing sector will generate these benefits. Most of these benefits have accrued through the use of IT, especially in services, so it is only if an important interaction between user and producer industries is necessary to achieve these benefits, that this might be so.

Of course, to focus exclusively on the contemporary benefits that accrue to a strong IT-producing sector would be a mistake in evaluating the costs of the EU's lag, relative to the US, in emerging sectors. The IT sector is long past its emergent phase and there may well have been important costs of the EU's falling behind that are hard to see now. Even if a comprehensive analysis suggests that these costs were large, however, that does not imply that the EU should seek to redress its lag in the IT sector; it may well be that a window of reasonable opportunity as well as the likely benefits to be recouped by so doing have passed. Instead, a better understanding of what has been lost in IT would provide the context for understanding what might be lost again from falling behind in

sectors that are only now emerging although the difficulties of ext rapolating from one case to another are, as always, fraught with difficulty.

The Expert Group also emphasised that we ought not to focus only on economic outcomes in discussing the impact of the EU's lag in emerging technologies. Indeed, in cases such as biotechnology, nanotechnology and new materials as well as environmental technologies, the social implications of leads and lags seem just as important to us. Yet, as recent research on biotechnology suggests, we cannot assume that these technologies are panaceas in improving health care and other social policies. As for the economic realm, serious effort is required to evaluate the social costs and benefits of being leaders or laggards in these fields.

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