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How to Turn on the Innovation Growth Machine in Europe?

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ABSTRACT

This contribution takes a close look at the evidence on Europe's innovation performance. Europe maintains an innovation system, with a few well performing countries, in which a slow process of convergence is taking place over time, but which continues on average to score badly when compared to its major competitors, particularly the US. Within the innovation eco-system, it is particularly the business sector that generates an innovation deficit. This business sector deficit is highly persistent over time. The lack of young innovative companies (Yollies) in young innovation based growth sectors is the major source of Europe's lagging business innovation deficit relative to the US. Europe simply has too few Yollies in the right sectors, which can form the nucleus for a capacity to shift towards new opportunities for growth. Access to early stage risk finance and industry science links are important for young firms with highly innovative growth projects. In both of these dimensions, Europe scores weaker than the US, The evidence suggests that policies aimed at raising R&D expenditure across all types of industries and companies does not address the root causes of Europe's innovation deficit. To do this, policies need to address the specific barriers to development of new high R&D-intensity sectors and companies. This includes inter alia access to external finance for fast growing highly innovative projects, by public funding and/or by leveraging private risk funding.

CONTENTS

1. INTRODUCTION

Europe maintains lofty ambitions for building its future growth and prosperity and safeguarding its social model through innovation. The European Union carved its ambition to become the most competitive *knowledge based* economy in the world into its 2002 Lisbon Strategy. And in its subsequent EU2020 strategy and Innovation Union Flagship, it set out a roadmap for a sustainable and inclusive growth that needs to be *smart*. An ambitious target of devoting 3% of GDP to R&D by 2010 was already set in 2002. The same 3% was again targeted in the EU2020 strategy.

Despite this policy of attention to innovation-based growth and R&D targeting, Europe's performance on innovation remains weak to date. As an example, the R&D-to-GDP ratio is making no progress and remains below 2%. *Why is it so hard to improve Europe's innovative performance? Does Europe have the capacity for knowledge based growth?*

This contribution takes a close look at the evidence on Europe's innovation performance (section 2). Europe's performance on R&D investment is examined within a broader evaluation of its innovation capacity, going beyond R&D *sensu stricto*. We look at heterogeneity across European countries: *Do some countries or parts of Europe do better than others? Is there a convergence over time among European countries in innovation capacity along a process of integration?* The analysis finds that Europe maintains an innovation system, with a few well performing countries, in which a slow process of convergence is taking place over time, but which continues on average to score badly when compared to its major competitors, particularly the US. Within the innovation eco-system, it is particularly the business sector that generates an innovation deficit. This business sector deficit is highly persistent over time.

Why does Europe's business sector, despite having some top performers, have a persistently lower innovative capacity on average when compared to the US? Section 3 looks at the age and sector composition of Europe's business innovation structure. It identifies the lack of young innovative companies (Yollies) in young innovation based growth sectors as the major source of Europe's lagging business innovation deficit relative to the US. Europe simply has too few Yollies in the right sectors, which can form the nucleus for a capacity to shift towards new opportunities for growth.

The obvious next question examined is *why Europe is less capable of nurturing strong innovative firms in new sectors, which can turn new ideas into growth and jobs? What are the major impediments facing innovative firms in new sectors in Europe? Lack of finance? Lack of skills? Lack of demand?* Section 4 focuses on the impediments that hamper young firms with highly innovative growth projects, namely access to early stage risk finance and industry science links.

Section 5 ends with some policy implications. *What can Europe do to make its ambitions for a knowledge based growth more realistic?* A policy agenda that can tackle the systemic deficit is not easy to establish and requires a long-term commitment to support innovation. The substantial heterogeneity between European countries can be viewed as "a glass half full", suggesting scope for catching-up by learning from best practices. However, in view of the relatively slow pace of convergence, the glass can also be seen as half empty, with innovation-based growth only realistic for a handful of smart specializing countries.

2. THE CONTRIBUTION OF INNOVATION TO GROWTH

Before starting the analysis on innovation, we first briefly illustrate the importance of innovation as a source of growth for Europe. *Why do we care about innovation? Is it important as source of growth? For all European countries?*

The table below shows the contribution to growth from innovation for European Union countries in the pre-crisis period (1998-2008). It uses Total-factor productivity (TFP) as a measure for innovation. TFP is a 'residual' growth factor not caused by capital and labour, commonly interpreted as reflecting technological progress[2].

The table shows that there is substantial heterogeneity in TFP contribution depending on the level of technological development of the country. TFP is more important for growth for older Member States countries than for 'catching-up' countries and is so for both sub-periods considered, although there is some convergence over time. But even within both blocks there is substantial heterogeneity. There are substantial differences between the older countries, with TFP accounting for 60% of growth in Sweden & Finland, 70% in Germany versus only 10% in Italy. The share of TFP in potential growth has diminished over time in the non-frontier countries, increasing further the difference between frontier and non-frontier countries in the block of older countries.

Among the 'catching-up' countries, there are substantial differences between EU-12 and the former cohesion countries, with TFP much more important for growth in the EU-12 in the earlier period. The contribution of TFP to potential growth declined substantially over time in this group. Among NMS, the Czech Republic has the highest TFP share in growth (63% in 2003-2008), while Bulgaria is at the bottom (23% in 2003-2008)[3]. Also among the former cohesion countries, there is substantial heterogeneity: Ireland has 33%, while Spain only 6%.

[2] As a 'residual', TFP basically accounts for effects in total output growth not caused by capital and labour. TFP is commonly interpreted as a measure of the technology of production and its rate of growth as a measure of technical progress (World Bank, 2008, p.54). Being a residual concept, TFP calculations are plagued by substantial measurement errors. Nevertheless, the concept is widely used for measuring the contribution of innovation to growth.

[3] Also Iradian (2009) found wide heterogeneity across countries in the contribution of TFP to growth. Iradian's (2009) TFP calculations for 1996-2006 showed that the average annual TFP growth in the Commonwealth of Independent States (CIS) was higher than in central Europe and in six south-east European economies, but was lower than in the Baltic states. The central and eastern European (CEE) region also exhibits wide heterogeneity, with the Baltic states and Poland scoring high in terms of the TFP contribution, while Romania, Bulgaria and the Czech Republic score low.

Table 2.1: Growth and TFP Contribution in Europe (1998-2002/2003-2008)

	Potential Growth		**TFP Contribution**		**TFP share in Growth**	
	1998-2002	**2003-2008**	**1998-2002**	**2003-2008**	**1998-2002**	**2003-2008**
US	3.20	2.5	1.3	1.1	41%	43%
EU-27	2.45	2.26	1.18	0.97	48%	41%
Older MS (11)	2.17	1.91	1.16	0.95	53%	46%
Frontier (4)	1.82	1.60	1.22	1.08	67%	67%
Non-Frontier (7)	2.35	2.06	1.13	0.88	48%	43%
'Catching-up' countries (16)	3.8	4.02	1.26	1.09	33%	37%
EU-12	3.47	4.89	2.13	2.20	61%	33%
Former Cohesion (4)	3.96	3.66	0.88	0.60	22%	27%

Source: Own calculations on the basis of EC-ECFIN Ameco, 2008; Note: Frontier countries are SWE, FIN, DK, DE. 'Catching-up' countries include the Transition/12 NMS as well as the 4 former Cohesion countries (ES, IE, PT, EL).

Overall the TFP evidence shows the importance of innovation for growth in Europe. At the same time, it shows there is considerable heterogeneity across European countries in the importance of TFP for growth. This is not a simple older/newer Member States divide. Particularly striking is the low contribution in Italy, Greece, Spain and Portugal. Country heterogeneity prevails not only on the importance of innovation for growth, but one may also expect a large heterogeneity across countries in what this "residual" TFP component entails. The next section will investigate directly the innovation dimensions that go into the TFP component.

3. EUROPE'S DEFICIT IN INNOVATION PERFORMANCE

Does Europe have the capacity for innovation based growth? For assessing a country or region's innovative capacity, defined as the ability of a system not only to produce new ideas but also to bring them to markets and translate them into economic growth and prosperity, a range of factors deemed important for effective innovation effort need to be explored. Going beyond the availability of R&D inputs, R&D infrastructure and financing, this also includes the presence of incentives for innovation efforts and for being able to capture value when introducing innovations (Furman *et al* (2002)). The latter includes the presence of markets for innovations and clear IPR regimes.

This section will assess Europe's capacity for innovation-based growth compared to its major international benchmarks. To this end, it will not use the residual TFP concept, but will revert to direct evidence for the various dimensions composing a nation's innovation capacity.

A. EUROPE'S OVERALL INNOVATION CAPACITY DEFICIT

A broad indicator for assessing a country's innovation capacity is the Innovation Union Scoreboard (IUS) indicator, developed by the European Commission in support of its Innovation Union Strategy[4,5].

According to this IUS indicator, Europe is not doing well. The US has the highest IUS score, closely followed by Japan. The US score in 2010 was 49% higher than the EU27. Furthermore, this gap has remained very stable over the period considered (2006-2010), with little catching up by Europe. In 2006 it stood at 46%. Europe still has a substantial lead relative to the emerging markets, but especially China is fast catching up (IUC 2011)).

Europe's gap relative to the US holds across almost all individual indicators that go into the IUS score. This is a reflection of the *systemic* nature of Europe's failing innovation capacity. Only on public R&D expenditures is there a small (and increasing) European lead (-13%). [6] On private R&D expenditures, however, the US lead is substantial (61%). The following section looks into these public and private R&D expenditures in more detail.

B. EUROPE'S DEFICIT IN R&D EXPENDITURES

A crown indicator used to assess a nation's innovative capacity is its investments in R&D at a globally competitive level. R&D investment, both public and private, is crucial for the development of new scientific and technological knowledge and for building the capacity to absorb and use this knowledge. And as knowledge is produced and used by people who need to have the right skills, investment in particularly tertiary education also needs to be assessed. Too low investment levels signal a problem in the supply of innovative resources. At the same time, a lack of private investment may reflect too low incentives as a result of problems on the demand side or from appropriation difficulties. This section analyses Europe's investment in knowledge generation, covering R&D and tertiary education, public and private expenditures.

Europe's R&D-to-GDP-ratio currently stands below 2%, significantly lower than the US, Japan, South Korea and Singapore. Furthermore, there are relatively few signs of progress, despite the Barcelona target of 3% set in 2002 by European Union countries. China is fast catching up and already on par with the EU.

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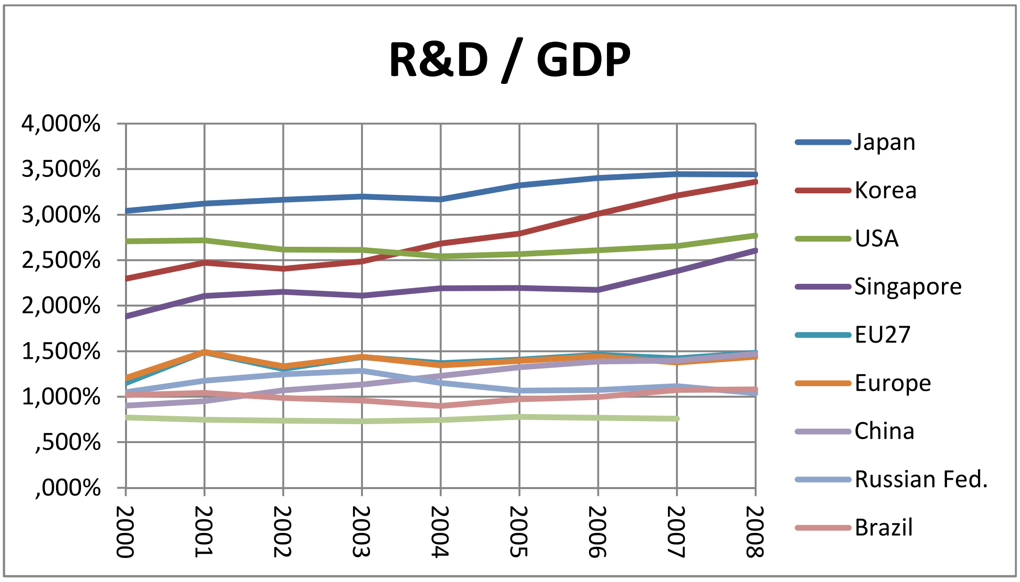
[4] IUS is a composite indicator capturing 8 dimensions of innovation: Human Resources, Research Systems, Finance, Firm Investment, Linkages, IPR, Innovations, Economic Effects. For the international benchmarking of Europe, it uses information from 12 indicators to assess these 8 dimensions.

[5] The correlation between the TFP-to-growth ratios for the EU27 countries (2003-2008) and the IUS score for 2008 shows a correlation coefficient of +0.30. Within the group of older MS this correlation is much more stable with a coefficient of +0.70. Within the group of 'catching-up' countries, the correlation is much weaker, even negative -0.30. All this suggests that the content of TFP being a residual indeed varies substantially according to country category, with other components beyond innovation composing TFP in Europe's 'catching up' countries.

[6] Also on knowledge-intensive service exports there is a slight lead over the US as well as Japan. India is a stronger performer in this area, being the lead country on this dimension.

Figure 3.1: R&D Expenditures as a Share of Economic Output of Selected Countries: 2000–2008



Source: Based on UNCTAD data; Note: Europe includes EU-27 Norway, Switzerland, Albania, Bosnia, Croatia, Iceland, Serbia, Turkey.

Europe's gap in overall R&D investment levels is due to the business component, as Table 3.1 details. Furthermore, while the public R&D component relative to GDP has been improving over time and even outpaced the US and Japan in 2009, private R&D investments continue to lag behind the US. Also compared to Japan and South Korea, Europe maintains a gap in business R&D to GDP.

Table 3.1: Private and public R&D

	Business RDtoGDP 2000	Business RDtoGDP 2009	Government RDtoGDP 2000	Government RDtoGDP 2009
EU	1,21	1,25	0.64	0.74
US	2.01	2.01	0.59	0.65
Japan	2,16	2,70	0.74	0.69
SKorea	1,70	2,54	0.56	0.78
China	0,54	1,12	0.36	0.41

Source: IUCR 2011; Note: US public R&D does not include capital expenditures.

4. TRENDS IN HETEROGENEITY IN EUROPE ON INNOVATION

Do some countries or parts of Europe do better than others on innovative capacity? Heterogeneity in innovative capacity should not come as a surprise, as section 4.1 briefly discusses. But along a process of economic convergence *do we also see a convergence in innovative capacity in Europe?* The evidence detailed in this section will show that Europe is not a homogeneous block when it comes to innovation. European countries rather are marked by heterogeneity in their innovation capacity. Although integration has resulted in some level of convergence in innovation, the pace of convergence is slow. There still remain substantial country differences, not only in terms of stock of knowledge, but also varying capacity to leverage knowledge into growth.

A. HETEROGENEITY IN INNOVATION FROM DIFFERENCES IN DEVELOPMENT

What can we expect in terms of heterogeneity in innovative capacity in Europe and convergence in innovative capacity? An important dimension explaining heterogeneity across countries in their innovation capacity relates to differences in levels of initial development and a country's initial position relative to the technology frontier (Aghion & Howitt (1998)).

For countries still at early stages of development, far from the technology frontier, technology contributes to growth through the country's ability to effectively absorb new technologies (World Bank, 2008; Lall 2002). There are two key ingredients explaining differences across countries in effective technology take-up. The first is ***access to (foreign) technology***. This requires openness through trade, foreign direct investment (FDI) and other forms of international cooperation. Second, access to (foreign) knowledge needs to be combined with a sufficiently developed indigenous 'absorptive capacity' (Cohen and Levinthal, 1990) or 'social capability' (Abramovitz, 1986), in order to deliver growth. This ***absorptive capacity*** depends on many factors, including the extent to which a country has a technologically literate workforce and has adequate public sector institutions to promote the take-up of critical technologies when private demand or market forces prove inadequate (World Bank, 2008).

For countries at higher levels of development, closer to the technology frontier, ***indigenous innovative capacity*** comes into play (Hoekman et al, 2005). At this stage, countries require technological know-how, reflected in public and private R&D resources. They also need to be able to incentivise or reward innovation (e.g. Furman et al, 2002).

A set of factors shaping the country's capacity for a virtuous innovation-growth link needs to be present. In addition to R&D, technology and ICT infrastructure, these additional factors include access to large markets, (international) openness of markets, competition, access to a highly educated and skilled population (especially tertiary level), well-developed financial markets and, finally, quality institutions. It is important to note that these factors should not be seen in isolation, but as part of a **system of key prerequisites** for innovation-based growth. The relative importance of each these factors in the required system depends on the level of initial development and a country's initial position relative to the technology frontier. We can thus expect substantial heterogeneity among European countries, because of different capacities to put in place a virtuous innovation-growth eco-system, but also because of differences in initial conditions requiring eco-innovation systems composed in a different way. At the same time, we can also expect the process of economic convergence to push convergence in innovative capacity.

B. EMPIRICALLY ASSESSING HETEROGENEITY IN INNOVATION WITHIN EUROPE

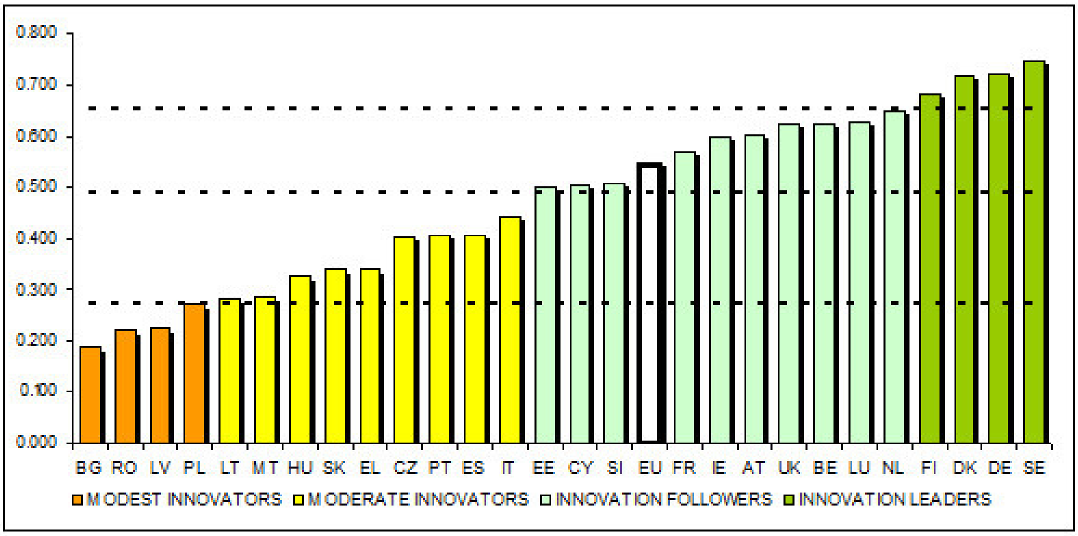
To measure heterogeneity, we use the σ-coefficient, i.e. the coefficient of variation (√VAR/MEAN). σ-convergence occurs when the dispersion across a group of economies decreases over time (Quah, 1996).

1. DIFFERENCES IN INNOVATION CAPACITY

To capture the heterogeneity across European countries on the different dimensions of innovation capacity needed to transfer technology into growth, we revert to the summary assessment of the EC's Innovation Union Scoreboard (UIS), as it assesses a broad range of factors of relevance for assessing innovative capacity (cf. supra): Human Resources, Research Systems, Finance, Firm Investment, Linkages& Entrepreneurship, IPR, Innovations, Economic Effects.

For the comparison across the 33 European countries considered, it uses information from 24 individual indicators to assess the 8 dimensions of the Innovation System.

Figure 4.1: Intra-European Heterogeneity on Innovation Capacity (2011)



Source: Innovation Union Scoreboard (IUS) 2012.

In the 2011 IUS exercise, the best performing (frontier) countries were Sweden, Denmark, Germany and Finland[7]. The weakest group of countries includes most transition economies. At the bottom, we have Latvia, Bulgaria, Lithuania, Romania.

The innovation divide in Europe, however, does not follow a simple transition divide. The weakest group of countries also includes some of the older Member States, most notably, Greece, Spain, Italy and Portugal. At the same time, some of the transition countries, in this instance Estonia and Slovenia, have already made it into the lower-middle group of innovative countries. It also does not follow a simple development 'catching-up' divide, with Italy as the clearest negative outlier as a developed European country with a low innovative capacity. Among the former cohesion countries, catching up in innovative capacity differs substantially. Ireland is the best performer and has already made it into the middle group, above the EU average[8].

[7] Note that it is not possible to compare this IUS ranking with the US, as only 12 of the 24 indicators used to construct IUS are also available for the US.

[8] Similar results were also found by Radosevic (2004)). In addition to a high-tech "north" cluster composed of four countries with the highest national innovation capacities in EU (Finland, Sweden, Denmark and UK), he obtained two other clusters comprised of the majority of the 'catching-up' MS as well as some other MS.

As Table 4.1 shows, the coefficient of variation on the IUS score is high, illustrating the high level of heterogeneity on innovation capacity in Europe. Although it has slightly decreased in the period 2006-2010, reflecting a slow process of σ-convergence, dispersion remains substantial. This dispersion holds between frontier and 'catching-up' countries as the difference in average scores of both groups demonstrates (Panel B). Over the time period considered, a slow catching-up has taking place between the 'catching-up' and the frontier countries in Europe, as the gap scores indicate, but the gap remains considerable. Within both groups, however, there is also substantial heterogeneity, particularly in the group of 'catching-up' countries, as the coefficient of variation indicates (Panel C). This dispersion has only slightly decreased in the period considered. Also in the group of frontier countries, the gap between the top 5 and the rest is highly stable over time.

Table 4.1: Heterogeneity in Europe in Innovation

Panel A: Within Europe

IUS	**2006**	**2010**
Average Europe	0.41	0.45
Coefficient of Variation	0.43	0.40
Top countries	SE, CH, DK, DE, FI (0.758-0.638)	CH, SE, DK, FI, DE (0.831-0.696)
Bottom countries	BG, LV, TK, RO (0.159-0.219)	LV, TK, BG, LI, RS,RO (0.201-0.237)

Note: The range, in brackets, of IUS scores for the group of countries considered[9] Europe also includes, in addition to the EU-27, Switzerland and accession countries.

Panel B: Frontier versus 'Catching-up'

IUS	**2006**	**2010**
Average Frontier countries	0.59	0.62
Coefficient of Variation	0.20	0.19
Average 'Catching-up'	0.30	0.34
Coefficient of Variation	0.36	0.33
Gap 'Catching-up'/Frontier (=100)	0.51	0.55

Note: The 'catching-up' countries include the NMS, the 4 former cohesion countries, the other transition countries and Turkey. There are 13 frontier countries (AT, BE, DK, FI, FR, DE, IT, LU, NL, NO, SE, CH, UK).

Panel C: Within Frontier; Within 'Catching-up'

IUS	**2006**	**2010**
Average Frontier countries	0.59	0.62
Top 5	0.70	0.74
Non-Top 5	0.52	0.55
Average 'Catching-up'	0.30	0.34
Former Cohesion Countries	0.39	0.44
NMS	0.29	0.33
ACC	0.27	0.29

Note: The Top 5 countries are SUI, SE, GE, FI, DK; Former cohesion countries are ES, PT, IE, GR;
Source: based on Innovation Union Scoreboard (IUS) 2011;

One cluster is composed of the 3 cohesion states (Spain, Portugal and Greece) and 6 less advanced NMS (Slovakia, Romania, Latvia, Lithuania, Poland and Bulgaria). They are characterized by rather weak national innovation capacities. The 4 more advanced NMS (Czech Republic, Slovenia, Estonia and Hungary) together with 6 old MS (Austria, Belgium, Germany, France, Italy and Ireland) form a kind of a "middle level" group of the EU.

[9] We do not report on LU, MT, CY, MK, IC, given their small size.

2. DIFFERENCES IN BUSINESS R&D INVESTMENT

As section 3 showed the business sector to be responsible for the R&D intensity gap of Europe relative to the US and Asia, and as this dimension shows a persistent time pattern, we further zero in on heterogeneity across European countries in the business component of R&D expenditures.

Table 4.2: Business R&D expenditures (BERD) in Europe

Business R&D as % of GDP	**2004**	**2008**
Average EU-27	1.16	1.21
Coefficient of Variation	0.98	0.86
Top countries	SE, FI, CH (2.63-2.14)	FI, SE, CH, DK (2.76-2.01)
Bottom countries	BG, TK, PL, LI, EL, LV, RO (0.12-0.21)	RS, BG, LV, EL, RO (0.10-0.17)

Source: Own calculations based on IUS (2010).

The heterogeneity in Business R&D performance across European countries is substantial, as the coefficient of variation shows. And although the coefficient of variation has decreased over time, demonstrating σ-convergence, the pace of convergence is slow. The process of convergence in Business R&D (BERD) intensity is even slower than the convergence in total R&D intensity (Business and Public) (Veugelers & Mrak (2009)).

The countries best performing overall on innovation capacity are also the countries with the strongest position in Business R&D investments. Switzerland and the Scandinavian countries, Sweden, Finland, and Denmark have the best Business R&D-intensity performance, even better than the US (cf. Table 2.1). At the bottom of the ranking are most of the transition countries, although Greece also scores persistently low on this indicator. These countries are also at the bottom of the overall innovation score. Although there is some reshuffling in country positions over time, the top and bottom group of countries are a relatively stable set.

Overall, the data show an extreme immobility in business R&D performance in Europe, with a persistent gap of Europe relative to the US and Asia. At the same time, there is a substantial heterogeneity within Europe, which goes beyond the EU-12/NMS divide and also involves countries like Greece at the bottom. The process of convergence/catching up within Europe is very slow, with a very stable ranking of European countries over time on business R&D performance.

5. EUROPE'S PERSISTENT BUSINESS R&D PERFORMANCE DEFICIT RELATED TO AGE & SECTOR COMPOSITION EFFECTS

The continued business R&D deficit is central in Europe's innovation deficit. It is a symptom of the overall weakness in Europe's capacity to innovate and its low capacity for structural change and shifting towards new growth areas.

What explains this continued business R&D deficit? Why does Europe's business sector have less innovative capacity on average when compared to the US, despite its top performers? as In line with O'Sullivan (2008) Aghion et al. (2007) and others, we will claim that Europe's persistent business innovation gap is correlated with its industrial structure. New firms fail to play a significant role in the dynamics of European industry, especially in the high-tech sectors. This is illustrated by their inability to enter, and more importantly, for the most efficient innovative entrants, to grow to world leadership. The churning that characterizes the creative destruction process in a knowledge based economy encounters significant obstacles in the EU, suggesting barriers to growth for new innovating firms that ultimately weaken Europe's growth potential. Bartelsman et al. (2004) found that post entry performance differs markedly between Europe and the US, which suggests the importance of barriers to company growth as opposed to barriers to entry. This inability for new European firms to grow large seems to manifest itself particularly in the high-tech, high-growth sectors, most notably the ICT sector (Cohen and Lorenzi (2000)). This correlates with a lower specialization of the European economy in R&D intensive, high growth sectors of the nineties, again most notably the ICT sectors (O'Mahoney & van Ark (2003), Denis et al. (2005), Moncada et al. (2009)).

This structural European innovation deficit story, related to company age and sectoral make-up of its economy, has recently attracted much attention. It has been investigated in more detail in a Bruegel Policy Brief and Contribution (Veugelers & Cincera (2010)), decomposing the JRC-EC-IPTS Industrial R&D Scoreboard (European Commission 2008) figures of global R&D expenditures of leading innovators by age cohort and sector. Their analysis confirms that the major source of Europe's lagging business innovation deficit relative to the US is the lack of young companies that have grown into world-leading innovators ("Yollies") in new innovation based growth sectors[10].

A. EUROPE'S LEADING INNOVATORS' AGE COMPOSITION

Does Europe have a different age composition in its leading innovators? Is it missing young leading innovators? And if this is the case, does that explain its business R&D deficit? Yes;

Among the US's leading innovators in the Industrial R&D Scoreboard, more than half are "young" (i.e. born after 1975). We label these young world-leading innovators "Yollies". US Yollies include Microsoft, Cisco, Amgen, Oracle, Google, Sun, Qualcomm, Apple, Genzyme, Ebay ,… By contrast, in Europe only 1 out of 5 leading innovators is "young".[11] In the US, Yollies account for 35% of total R&D, in Europe this is a mere 7%! Japan represents the "old" model, with almost no young companies among its leading innovators.

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[10] Due to data restrictions, this analysis can only be performed at the aggregate EU level. As the number of observations quickly diminishes, particularly when age groups in sectors in regions have to be analysed, the level of individual European countries cannot be used for analysis.

[11] Of the 74 European Yollies in the Scoreboard, 20 are UK based. Switzerland, France and Germany each have 9, while the Netherlands has 8 Yollies. In relative terms, when looking at the share of Yollies among a country's total number of leading innovators, Italy, consistent with its low ranking in the IUS, does poorest with only 3%, but also Germany and Sweden only have a mere 4%, far below the European average of 7%. The Netherlands with 15% is above average. Switzerland, the top IUS country, scores highest in Europe with 24%. But even this share is still significantly below the US with its 35%. European Yollies include UK based Vodafone in telecom services, UK Shire specialising in biopharmaceuticals, Swedish Hexagon in measuring technologies, Dutch ASML in semiconductors and French Ubisoft in entertainment software.

Table 5.1: Share of Yollies in Number of Companies, R&D, Sales and Employment

By region (2007) (in %)

	Europe	US	Japan	World
Number of Leading Innovators	357	425	207	1111
Number of Young Leading Innovators	74	219	4	368
Share of Young Companies in Region's Leading companies	21	52	1.9	33
Share of Young Companies in Region's Leading R&D	7	35	0.5	19
Share of Young Companies in Region's Leading Net sales	5	16	1.9	10
R&D intensity of Ollies	2.8	3.5	3.7	3.1
R&D intensity of Yollies	4.4	10.2	1.1	6.3

Source: Based on Veugelers & Cincera (2010).

As Table 5.1 shows, the share of Yollies in R&D is higher than their share in Net Sales, indicating that Yollies have a higher R&D intensity compared to their older counterparts. But for the US this differential is more outspoken, leaving a higher R&D intensity differential for US Yollies when compared to Europe.

The R&D intensity of European leading companies, whether old or young, is on average smaller than the world average, and particularly compared to the US. With the US benchmarked at 100, Europe's overall R&D intensity-gap-score is 63%. This gap holds both for Ollies and Yollies. But the difference is more pronounced for Yollies. While Europe's R&D intensity-gap-score is 80% for Ollies, this score for Yollies is 43%.

The lower overall R&D intensity of Europe's leading innovators can thus be explained by the combination of the following facts:

- Europe has less Yollies than the US. This matters because Yollies have a higher R&D intensity when compared to Ollies;
- Europe-based Yollies are less R&D intensive than their US counterparts;
- Also European Ollies are less R&D intensive than their US counterparts.

As the difference in RDI between Europe and the US is small for Ollies, most of the weight allowing us to explain the overall RDI deficit comes from Yollies: not only that Europe has less of them, but particularly the Yollies that Europe has, are less R&D intensive[12].

B. EUROPE'S LEADING INNOVATORS' SECTOR COMPOSITION

Is Europe specializing in the wrong sectors? Yes!

To analyse the sectoral composition problem for explaining Europe's lagging business R&D deficit, we look at the sectors in which Europe specializes its R&D activities. We are particularly interested in the position of Europe in the sectors that offer the largest scope for knowledge-based growth. To

[12] In Veugelers & Cincera, (2010), a decomposition analysis is performed to calculate the exact size of these effects. This decomposition analysis shows that the deficit on the Old Leading Innovators is small and of only minor importance to explain the overall poor innovation performance of Europe. The most important factors to explain Europe's overall poor business R&D performance are that Europe has less Yollies, but particularly that the Yollies it has are less R&D intensive. This last effect accounts for more than half of the business R&D deficit with the US.

this end, we identify sectors that (i) have an R&D intensity above average, (ii) an R&D growth rate above average and/or (iii) an above average share of young companies among its leading innovators. This set of sectors includes *aerospace, biotechnology, computer hardware & services, health care equipment & services, internet, pharmaceuticals, semiconductors, software, telecom equipment*. These are all sectors in the ICT and the health nexus. We label these sectors innovation-based growth sectors (IBG sectors).

Table 5.2 shows the sectors in which Europe is specializing its R&D efforts. The IBG sectors are indicated in italics. It confirms that Europe specializes its R&D in sectors characterized as medium R&D intensive, found also by Moncada et al. (2009). These include *aerospace, automobiles, chemicals, electrics, industrial machinery*, *telecom services*. None of these sectors are young or have a high R&D-intensity. All of them are older, medium R&D intensive sectors. Furthermore, *automobiles, chemicals* and *electrics,* are sectors with below average R&D growth. When looking at the individual IBG sectors (in Italics in Table 5.4), Europe only has an RTA in *aerospace, pharmaceuticals and telecom equipment*, of which only the latter is a “young” sector. The US, by contrast, is specializing in all IBG sectors.

Table 5.2. Sector Specialisation of R&D activities (RTA Indexes)

	EUR	**US**
Aerospace & defence	*1,5*	*1,13*
Automobiles & parts	1,26	0,58
Biotechnology	*0,32*	*2,2*
Chemicals	1,31	0,64
Commercial vehicles & trucks	1,3	1,06
Computer hardware & Computer services	*0.08*	*1,39*
Electrical components & equipment	1,56	0,18
Electronic equipment & Electronic office equipment	0,18	0,37
Fixed & Mobile telecommunications	1,53	0,2
Food,Beverages & Tobacco	0,92	0,74
General industrials	0,61	1,49
Health care equipment & services	*0,7*	*1,86*
Household goods	0,84	1,6
Industrial machinery	1,84	0,24
Industrial metals	1	0,3
Internet	*0*	*2,54*
Oil	1	0,85
Personal goods	1,44	0,69
Pharmaceuticals	*1,27*	*1,16*
Semiconductors	*0,5*	*1,72*
Software	*0,51*	*2,05*
Support services	0,78	1,19
Telecommunications equipment	*1,38*	*1,09*
All IBG sectors	***0.89***	***1.43***

Note: RTAs are calculated as the share of the region in total sectoral R&D relative to the share of the region in overall R&D. An RTA value higher than 1 reflects that the region is technology specialized in this sector. IBG sectors are in italics;
Source: Based on Veugelers & Cincera (2010).

C. EUROPE'S LEADING INNOVATORS' AGE & SECTOR COMPOSITION

Is Europe lacking young leading innovators in better sectors? Yes!

Europe's sectoral composition, with a failure to specialize in the sectors with the biggest opportunities for knowledge-based growth, does not only explain Europe's overall lagging R&D performance. It can also explain why Europe's young leading innovators are underperforming on R&D, as diagnosed supra. European Yollies are operating more significantly in less R&D intensive sectors (the so-called structural effect), rather than because European Yollies are less R&D intensive when compared to their US counterparts in the same sectors (the so-called intrinsic effect).

Table 5.3 shows that Europe has significantly less of its Yollies in the sectors with the highest opportunities for innovation-based growth. In the Internet sector, Europe has no company that has achieved Leading Innovator status. This contrasts with the US, which has champions like Google, Amazon, EBay, Yahoo. Also in biotechnology, Europe has less Yollies when compared to the US. Both of these sectors thus serve to illustrate Europe's inability to raise young innovators to leading status in sectors with high innovation-based growth potential (structural effect). But the young innovators it has in these sectors are as R&D intensive as their US counterparts, if not even more. This holds particularly in the ICT sectors. Table 5.3 thus confirms that the lower R&D intensity of Europe's Young Leading Innovators, when compared to their US counterparts, is due to a structural, sectoral composition effect with a failure to be present in the innovation-based growth sectors (see also Veugelers & Cincera (2010)).

Table 5.3: Yollies in Innovation Based Growth sectors

	Europe	US
Share of Yollies in IBG sectors	62	84
RDI of Yollies in IBG sectors	13.9	12.6
RDI of Region in IBG sectors	12.0	10.0

Source: Based on Veugelers & Cincera (2010).

6. EXPLAINING EUROPE'S AGE AND SECTORAL STRUCTURAL INNOVATION DEFICIT

What accounts for Europe's weakness, compared to the US, in "shifting" to new technology-based sectors, particularly biotechnology and ICT? Why are there fewer companies starting up and growing into world leading innovators that spend significant resources on R&D to make it onto the Scoreboard of largest R&D spenders? And why is this happening relatively less, compared to the US, in new technology-based sectors, particularly biotechnology and ICT?

A. BARRIERS TO INNOVATION

The most frequently cited explanation for the differences in dynamic structure between Europe and the US is a greater willingness on the part of US financial markets to fund the growth of new companies in new sectors (O'Sullivan, 2008).

Survey evidence from the German Community Innovation Survey confirms the importance of financial constraints for innovating companies in general, and particularly for young innovating companies.

Table 6.1: Perceived Obstacles to Innovation

Barriers to innovation	% companies reporting barrier as relevant: YICs	% companies reporting barrier as relevant: Other innovators	Significant and Robust Difference in mean score between YICs and other innovators
External financial constraints	95.65%	75.75%	YES***
Internal financial constraints	93.30%	66.42%	YES ***
Innovation costs too high	93.33%	87.71%	YES***
Uncertain demand for innovative products	89.13%	74.60%	NO
Difficulty of finding cooperation partners	67.39%	53.90%	NO
Regulations	71.74%	64.70%	NO
Lack of qualified personnel	71.74%	72.56%	NO

Source: Schneider and Veugelers (2010);
Note: Respondents were asked to give a score to each (potential) constraint factor on a scale from zero (not relevant) to three (high). The numbers indicate the share of companies that considered this factor to be relevant (i.e. companies that scored it as one or more). The last column reports whether the difference is statistically significant and robust to a multivariate correction. ***, significantly different at 1%, ** at 5%. Only a selection of barriers is reported. For the full results, see Schneider and Veugelers, 2010.

Young Highly Innovative Companies (YICs) [13] report on average higher obstacles to innovation than other innovating firms. When comparing across barriers, the results confirm the presumption that financial constraints – both internal and external – are the main barriers to innovation for YICs. Although this ranking also holds for other innovating firms, the YIC differential is largest on both types of financial constraint and is strongly statistically significant. It is also the only barrier that survives an econometric analysis to test for differences between YICs and other innovators[14].

Although the evidence clearly supports the importance of access to finance for highly innovative growth projects, the evidence also shows nevertheless that one cannot ignore the importance of other impediments to innovation. These other barriers relate to problems in the demand for innovations, regulatory burdens, access to skills and problems in partnering. All this is a strong reminder that the innovation deficit in Europe is systemic. Access to finance cannot be tackled in isolation, but should be embedded in an innovation environment that also addresses the other barriers to innovation. As these other barriers reduce the expected rates of return on highly innovative projects, they affect the appetite of financers to provide funds for these projects. In the

[13] Young Innovative Companies are defined in the EU State Aid Rules as small enterprises, less than 6 years old, having being "certified" by external experts on the basis of a business plan, as capable of developing products or processes that are technologically new or substantially improved and that carry a risk of technological or commercial failure, or have R&D intensity of at least 15% in the last three years or currently (for start-ups).

[14] The econometric analysis, correcting for other company and industry characteristics, confirms that small innovators are more likely to be financially constrained (both internally and externally), and so are innovators that have a more basic innovative profile. But on top of this, YICs – a cocktail of small, young and highly innovative – are significantly more likely to be financially constrained both internally and externally (Gaspar, Bovha-Padilla & Veugelers (2009)).

next sections we will discuss the access to finance problem (section 6.2.) and industry science links (section 6.4).

B. EUROPE'S ACCESS TO EXTERNAL FINANCE PROBLEM FOR INNOVATORS

The importance of access to external finance for innovators and particularly for young fast growing innovators should not come as a surprise. Risk and informational asymmetries create capital market imperfections. A company's lack of reputation and collateral become crucial elements in the way they are disadvantaged by these asymmetries. Although *young* highly innovative companies are rich in intangible assets such as technology and specialist knowledge, they lack the sort of collateral assets that help them to access external finance. Young innovators, combining the disadvantages of small scale, a short history, little or no retained earnings and more risky innovative projects, can therefore be expected to be more affected by financial barriers.

In view of the critical role played by access to external finance for young innovative companies, a greater willingness on the part of the US financial markets compared to Europe to fund the growth of new sectors and new companies can thus go a long way towards explaining the US-Europe divergence in enterprise and industry dynamics, and the persistent business R&D deficit of Europe relative to the US.

The segment of the capital market most adept at addressing the need of external financing for highly innovative growth projects coming from young companies lacking internal funds is the **venture capital** market. The high risk profile of young highly innovative growth companies often impedes other modes of external financing, like bank loans.

To this day, the US has by far the largest and most developed VC market. In 2008, the US accounted for 49% of total venture capital investment in OECD countries (OECD, 2009). In Europe, the most developed VC market is the UK, representing more than 10% of the OECD total.

Within Europe, availability of venture capital varies considerably across countries (Table 6.2). Relative to their GDP, Scandinavian counties are comparatively VC intensive. Belgium and especially Switzerland have improved their VC availability.

Table 6.2: Venture Capital in Europe[15]

Venture Capital as % of GDP	**2004**	**2009**
Average Europe	0.107	0.110
Coefficient of Variation	1.016	0.658
Top countries[2]	UK, SE (0.236-0.190)	UK, SE, CH, FI, BE (0.263-0.141)
Bottom countries	CZ, EL, SK (0.006-0.011)	EL, CZ, HU (0.01-0.019)

Note: For Europe, only 22 countries are available.[2] Luxemburg is not included (0.493%);
Source: Own calculations based on IUS (2010).

[15] EUROSTAT reports for the US a ratio of 0.18% in 2009. But European and US venture capital data are notoriously difficult to compare.

In addition to being smaller and more fragmented, the European venture capital industry is structurally different from the US venture capital industry (NESTA 2009). The larger more experienced US venture capital market is more likely to be funding the initial stages of the larger growth projects of their young innovative companies, supporting them in their path to grow into world leading innovators (WorldBank (2012)).

There is an ongoing debate on whether the problem in the VC market in Europe is one of undersupply of venture capital funds (i.e. the “equity gap”; companies being unable to secure venture capital funding), or rather a problem on the demand side, with a gap in the number of viable propositions (the so called “investment readiness gap”) (Veugelers (2011).

The current ineffective capital market for young, highly innovative companies in Europe should not be seen exclusively as a difficulty of either the supply of finance or the supply of attractive projects to be financed, but rather as a combined problem. Markets are too thin; they are defined by a limited numbers of investors and companies within the economy that have difficulties in finding and contracting with each other at reasonable costs. Poor investment returns from early stage investments in Europe relative to risk and high costs on a smaller deal flow have significantly reduced the appetite for early stage venture capital investing. Thick markets, characterised by high levels of interaction between venture capital funds and firms, are needed to build critical scale and expert human capital in the European venture capital market.

C. DEFICIENT INDUSTRY SCIENCE LINKS

Part of the story of Europe’s lack of “shifting” capacity are the shortcomings exhibited by its innovation 'eco-system', which does not effectively **link** the institutions and organisations that are active in innovation. Links between innovators and their suppliers and customers in large integrated markets for innovative products are important; but the same can be said for a well-functioning interface between the science system and the corporate sector. This is particularly important for new emerging technologies, which are often built on new insights from frontier research, developed at universities or research institutes.

It is often claimed that the US is not only fortunate to have top research universities producing frontier research, but that its top research universities are also much better in developing complex interactions with the world of business.

The indicators available for empirically demonstrating the strength of the links between industry and science across countries and time is extremely limited. The IUS uses public/private co-publications as measure for industry-science links. It shows that the top countries in Europe in co-publications are the Scandinavian countries, which are also the innovation leaders overall, indicating that a good linkage between universities and the private sector is a necessary component of a well-functioning innovation system.

Table 6.3: Public/Private Co-publications in Europe

Co-publications per million inhabitants	**2000**	**2008**
Average Europe	132	266
Coefficient of Variation	0.71	0.59
Top countries	SWE, DK, FIN, NL, BEL (726-467)	SWE, DK, FIN, NL, BEL (1306-1037)
Bottom countries	RO, LV, PO, BU, LI (118-199)	RO, LV, LI, BU, PO (44-102)

Source: Own calculations based on IUS (2010). Information only on EU-27.

To illustrate the capacity of a nation's science system to contribute to technological developments, Table 6.4 looks at another indicator, namely patenting by universities. We look not only at the generation of academic patents, but also at the use of these academic patents by the corporate sector for their follow-on innovations. To this end, we also look at the corporate patents that cite university patents as prior art for their technology developments[16].

Table 6.4. Corporate Citations to University Patents by Country

Country	**University patents**	**Country share in university patents**	**Country share in all corporate citations received by university patents**	**% university owned patents that are cited by company patents**	**Impact of cited university owned patents**
US	13.088	69.8	66.8	14%	6,03
UK	1.813	9.7	6.5	15%	3,96
BE	553	2.9	6.2	36%	5,17
FR	455	2.4	2.3	28%	3,03
NL	427	2.2	3.0	28%	4,26
DE	278	1.5	1.4	22%	3,89
JP	272	1.4	3.8	49%	4,77
CH	180	0.95	1.1	23%	4,29
ES	124	0.66	0.9	40%	2,98
IT	101	0.53	0.5	21%	3,90
EU-15 (avg)	4062	21.65	22.8	27,8%	3,74

Source: Veugelers, Callaert, Van Looy (2012).

Table 6.4 shows the citation-based statistics for all countries that have at least 100 university patents. The table clearly reveals different profiles for each of these world regions. In terms of quantity, the US is clearly dominant: it produces a large volume of university patents, leaving the EU-15 far behind. However, only a limited number of US academic patents are, in the end, cited by the corporate sector (14%). This citation rate is much higher for university patents from the EU-15 (28%) and particularly for Japan (48%). Hence, these countries have fewer but more frequently cited

[16] The analysis uses EPO application data for the years 1980-2000, which allows a citation window of 10 years (until 2010). Citations are from all patent systems (USPTO, EPO…). For more information on the database and further analysis, see Veugelers et al (2012)).

university patents. However, when looking at the average number of citations received, conditional on being cited, the US again takes a strong lead over the EU-15 and Japan, with their university patents having a higher impact on average. This is reminiscent of US university patents having a higher likelihood to become a top cited patent.

These results suggest that, in terms of profiles, the US model of university technology creation seems to be one of experimentation on a large scale. They generate a large volume of university patents, from which only a minor portion end up being 'used' in subsequent corporate technology creation. This large volume allows simultaneously for a more fertile ground for university patents to bloom into 'hits', or highly cited patents, at least for a few. This experimentation process is especially typical of the Biotechnical (Pharmaceutical) field. The profile of Europe suggests more mediocrity: universities are much less active in generating patents, only bringing out those ideas that have a relatively high probability of becoming 'used'. However, with less experimentation going on, they are less likely to result in 'high impact'. Heterogeneity in Europe, in terms of both institutional texture as well as legislative framework conditions pertaining to the ownership of publicly funded research, is partly responsible for the observed country differences (Veugelers et al (2012)) [17].

Further analysing the citation flows (from industrial patents towards academic patents) across countries confirms that such citation flows are to a large extent 'localized' (Veugelers et al (2012)). At the same time, it can be noted that these localized patterns are mainly observed for European and Asian countries. US universities are always (for all citing countries) by far the largest recipient of corporate citations. Nevertheless, for non-US corporations, compared to US corporations, it appears to be more difficult to link to US academic patents. US companies are the only ones that display a citation pattern of university patents that reveals 'sourcing' of knowledge on a truly global scale. To the extent that such global science sourcing is instrumental for innovation, the US displays the strongest profile.

7. RECOMMENDATIONS FOR INNOVATION POLICY MAKING

The evidence presented in this contribution has daunting implications for Europe's innovation policy agenda, which is going through a period of reappraisal. The evidence suggests that policies aimed at raising R&D expenditure across all types of industries and companies do not address the root causes of Europe's innovation deficit. To do this, policies need to address the specific barriers to development of new high R&D-intensity sectors and companies, as the evidence has shown how pivotal these sectors and companies are for tackling Europe's deficit "shifting" capacity. These specific barriers are rooted in problems of access to early risk financing, access to frontier research, specialised knowhow and skills.

What types of policy interventions are needed in Europe to address these specific barriers? And how targeted do they need to be? A first important remark is that a general innovation policy aimed at improving the environment for innovation remains necessary. Because Yollies need to interact with

[17] Within the EU-15, Belgium's university patents hold a top position in terms of corporate citations received. Not only do Belgian university patents have a higher probability of receiving citations by corporate patents, they also have the highest impact in Europe. The Belgian university patenting success story largely benefits from the presence of IMEC, an interuniversity centre for micro-electronics.

other innovators, and because innovators should not be impeded while they mature, a policy to address the lack of young companies in young highly R&D-intensive sectors needs to fit into an overall innovation policy. This overall innovation policy should further the integration of the European capital, labour, product and services markets, make it easier for players in the innovation system to interact and, at the same time, ensure healthy competition.

Such an overall innovation policy will be necessary, but it will not be sufficient.

Policy measures are also needed to tackle the specific barriers faced in new sectors by new companies. This includes *inter alia* access to external finance for fast growing highly innovative projects, by public funding and/or by leveraging private risk funding. Veugelers (2011) discusses a number of concrete proposals for EU action on this front. First and foremost, the fragmentation in the EU venture capital market should be addressed: the critical size for a viable, fluid, thick European VC market can only be reached when VC markets operate at an integrated European scale and are open to the world. Beyond furthering the single market agenda, Member State initiatives should be supported and best practices disseminated. The multitude of small existing EU instruments should be re-aligned into a holistic policy framework. A system of grants for high risk taking innovative projects of young companies, during the critical start up and development stages, when financial market barriers are at their highest, is still lacking.

At this stage of the analysis, when there are still too many unknowns about whether and which interventions are effective for which countries, policy-makers are advised to engage in close monitoring of emerging innovative markets. This is in order to determine whether the right mix of policy instruments is present in the country and if the mix is effective for ensuring the smooth development of companies in new markets, and so that policies can be adapted or dropped if ineffective. Monitoring should include a strong prospective angle, able to identify new emerging markets well in advance so that a pro-active policy mix can be identified for the very earliest phases of development, when the risk of market failure is at its highest.

8. REFERENCES

Aghion P., E. Bartelsman, E. Perotti and S. Scarpetta (2008) 'Barriers to exit, experimentation and comparative advantage', RICAFE2 WP 056, London School of Economics.

Bartelsman E., J. Haltiwanger and S. Scarpetta (2004) 'Microeconomic evidence of creative destruction in industrial and developing countries', Tinbergen Institute Discussion Papers 04-114/3, Tinbergen Institute.

Dewatripont, M., Sapir, A., van Pottelsberghe B., Veugelers, R., 2010, Boosting Innovation in Europe, Intereconomics: Review of European Economic Policy, 45, 5, 264-286 and Bruegel Policy Contribution 2010/06, Bruegel, Brussels

European Commission (2010), Innovation Union Scoreboard 2010.

European Commission (2011), Innovation Union Competitiveness report.

Gaspar, V. S. Bovha-Padilla and R. Veugelers (2009), Finance for Innovation and Growth, Proceedings of the SUERF Colloquium on Financing SMEs in Europe, SUERF Studies 2009/3, Vienna.

Furman, J., Porter, M. and Stern, S. (2002) 'The determinants of national innovation capacity', *Research Policy* 899-934

Iradian, G. (2007) 'Rapid Growth in Transition Economies: Growth-Accounting Approach', *IMF Working Paper* No. 07/164

Nelson, R. (1993) *National innovation systems: a comparative analysis*, Oxford University Press, New York

NESTA, 2009, From funding gaps to thin markets: UK Government support for early-stage venture capital

OECD (2009) Science, Technology and Industry Scorecard 2009, Paris, OECD.

O'Sullivan, M. (2008) The EU's R&D deficit and innovation policy, report of the Expert Group on Knowledge for Growth, European Commission, Brussels.

Moncada-Paterno-Castello P., C. Ciupagea, K. Smith, A. Tubke and M. Tubbs (2009) 'Does Europe perform too little corporate R&D?' Research Policy 39, 523-536.

Schneider, C. & R. Veugelers, 2010, On Young Highly Innovative Companies: why they matter and how (not) to policy support them, Industry and Corporate Change, 19, 4, 969-1007.

Veugelers, R., Callaert, X. Song, B.Van Looy, 2012, The participation of universities in technology development: do creation and use coincide? An empirical investigation on the level of national innovation systems, Economics of Innovation and New Technologies, 21, 5-6, 445-472. .

Veugelers, R., 2011, Mind Europe's early stage equity gap, Bruegel Policy Contribution, 2011/660, Bruegel, Brussels;

Veugelers, R. and M. Cincera, 2010, Europe's Missing Yollies, Bruegel Policy Brief 2010/06, Bruegel Brussels

Veugelers, R. and M. Cincera, 2010, Young Leading Innovators and EU's R&D intensity gap, Bruegel Policy Contribution 2010/09, Bruegel Brussels

Veugelers, R. and Mrak, M. (2009) 'The Knowledge Economy and Catching-up Member States of the European Union', report prepared for Potocnik's Knowledge-for-Growth Expert Group

World Bank (2008) *Global Economic Prospects 2008: Technology diffusion in the developing world*, Washington DC.

World Bank (2012) Restoring the lustre of the European economic model, Chapter 5: Innovation, Washington DC.