Innovation

Google did not exist in 1995. Today, its market value is about $150 billion. Google’s story epitomizes the success of the American “innovation machine.” In 1999, roughly a third of the world’s 1,000 largest firms by market capitalization were based in the United States, and of these, 35 percent were founded after 1950. Europe had only 181 firms among the 1,000 largest, and of these, only 14 percent were founded after 1950 (Cohen and Lorenzi 2000). Europe is a “convergence machine” but not an innovation machine. Over the past 15 years, with a few exceptions in the north, Europe has started falling behind the United States in productivity growth (see spotlight one).

Europe’s most successful companies seem to grow by doing what they are already doing—but better. Following the slogan of the German car manufacturer Audi—Vorsprung durch Technik (Leading through Technology)—they have developed ever-more efficient versions of traditional technology hits. But European companies have not shifted to radically new technologies, especially information and communications technologies (ICT).

As the Google success story unfolded, another was in the making in tiny Estonia. In 2003, four Estonian programmers, along with a Swedish and a Danish entrepreneur, founded Skype. A U.S. venture capital firm, Draper and Company, provided seed capital and further investments before eBay took over the company in 2005. Despite ups and downs and disputes among the founders and subsequent owners, the company was sold for $8.5 billion to Microsoft in 2011. Skype’s success demonstrates that Europe can produce young, innovative companies.

But the average productivity gap between Europe and the United States will likely persist until Europe’s larger continental economies emulate their intrepid northern neighbors in innovative enterprises. Europe’s most successful new entrepreneurs are small: while Europe does produce internationally competitive innovators in niche markets, the United States dominates among the world’s leading innovators, and this has Europe-wide effects.

How much does Europe’s innovation deficit matter?
Why does Europe do less R&D than the United States, Japan, and the Republic of Korea?
What are the special attributes of a successful European innovation system?
What should European governments do to increase innovation?
This chapter asks whether Europe has fundamental flaws in its economic environment that make its innovation deficit a fact of life. It looks at both the degree of innovative activities and the way innovative firms grow. In dimensions important for innovation, such as the availability of venture capital funding for European innovators, the business orientation of scientific research, and the share of people with tertiary education, Europe lags the United States. Denmark, Finland, Germany, Sweden, and Switzerland have been building strong national innovation systems that go toe-to-toe with the best in North America and East Asia, suggesting that there are other factors holding Europe’s leading innovators back from growing to a global scale. One big obstacle is Europe’s fragmented internal market for services. Until Europe realizes the gains from market integration and continentwide competition, it is unlikely that enterprises in innovation-intensive sectors such as ICT will match the growth of U.S. enterprises like Amazon, Apple, Facebook, Google, and Microsoft.

In analyzing Europe’s innovation performance and comparing it with Europe’s peers in America and Asia, this chapter answers four questions:

- **How much does Europe’s innovation deficit matter?** The innovation deficit explains why Europe has lagged the United States in productivity growth since the mid-1990s—but it is not the only factor. Using various measures of innovation, such as research and development (R&D), patent registration, and the introduction of new products and processes, this chapter shows that these measures correlate with the rate of productivity growth across both countries and firms. But the relationship is complex. Productivity growth depends on firms’ performance at the frontier as well as below it. Having leading innovators in fast-developing sectors, as the United States does, is important to push out the technological frontier. For companies below the frontier and for Europe’s lagging economies, lifting barriers to general investment and human capital formation may be as important as reducing barriers specific to innovation.

- **Why does Europe as a whole do less R&D than the United States, Japan, and the Republic of Korea?** The short answer is that Europe has fewer innovators in sectors that require a lot of investment in R&D. Otherwise identical enterprises are as likely to engage in R&D in Europe as they are in other advanced countries, but in Europe leading innovators are less likely to engage in R&D-intensive sectors like biotech and the Internet. So, what keeps entrepreneurs from venturing into new activities? While this chapter offers no definite answer, it suggests that one reason may be the lack of an integrated market for digital services, which leads Europe’s entrepreneurs to benefit less from clustering together than their peers in Silicon Valley or Tokyo.

- **What are the special attributes of a successful European innovation system?** Successful European economies—Denmark, Finland, Germany, Sweden, and Switzerland—have essentially downloaded the “killer apps” that have made the United States a powerhouse for innovation. The apps include incentives for enterprise-based private R&D, an abundant supply of workers with tertiary education, and public funding mechanisms and intellectual property regimes that foster links between universities and firms. But Europe’s leaders are constrained by their market’s small size and incomplete integration.
What can European governments do to increase innovation where it is most needed? The answer is a two-pronged approach. First, reform the innovation ecosystem—regulations, finance, science, and incentives—to ease entry and reward risk-taking. Second, increase the size of the market for European innovators by strengthening the single market for digital and other modern services, which would allow agglomeration.

Google’s success provides some clues about priorities and payoffs (box 5.1). The most important may be that to compete with the United States, Japan, and soon China, Europe has to bring together academic intellect, public funding, and private finance on a European scale.

Europe’s innovation deficits matter—but not equally for everyone

In 1950–73, the Golden Age of European growth, productivity in Western and Eastern Europe converged rapidly toward that in the United States, the world’s leading industrial economy. Growth and income convergence slowed over 1973–95, but for productivity it continued, as European working hours fell to less than those of the United States. During this period, the cohesion countries of Southern Europe and Ireland caught up rapidly with the European Union’s founding members. Since 1995, the “old” EU members (EU15) have recorded slower productivity growth than the United States and have essentially stopped converging, while the new member
Innovation as a source of long-term growth differentials

Innovation as a driver of long-term productivity growth has contributed to the EU15’s failure to close its productivity gap with the United States. Economists have long linked long-term growth to technological improvements (for example, Solow 1956), but how technology improved remained a black box. More recently, Romer (1990) and Aghion and Howitt (1992 and 1998) proposed theories that link an economy’s growth rate to its innovation rate. Aghion and Howitt’s theory is of particular interest, because it accounts for empirical phenomena that characterize economic growth and convergence in Europe (Aghion and Howitt 2006):

- Productivity growth results from improvements in product quality, as firms that innovate substitute old, obsolete production with new, better-quality production. This “creative destruction,” described first by Joseph Schumpeter, has led to accelerated structural change and productivity catch-up in Eastern Europe (Alam and others 2008).

- Firms innovate both by pushing out the technological frontier and by adapting technologies from the stock of global knowledge. As the stock grows, so too do the returns to innovation for all technological followers. Innovation has positive spillovers that can account for long-term growth differentials among economies. The European Union has targeted an increase in R&D investments as a key policy variable for improving long-term growth prospects.

- The forces driving innovation at or below the frontier differ. Competition spurs firms at the frontier to innovate to “escape” competitors, but for firms
well below the frontier, competition may discourage technological adaptation, because it reduces the rents available from adapting better technologies. As a result, policies to promote productivity growth through innovation depend on whether a country’s firms are below or at the technological frontier. For instance, comprehensive secondary education may be critical during catch-up, but tertiary education acquires greater weight once a country has reached the frontier; bank-led relationship-based financing may be optimal during catch-up, but for innovation at the frontier, equity (or venture capital) financing is likely better suited. Europe moved from below the frontier in the period of rapid convergence to close to it by the mid-1990s, and therefore the same policies that were good for growth before may not be optimal now (Abramovitz 1986; Eichengreen and Vazquez 2000; Aghion and Howitt 2006).

Considerable empirical literature supports the importance of structural change and innovation for productivity growth. Van Ark, O’Mahony, and Timmer (2008) decomposed economic growth in the United States and Europe into the contribution of several inputs to understand the productivity gap between the United States and the EU15 since 1995. The authors find that the key factor is the different rate of multifactor productivity growth in market services, such as retail trade, finance, and business. Jorgenson and Timmer (2011) further show that the United States has benefited from much faster total factor productivity (TFP) growth in distribution and personal services than has the European Union. While the different rate of investment in ICT made a small contribution, organizational changes and product and process innovation in services—rather than capital deepening as a result of the introduction of ICT—lie behind the divergence in performance between the United States and Europe. In short, the United States gets a bigger productivity kick out of ICT than does Europe.

In addition, vast empirical literature investigates innovation’s role in productivity and growth across enterprises or sectors of an economy. Hall, Mairesse, and Mohnen (2009) and Hall (2011) estimate the return on investments in R&D from those that link innovation to productivity growth through qualitative measures of product and process innovation (see box 5.2 for definitions of the various forms of innovation). The distinction is important because measures of investment in innovation, such as R&D spending, might not fully capture the nature of innovation in service industries such as retail or finance, which have been important in driving productivity growth differences between Europe and the United States. The conclusion from the empirical literature confirms the intuition behind recent

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**Box 5.2: Defining innovation**

- **Innovation**: The development and commercialization of products and processes that are new to the firm, the market, or the world. Activities involved range from identifying problems and generating new ideas and solutions to implementing those solutions and diffusing new technologies.

- **Product innovation**: The development of new products representing discrete improvements over existing ones.

- **Process innovation**: The implementation of a new or greatly improved production or delivery method, or of a new organizational method in firms’ business practices, workplace organization, or external relations. This includes “soft innovation,” such as layout reorganization, transport modes, management, and human resources.

- **Incremental innovation**: Innovation that builds closely on technological antecedents and does not involve much technological improvement upon them.

Source: Goldberg and others (2011), based on the Organisation for Economic Co-operation and Development.
endogenous growth literature: innovation is positively associated with higher firm productivity and growth, and the social rate of return on innovation exceeds the private rate of return because of positive spillovers from growth in the available stock of knowledge.5

How large is Europe’s innovation deficit?

Given the role of innovation in productivity growth, how does Europe measure up? Comparing the share of R&D investment in GDP in Europe with that in the United States and East Asia’s high-income economies, Europe as a whole does less R&D (figure 5.2). Moreover, China has increased its R&D investment rapidly over the past decade, closing the gap with the EU15 and exceeding the new member states (EU12), EU candidate countries, and European partnership states. As chapter 1 shows, Europe’s gap in R&D investments is due entirely to the lower R&D investments of Europe’s business sector.

Aggregate comparisons, however, may be misleading. Innovative activity varies across European countries, and a wider range of indicators depicts a more varied landscape than a simple comparison of aggregate investment rates in R&D. One recent comparative data collection effort is the Innovation Union Scoreboard (IUS) prepared by the European Commission (European Commission 2011b), which compares innovation efforts across countries in Europe and is benchmarked against the United States and Japan.6

R&D investments and patent counts are the measures of innovation used most in enterprise-level studies linking innovation with productivity (Hall, Mairesse, and Mohnen 2009; figure 5.3). The leading countries in business investment in R&D are also the leading countries in patent counts.7 Europe’s leaders in both fields perform as well as or better than the United States and Japan.8 The data on public R&D investments and international revenues from patents and licenses present a less clear pattern. Austria, France, the Netherlands, and

Figure 5.2: Europe has a large innovation deficit relative to both the United States and East Asia’s high-income economies (R&D expenditures as share of economic output of selected countries, 2000–08)

Note: Europe includes the EU27, EFTA, and EU candidate countries. Source: UNESCO.
Norway are among Europe’s leaders and have higher spending on public R&D than do the United States or Japan. License and patent revenues from abroad show a diverse pattern, with the Benelux, Hungary, Ireland, Malta, and the United Kingdom performing well alongside Japan, Switzerland, Scandinavia, and the United States. Overall, these four measures are highly correlated: the correlation coefficient between a country’s business and public R&D investment is 0.71, between a country’s business R&D investment and its international patent count is 0.91, and between business R&D investment and international license and patent revenues is still 0.63.

The European Commission also collects data for non-R&D innovation spending, as well as the share of companies undertaking product, process, and organizational innovation. These data are collected only for European countries. Non-R&D innovation spending is high in Europe’s emerging economies, such as Bulgaria, Croatia, Estonia, Poland, and Romania (figure 5.4). Interpretations are speculative, but one possibility is that firms in emerging economies, particularly in the
transition economies of the former Soviet bloc, now are trying harder to adapt advanced technologies to local circumstances.

The Community Innovation Survey collects data on the share of companies undertaking innovative activities, measuring countries’ share of all companies undertaking some kind of innovation, collaborating with partners outside Europe (China, India, and the United States), and collaborating with other companies or research institutions as opposed to doing it in-house (table 5.1). The survey measures collaboration with other companies to gauge the extent of innovation spillovers within and outside Europe. Several observations follow from looking at this survey alongside parallel data on small and medium enterprises (SMEs) (from the IUS but also based on Community Innovation Survey data).

There is a high correlation between the overall share of companies innovating and the share of SMEs innovating (0.85). The country with the largest share of companies innovating overall is Germany (close to 80 percent). The lowest proportion of innovating companies, as well as innovating SMEs, is in the transition economies of Eastern Europe: Latvia, Poland, Hungary, Lithuania, Bulgaria, and Romania.

There is also a close correlation between the share of companies undergoing process and product innovation and the share undertaking marketing and organizational innovation (0.79). As Hall (2011) summarizes, at the firm level, distinguishing the type of innovation is important, because firms may have different effects on productivity. At the country level, the data suggest countries that have innovative firms tend to have more of innovation overall.

The share of companies collaborating with others is also consistent across all firms and the subpopulation of SMEs (correlation of 0.81). Top performers are the United Kingdom, Denmark, Belgium, Estonia, and Slovenia. The least cooperation takes place in Romania, Latvia, and Bulgaria. German and Italian companies are far less likely to cooperate and consequently appear to be doing most of their innovation in-house. When looking at where companies’ partners are located, a distinct group of countries emerges that cooperate more internationally than others. This group includes Finland and Sweden as
Table 5.1: A large share of companies in Europe innovate, less so in the east

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<thead>
<tr>
<th>Country</th>
<th>SMEs innovating in-house</th>
<th>Innovative SMEs collaborating with others</th>
<th>Total innovating SMEs</th>
<th>SMEs introducing product or process innovation</th>
<th>SMEs introducing marketing/organizational innovation</th>
<th>Total share of innovating enterprises</th>
<th>All types of cooperation</th>
<th>Cooperation with United States</th>
<th>Cooperation with China and India</th>
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<tr>
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<td>3.5</td>
<td>31.3</td>
<td>18.3</td>
<td>18.1</td>
<td></td>
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<tr>
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<td>5.3</td>
<td>33.5</td>
<td>29.5</td>
<td>50.3</td>
<td></td>
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<tr>
<td>EU candidates</td>
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<td>7.6</td>
<td>30.8</td>
<td>29.6</td>
<td>32.9</td>
<td>44.2</td>
<td>38.1</td>
<td>2.3</td>
<td>1.1</td>
</tr>
</tbody>
</table>

Note: Data refer to different years by country and data source.
Source: European Commission 2011b and sixth Community Innovation Survey (CIS).
leading international cooperators, but also the Benelux, Slovenia, and—to less extent—France. The United Kingdom does not report which countries its firms collaborate with, but likely belongs with this group.

In sum, there appears to be a group of leading innovators in Europe, distinguished by sizable investments in business R&D, a strong record in international patent registrations, and a substantial proportion of companies that undertake one type of innovation or another. This group does not have an innovation deficit relative to the United States or Japan, though it still lags behind the United States in productivity, particularly in services. Many other European countries do, however, have an innovation gap. Among the top performers in Europe, there is a distinct difference between the pattern in Germany—with many firms innovating mostly in-house—and the pattern in Scandinavia or the Benelux, where there is a stronger propensity for firms to innovate through collaboration with other companies or research institutes. Europe’s emerging economies in the east are lagging behind on most indicators of innovation (with some notable exceptions such as Slovenia and Estonia) except for investments in non-R&D-related innovation.

The North innovates more than others; in the East investment matters more

Do these patterns help to explain the strong economic performance of Europe’s northern economies relative to the less impressive performance in the south, as demonstrated in chapter 4? And how can we account for strong productivity growth in Eastern Europe, given that most transition economies do not seem to invest a lot in innovation or have a large share of innovative firms? The answer to the first question is to some extent. The answer to the second is that innovation is only one input into the productivity of firms, and the rate of return on innovation investments varies not only across companies but also across countries.

Figure 5.5: Innovation: another north-south gap in Europe

Note: Data are normalized to lie between zero (worst) and one (best) and refer to different years by country.
Source: European Commission 2011b; sixth Community Innovation Survey (CIS), UNESCO; IMF BOPS.
A word of caution: this chapter makes no attempt at a robust growth-accounting exercise that would allow the contribution of country-level innovation to be disentangled from other factors such as investments in physical and human capital. We undertake two simple exercises. The first shows the average scores by geographical country groups across all indicators used to measure innovation in figures 5.2 and 5.3 and table 5.1 (figure 5.5). The country groups are the same as used in chapter 4: the EU15 split into a northern group (Ireland, Scandinavia, and the United Kingdom), a continental group (Austria, Benelux, France, and Germany), and a southern group (Greece, Italy, Portugal, and Spain), and all of the new EU member or candidate countries in the sample (not distinguished here between subgroups among the emerging European countries). These scores tell a clear story: across most innovation measures the southern group lags the northern and the continental (figure 5.5). The only exception is the share of SMEs that introduce product and process innovation or marketing and organizational innovation.

The emerging economies in Eastern Europe score poorly on most dimensions of innovation, despite their strong productivity growth record, though they outperform the south in the share of enterprises cooperating with others inside and outside Europe and in non-R&D spending.

The second simple exercise correlates the measures of innovation introduced above with a measure of TFP, drawn on the ECFI-AMECO database for TFP calculations available annually for 1998–2008 (figure 5.6). In the EU15, there is a clear positive correlation between TFP growth and two of the three measures of innovation in figure 5.6: business R&D and registered international patents. The total share of firms innovating is not correlated with TFP growth in the EU15. In the EU12, the correlation between innovation and TFP growth is slightly negative. In other words, while innovation matters, it matters much more in “old” Europe than in “new” Europe to explain differences in productivity growth.

In sum, there is no single innovation and productivity gap between Europe and the United States. Europe’s leading innovators in the north (and to less extent, the continental countries) have kept pace with U.S. productivity growth and seem
Box figure 1: R&D level may not show innovation problem

Note: R&D expenditure (percentage of GDP) is average for 1995–99. Tax on innovation is the calibration of the model by Maloney and Rodríguez-Clare (2007), adjusting for natural resources activities. The calibration is done using data for the 1990s, except for Hong Kong SAR, China (1980s).

Source: World Bank staff calculations, based on WDI, statistical yearbook (Taiwan, China), and UNESCO (South Africa).
others. When these factors are binding, innovation may matter less. Comparing Europe’s leading innovating companies with those in the United States and Japan, how does Europe perform “at the frontier”?

Why European enterprises do less R&D—not enough Yollies

If Europe’s most innovative countries invest as heavily in R&D as the United States and Japan, comparing favorably with these peers on innovation indicators, why don’t we find Googles and Apples in Sweden and Finland? One answer is that Europe’s leading innovators are mostly older companies operating in less innovation-intensive sectors. Europe struggles to nurture young, innovative companies in sectors characteristic of the “new” economy, such as ICT, biotechnologies, or medical services, which would grow into global leaders. Europe’s leading innovators are more

Box 5.4: Why don’t lagging countries do more R&D?

Although R&D spending is associated with inventions at the frontier, Cohen and Levinthal (1989) stress the “second face” of R&D, which facilitates the adoption of existing technologies from abroad. Griffith, Redding, and Van Reenen (2004) test this using sectoral time series data from 11 OECD countries. They find that countries further from the frontier had rates of return almost twice those at the frontier. For instance, the United States had a total rate of return of 57 percent while Finland and Norway had rates of return close to 100 percent, with 50 percent due to enhanced learning. These numbers are extraordinarily high, but not necessarily out of line with those found in other studies (see Jones and Williams 1998, and Hall, Mairesse, and Mohnen 2009).

Jones and Williams (1998) calculate that at these returns, the United States should be investing roughly four times what it does presently. The question arises, if returns increase as we get further from the frontier, why would lagging countries invest in anything besides R&D? Shouldn’t the southern and eastern countries of Europe invest more than those at the frontier?

Using a country-level panel, Goñi, Lederman, and Maloney (2011) confirm previous findings that, up to a point, returns rise with distance from the frontier (box figure 1). Each point corresponds to a distance from the frontier represented by a particular country in a particular five-year period, though the estimates, based on a rolling window, do not correspond to that particular country-time combination per se. To the right, we see rich countries with returns consistent with the literature, and then as we move left and away from the frontier to countries such as the Republic of Korea and Greece in 1996-2000, the returns rise. Beyond the distance corresponding to Mexico, Chile, and Hungary in 1996-2000, returns begin to fall. At Romania’s distance from the frontier, countries actually experience negative returns to R&D. Perhaps the finance minister of Romania is reasonable not to see a 3-percent-of-GDP target as a good use of his resources.

Why is this the case? As we get further from the frontier, the business climate is likely to worsen and the private sector become less sophisticated, such that even the best of ideas will yield limited fruit. Moreover, progressively weaker human capital in both the public and private sector could imply few good ideas that actually result from R&D investments. To the degree that they displace more feasible investments in education or infrastructure, the overall return on R&D could be negative.

Box figure 1: Rate of return on R&D versus distance from the frontier

Source: Goñi, Lederman, and Maloney 2011.
likely to push out the technological frontier in established sectors by developing better-quality versions of the same basic product. But they are less likely than their American counterparts to push into new fields.

A word of caution: this section does not directly examine the link between the presence of young, leading innovators and economywide productivity growth. However, the basic argument linking productivity and innovation to the age, size, and sectoral structure of an economy has received significant empirical support (O’Sullivan 2007; Aghion and others 2008). Bartelsman, Haltiwanger, and Scarpetta (2004) found, for instance, that postentry performance differs markedly between Europe and the United States, suggesting barriers to firm growth as opposed to barriers to entry. New European firms’ inability to grow large manifests 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, most notably the ICT sectors (O’Mahony and van Ark 2003; Denis and others 2005; Moncada-Paternó-Castello and others 2010).

The global expenditures of leading innovators by age cohort and sector, taken from the JRC-EC-IPTS Industrial R&D Scoreboard (Hernández Guevara and others 2008), demonstrates Europe’s lower rate of investment in R&D compared with the United States. Comparing the innovative profile of young, leading innovators (which we will call “Yollies”) with that of old, leading innovators (“Ollies”) shows how the lower share of Yollies contributes to Europe’s lagging business innovation performance.

Europe has fewer Yollies than the United States, and its Yollies invest less in R&D

Among the United States’ leading innovators in the Industrial R&D Scoreboard, more than half are “young” (born after 1975; figure 5.7). U.S. Yollies include Microsoft, Cisco, Amgen, Oracle, Google, Sun, Qualcomm, Apple, Genzyme, and eBay. By contrast, only one in five leading innovators in Europe is “young.” In the United States, Yollies account for 35 percent of total R&D of leading innovators; in Europe, a mere 7 percent! Notably, Japan has almost no young firms among its leading innovators. The remaining firms in the sample of leading innovators (mostly from emerging Asia) have a high share of young firms, to be expected given the recent economic take-off of these countries.

Of the 74 European Yollies in the Scoreboard, 20 are based in the United Kingdom. France, Germany, and Switzerland each hold nine, the Netherlands has eight. In relative terms, when looking at the share of Yollies in a country’s total R&D of leading innovators, Italy does poorest with only 3 percent, but Germany and Sweden have surprisingly low shares at 4 percent, way below the European average. The Netherlands, with 15 percent, is above average. Switzerland scores highest in Europe with 24 percent. But even this share is far below the United States’ 35 percent. European Yollies include U.K.-based Vodafone in telecom services, UK Shire in specialty biopharma, Swedish Hexagon in measuring technologies, Dutch ASML in semiconductors, and French Ubisoft in entertainment software.
The share of Yollies in R&D is higher than in net sales, indicating that Yollies have a higher R&D intensity than their older counterparts (figures 5.7 and 5.8). Once again, the United States stands out, with the highest relative R&D intensity of its Yollies. While on average, Yollies are about twice as R&D-intensive as Ollies, for the United States this ratio stands at almost 3. And for Europe, it is only 1.5. U.S. Yollies are by far the most R&D-intensive firms. Moreover, the gap between the United States and Europe in R&D intensity is larger for Yollies (57 percent) than for Ollies (20 percent).

Compared with their U.S. and European counterparts, Yollies from Japan and the rest of the world are less R&D-intensive. Not only does Japan have far fewer Yollies, but its Ollies are more R&D-intensive than its Yollies. This is a remarkable difference from the United States pattern, considering that Japan has just as high a share of business R&D in GDP as the United States. Japanese companies such as Toyota and Sony have retained global leadership through heavy investments in product and process innovation, while maintaining core focus areas. To some extent, the same can be said of firms in Europe’s export champion, Germany. While the United States has Amazon, eBay, Google, and Microsoft, Japan has Toyota and Germany has BMW and Mercedes Benz. Germany’s success relies on consumers in emerging markets who aspire to traditional quality consumer durables from Germany, and investors who prefer German machine tools. For Europe as a whole, as for Japan, the lack of Yollies does, however, reflect lower structural flexibility, reducing its economic competitiveness.

Three facts explain the lower overall R&D intensity of Europe’s leading innovators:

- Europe has fewer Yollies than the United States, which matters because Yollies have higher R&D intensity than Ollies.
- Europe’s Yollies are less R&D-intensive than their U.S. counterparts.
- Europe’s Ollies are less R&D-intensive than their U.S. counterparts, though to a lesser extent than its Yollies.

Figure 5.7: The role of Yollies among leading innovators is bigger in the United States than in Europe or Japan (percentage of young firms in leading innovators, 2007)

Figure 5.8: Yollies spend the most on R&D and U.S. Yollies are the most R&D-intensive of all firms (R&D intensity, percent, 2007)
Because the difference in R&D intensity between Europe and the United States is small for Ollies, the explanation falls to the Yollies. Not only does Europe have fewer Yollies, but those that Europe has are less R&D-intensive.\textsuperscript{16}

**Europe’s Yollies are in less innovative sectors so they invest less in R&D**

Why do Europe’s Yollies have lower R&D intensity than those in the United States? Europe specializes in less innovative sectors. Comparing Yollies within the same sectors shows that Europe’s Yollies are just as R&D-intensive as their U.S. competitors, as expected given the global markets for many of their inputs and outputs.
Disaggregating the R&D Scoreboard by sector—listing all that have above-average R&D intensity, above-average R&D growth, or an above-average share of young companies among its leading innovators—can show whether or not Europe specializes in innovation-intensive sectors (figure 5.9). The innovation-based growth sector includes aerospace, biotech, computer hardware and services, health care equipment and services, Internet, pharmaceuticals, semiconductors, software, and telecom equipment—all in the ICT and the health nexus (innovation-based growth sectors).

With the innovation-based growth (IBG) sectors identified, where are Europe’s R&D efforts concentrated? Europe spends a larger share of its R&D investments in sectors characterized as medium-R&D-intensive, as found by Moncada-Paternò-Castello and others (2010; table 5.2). These include automobiles, chemicals, electrics, industrial machinery, and telecom services. None of these sectors is young or has a high R&D intensity; all are older with medium R&D intensity. Further, automobiles, chemicals, and electrics have below-average R&D growth.

When looking at individual IBG sectors, it can be seen that Europe has a technological advantage (as indicated by an RTA>1) in aerospace, pharmaceuticals, and telecom equipment. Of these three, only telecom equipment is a “young” sector. The United States, by contrast, specializes in all IBG sectors (figure 5.10).

The final step in this decomposition analysis is comparing the relative importance and R&D intensity of Yollies in the IBG sectors across regions. Europe has significantly less of its Yollies in sectors with the highest opportunities for innovation-based growth (figure 5.11, top panel). But the ones it has in these
Figure 5.11: Europe has fewer Yollies in innovation-based growth sectors, but they are as R&D-intensive as in the United States (R&D intensity in innovation-based growth sectors, percent, 2007)

Note: The shares of Yollies in innovation-based growth sectors are in parentheses.

(a. Cells with fewer than five observations. Note: In the top panel, the shares of Yollies in innovation-based growth sectors are in parentheses. In the bottom panel, disaggregating the data into sectors, geographic areas, and age groups leaves few observations for analysis, calling for caution when interpreting results. Shaded cells are the young sectors. RDI refers to R&D intensity, which is, as defined above, R&D as percentage of total sales. Source: Bruegel and World Bank staff calculations, based on European Commission’s IPTS R&D Scoreboard.)
sectors are as R&D intensive as their United States counterparts, if not more. In other words, European Yollies are less R&D-intensive than their United States counterparts because they operate in less R&D-intensive sectors.

Across most IBG sectors, Europe’s Yollies are just as R&D-intensive as their U.S. counterparts, with a notable advantage in aerospace (figure 5.11, bottom panel). But Europe has a much smaller share of Yollies in the most conspicuous representatives of the knowledge-based economy, such as the Internet (where not one European company makes the list of leading innovators), telecom equipment, biotechnology, and health care. Europe’s comparable innovation deficit is due to a structural composition effect, not an intrinsically lower propensity to innovate among its firms (Veugelers and Cincera 2010b).

Japan demonstrates an alternative strategy to achieve productivity growth in traditional industries and to maintain global leadership. Germany might be following a similar route. But for Europe as a whole, greater success in innovation-intensive sectors such as ICT, biotech, and health care will be needed to catch up with the technological frontier represented by the United States.

European innovation systems need updating

What makes the United States better at generating new technological, organizational, or scientific ideas and applying them successfully in business? Many factors influence the innovation process. We call the interaction of these factors a country’s National Innovation System. The fundamentals include the actors—managers and firms—and the main inputs: capital, skills, and ideas. A review of these fundamentals shows that Europe has several economies that do as well as the United States at creating the basis for innovation—if not better.

National innovation systems

Firms decide whether to innovate using existing technologies. In deciding, a firm will typically start by examining its competitive position. Firms facing limited competitive pressure are less likely to innovate, since innovation needs both effort and money (Aghion and Howitt 1998 and 2006). The firm will want to know whether it faces a reasonably stable or highly uncertain outlook in its major markets, since innovation is a long-term business. The firm will consider its access to markets with the necessary income level and density of potential customers and suppliers to allow economies of scale inherent in many innovative technologies to be used to their potential. The firm may also respond to opportunities presented by public sector contracts. And last but not least, company managers decide whether to innovate. Quality of management differs, influencing these decisions and whether innovations succeed (Bloom and Van Reenen 2010).

A potential innovator will also examine the availability of new ideas that may present a business opportunity, though it is often a scientific discovery or intuition that generates a business idea. An innovator has to assess whether it has the necessary skilled workers to realize this opportunity. The innovator may also be spurred by upward shifts in an industry’s quality standards or by the
example of other innovators operating in similar markets. These are factors that influence the supply of ideas that innovators can use.

Intermediating between supply and demand are a host of other factors, some specific to innovation, some affecting any investment. Key among these are: the availability of credit, venture capital and “angel” investors (for innovators specifically), and direct public support; intellectual property rights (IPR); regulatory barriers that may discourage innovation (for example, the costs of licensing new technologies, starting up or closing a business, and changed complementary inputs such as hiring and firing labor); and other factors such as the structure and efficiency of the tax or legal system, which influence the probability that an innovator will retain profits. Another factor influencing both supply and demand—and recently receiving considerable attention—is the existence of an “entrepreneurial culture.” There is strong evidence suggesting that attitudes toward entrepreneurship vary across countries and regions (box 5.5). Moreover, the presence of other entrepreneurs may stimulate innovators to start a new venture. This explains the interest of policymakers in creating innovation clusters (Lerner 2009; Delgado, Porter, and Stern 2010).

Below are three additional observations on the National Innovation System framework (figure 5.12):

- Discussions of National Innovation Systems often overemphasize supply-side factors and inputs into the innovation process, neglecting the fact that the best test for any innovation is its success with customers. Understanding and reinforcing incentives for firms to innovate and for entrepreneurs to enter new markets is key to a successful innovation system. Without “market pull,” resources can be wasted. The painful transformation of public R&D institutes
due to the potentially large spillovers of R&D, there is often ample public support. Moreover, coordination failures in “discovering” a country’s competitive advantage have motivated calls for government intervention to promote particular sectors or industries assumed to have high positive spillovers (Rodrik 2004). Although well motivated by empirical examples, these calls should not divert attention from the more mundane barriers to investment, as detailed in chapter 4. “Setting the table” well is necessary for a successful National Innovation System (Lerner 2009).

- The interaction between supply and demand matters most. A comprehensive diagnosis is needed to understand what requires fixing. For Europe as a whole, there are important gaps in supply and demand, as well as in the links between them. But in each area where Europe is weak, several countries already achieve global best practice. To understand what might constrain leading innovators in these European top performers, we must turn to Europe-wide factors.

The fundamentals: management quality, adventurous capital, and skills

How do European countries compare with their peers—most importantly the United States—in key dimensions of their National Innovation Systems? Using the framework of figure 5.12, a survey of evidence highlights where Europe lags. The survey is selective rather than comprehensive, and is based on findings in the literature rather than original research. Aggregating the data across more dimensions to rank European countries against their peers confirms the findings of Europe’s main innovation weaknesses.
Management quality in the United States is higher than in Europe

In natural selection, the fittest organisms survive, adapting to their environment in unexpected ways. What is true in nature is also true for market economies, though many factors intervene in the selection process. Aghion and Howitt (1992 and 1998) stress competition’s importance in stimulating the innovation in companies near or on the technological frontier. But how competition stimulates innovation has only recently begun to be investigated in depth.

Bloom and Van Reenen (2010) report the results of research that scores the quality of company management in several thousand companies in 17 countries (figure 5.13). Managers in the United States scored the highest, while many European countries scored quite poorly (see Iwulska 2011 for a summary of the literature). Indeed, Greek companies seem to be as poorly managed as those in Brazil, China, or India. Germany and Sweden do almost as well as the United States—and better than Canada and Japan. The index can be broken down into subindices measuring the extent that managers monitor what is going on, manage human resources with appropriate incentives, and set the right targets and take action when outcomes deviate. The main reason for the United States’ lead is its higher score in managing human resources. Bloom and Van Reenen (2010) attribute the country’s greater use of incentives as management tools to its lighter labor market regulations, which allow poor performers to be more easily removed and top talent more easily attracted and retained. As chapter 6 shows, there are big differences among European countries in the quality of labor market regulations, but as a whole Europe struggles to attract and retain global talent.

Another important insight from the research on management quality is that weaker average management scores tend to be associated with tolerance of poorly managed companies, which allows these companies to stay in the

Figure 5.13: The United States outperforms Europe on management quality

Note: Numbers of firms are in parentheses. Data refer to 2006–08. Source: Bloom and Van Reenen 2010. For data, see Nicholas Bloom’s website at Stanford University, www.stanford.edu/~nbloom.
CHAPTER 5

market (Van Reenen 2011). This insight can be linked to evidence showing that in industries with higher exit rates, productivity growth is faster (Aghion and Howitt 2006). Competition spurs managers to innovate to escape their competitors, pushing poorly performing firms out of the market and raising a country’s aggregate performance. As chapter 4 shows, the survival of poorly performing microenterprises and SMEs is one reason for the poor productivity of Southern European countries such as Italy. Multinational firms and exporters are better managed than domestic firms and nonexporters—in line with results in chapter 4 on the role of foreign direct investment, internationalization, and export orientation for firm performance.

A final insight from this research is that better management may increase returns to new general purpose technologies such as ICT. Bloom, Sadun, and Van Reenen (2007) argue that greater use of managerial incentives in U.S. companies has led to better use of the reduction in information costs to decentralize key decisions within the firm hierarchy. This explains why the United States got a larger kick than Europe out of roughly the same levels of information technology investments during the second half of the 1990s, particularly in wholesale, retail, and financial services (van Ark, O’Mahony, and Timmer 2008).

**Venture capital markets in Europe are thinner than in the United States**

One of the most frequently cited explanations for the differences in dynamic structure between Europe and the United States is a greater willingness on the part of U.S. financial markets to fund the growth of new firms in new sectors (O’Sullivan 2007). Survey evidence from the German Community Innovation Survey confirms the importance of financial constraints for innovating firms in general, and particularly for young innovating firms (Schneider and Veugelers 2010).

The importance of access to external finance—particularly for young, fast-growing innovators—should not come as a surprise. Risk and informational asymmetries create capital market imperfections, and a firm’s lack of reputation and collateral

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**Figure 5.14: The United States has the largest venture capital market in the world**

(venture capital investment, percentage of GDP, 2010)

become crucial to how these asymmetries disadvantage it. Although young, highly innovative companies are rich in intangible assets such as technology and specialized knowledge, they lack the collateral assets that could help them access external finance. Young innovators, combining the disadvantages of small scale, short history, risky innovative projects, and less or no retained earnings, can be expected to be more affected by financial barriers.

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

The United States has by far the largest and most developed venture capital market, about twice the size of that of Europe’s leading innovators, Switzerland and Sweden, as a share of GDP (figure 5.14). It is not clear, however, whether this disparity reflects the supply side (insufficient funding for potentially profitable projects) or the demand side (insufficient profitable investment opportunities). The evidence provides arguments for both.

Kelly (2011) shows that European venture capital, while smaller, chases more deals—leading to fragmentation and smaller investment volumes per deal than in the United States. There is a substantial difference in average investment sizes between the United States and Europe, particularly at the initial stage of seed capital, where the average European investment is just €0.4 million against €2.2 million in the United States (table 5.3). There is also qualitative evidence suggesting that fewer venture capital investors in Europe have an entrepreneurial or engineering background themselves, potentially weakening links with investee companies (Kelly 2011). Venture capital investment in Europe is more diversified and less focused on ICT and biotechnology than in the United States, where IBG sectors account for 75 percent of all venture capital investments. Finally, the lower development of European equity markets means investments may be more costly (box 5.6). These factors put European innovators and especially European Yollies at a disadvantage to their U.S. counterparts in raising financing.

<table>
<thead>
<tr>
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<th>Europe</th>
<th>Investment stage (NVCA)</th>
<th>United States</th>
</tr>
</thead>
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<td>0.425</td>
<td>Seed/start-up</td>
<td>2.181</td>
</tr>
<tr>
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<td>1.425</td>
<td>Early stage</td>
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<tr>
<td>Expansion</td>
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<td>Expansion</td>
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</tr>
<tr>
<td>Replacement capital</td>
<td>7.208</td>
<td>Later stage</td>
<td>7.699</td>
</tr>
</tbody>
</table>

Table 5.3: Average deal size of venture capital investment
(euro, millions, 2003–06)

Note: Investment stages in Europe and the United States are defined by EVCA (European Private Equity and Venture Capital Association) and NVCA (National Venture Capital Association), respectively.

Yet Skype’s story suggests that venture capital is internationally mobile. In principle, a European yollie should have no difficulty raising financing in the deeper U.S. capital markets. For many years, returns on venture capital investments in the European Union were considerably worse than in the United States, though this gap may now be declining (Kelly 2011; Brandis and Whitmire 2011). Low returns explain low investment flows, and low returns might themselves reflect nonfinancing-related barriers to innovation. Indeed, a likely explanation for limited venture capital financing is that markets for venture capital are too thin. A limited number of investors and entrepreneurs have difficulties contracting with each other at reasonable costs. In European innovation leaders such as Sweden or Finland, though the size of the venture capital market relative to GDP is smaller, availability of financing may no longer be a binding constraint.

### Europe’s university research lags the United States’ in quality and business linkages

An available labor force with the skills to use new technologies is a key factor in encouraging innovation—whether by pushing out the technological frontier or by adopting global best practice in the domestic market. Universities play a key role in educating future cohorts of workers, but they also generate scientific...
RBF still dominates in Europe, but ALF are on the rise

Examining private sector credit and stock market capitalization, after controlling for the characteristics of individual countries—population, demographics, and other features such as being a transition country or an offshore financial center—indicates that banking sectors in Continental Europe are overdeveloped and that equity markets are underdeveloped (box figures 1 and 2). But this is not true for all countries. For instance, banking systems in the Baltic States, Bulgaria, Croatia, Hungary, and Slovenia perform above the world’s benchmark for private sector credit but have underdeveloped equity markets (except for Bulgaria and Croatia). The southern periphery of the European Union followed a similar path before the financial crisis. For instance, Spain has overdeveloped banking and equity markets, but Italy lags the “old” EU cohesion countries in stock market development.

From the standpoint of innovation finance, only a few countries in emerging Europe appear to have excessively expanded their credit markets. And sustained growth differentials relative to the EU15 have narrowed the productivity gap and increased the share of firms with characteristics more amenable to external financing through capital markets. Moreover, the supporting legal system is more open to ALF systems due to the nature of EU regulatory requirements.

Whether a country develops financially is more important than the relative weight of ALF and RBF systems. The experience of emerging Europe is interesting since foreign banks have become a part of RBF systems. But improvements in supporting institutions suggest greater scope for ALF systems in the future.

Source: This box draws on Wolf (2011), on the features of RBF and ALF systems, and on Sugawara and Zalduendo (2011), on the benchmarking of banking and capital markets.

Box figure 1: Private sector credit
(percentage of GDP, 1997–2008)

Box figure 2: Stock market capitalization
(percentage of GDP, 1997–2008)

Note: Arrows begin in 1997 and end in 2008, except for Ukraine, which begins in 1998. The arrows in the top-left panel are median values for each country group. The y-axis reflects the indicator referenced in the title of each chart after all effects of structural factors are filtered out and plotted against per capita income with cubic splines (dash lines). Specifically, each of the two indicators is regressed on the mentioned income and structural factors using median estimates of quartile regressions.


knowledge that becomes available for business applications. Close links between research institutes, universities, entrepreneurs, and venture capital investors are key ingredients of a successful National Innovation System. And universities are an important vehicle for countries that wish to attract global talent—both academics and students. The United States outperforms Europe on all three counts.

European governments regard scientific research as a primary responsibility of the public sector, placing less emphasis on leveraging private funding for scientific discovery. While total funding per student correlates closely with GDP per capita, in the United States the average ratio of spending per student to GDP per capita was 58 percent, against 55 percent in Canada and between 40 and 50 percent in most advanced European countries (Italy lags with less than 30 percent). Differences in private funding explain the bulk of spending
differences per student. Similarly, while public funding for researchers in the United States and Europe is roughly the same, Europe’s per capita funding per scientist is only around 40 percent of the United States’ level because the United States has far fewer publicly funded researchers. The European Research Council, with a budget of around €1 billion a year, attempts to provide more targeted and scaled-up research grants to European centers of excellence to overcome fragmentation.

Greater public funding has not led to a larger share of the workforce with higher education. Japan has the highest share of graduates in its population, with a mixed funding system (figure 5.15). The United States has a better average than the European Union, though several European countries with predominantly public funding outperform the United States.22 Public funding often comes with less flexible governance, allowing for less diversification in courses offered and weaker ability to attract, remunerate, and retain top faculty (Aghion and others 2005).
The consequences of this policy choice: First, Europe’s universities underperform their United States peers in indicators measuring the quality of scientific output and the education opportunities offered. Second, the links between scientific research and business are more developed in the United States, and the U.S. system is more likely to generate scientific discoveries that turn into commercial “hits.” Third, the United States outperforms Europe in attracting and retaining global talent to boost the quality of its workforce.

According to the rankings of the world’s top 100 universities produced by the Shanghai Jiao Tong University and the Times Higher Education Supplement index, European universities lag behind the United States—particularly at the top (figure 5.16). Moreover, both rankings show Europe losing to the United States over 2004–10. While in absolute numbers the United States dominates in quality universities, some European countries do well relative to their population. The United Kingdom, with two top 20 universities (Oxford and Cambridge), is an obvious example, but Belgium, Denmark, the Netherlands, Sweden, and Switzerland all have a higher share of top 200 universities per 1 million population than does the United States. Once again, within Europe there are innovation leaders that match the quality of the U.S. National Innovation System, even if Europe as a whole is falling behind.

Emerging technologies are often built on insights from frontier research, developed at universities or research institutes. The links between science and business are thus as critical as the quality of the science. Such links are forged more easily when researchers and entrepreneurs are close to one another, leading to attempts to create global innovation clusters around centers of academic excellence. The obvious examples are Silicon Valley in California for ICT, the greater Boston area and the area around Cambridge in the United Kingdom for biotech, and the Munich and Zurich areas for engineering. The United States is fortunate to have top research universities producing frontier research. The U.S. National Innovation System is unique in how its top research universities interact productively with businesses.

Interactions between science and industry can take various forms—including formal relationships, such as collaborative agreements between science and
industry; R&D contracting, but also own licensing policies and intellectual property management; and spin-off activities of science institutions. Behind this group of formal links are myriad informal contacts, personnel mobility, and science-business networks on a personal or organizational basis. These informal contacts and human capital flows exchange knowledge between enterprises and public research, creating spillovers. While more difficult to quantify, informal contacts are nonetheless important, often instigating more formal contacts.

There are few available quantitative indicators that demonstrate the strength of links between industry and science across countries. The IUS reports public-private co-publications as a measure for science-business links (figure 5.17). It shows that the top countries in Europe in co-publications are Switzerland and the Scandinavian countries, which are also the innovation leaders overall, indicating that strong links between universities and the private sector are necessary for a well-functioning innovation system.

University patents illustrate the capacity of a nation’s science system to contribute to technological development (table 5.4). When measured by quantity and use by the corporate sector, different profiles for Europe, Japan, and the United States emerge.

Table 5.4: United States universities produce more patents, and if picked up by business, the patents have greater impact

<table>
<thead>
<tr>
<th>Country</th>
<th>University patents</th>
<th>Country share in university patents (percent)</th>
<th>Country share in corporate citations of university patents (percent)</th>
<th>Percentage of university-owned patents that are cited by company patents</th>
<th>Impact of cited university-owned patents</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>13,088</td>
<td>69.8</td>
<td>66.8</td>
<td>14</td>
<td>6.03</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>1,813</td>
<td>9.7</td>
<td>6.5</td>
<td>15</td>
<td>3.96</td>
</tr>
<tr>
<td>Canada</td>
<td>868</td>
<td>4.6</td>
<td>3.1</td>
<td>14</td>
<td>4.34</td>
</tr>
<tr>
<td>Australia</td>
<td>605</td>
<td>3.2</td>
<td>1.2</td>
<td>9</td>
<td>3.90</td>
</tr>
<tr>
<td>Belgium</td>
<td>553</td>
<td>2.9</td>
<td>6.2</td>
<td>36</td>
<td>5.17</td>
</tr>
<tr>
<td>France</td>
<td>455</td>
<td>2.4</td>
<td>2.3</td>
<td>28</td>
<td>3.03</td>
</tr>
<tr>
<td>Netherlands</td>
<td>427</td>
<td>2.2</td>
<td>3.0</td>
<td>28</td>
<td>4.26</td>
</tr>
<tr>
<td>Germany</td>
<td>278</td>
<td>1.5</td>
<td>1.4</td>
<td>22</td>
<td>3.89</td>
</tr>
<tr>
<td>Japan</td>
<td>272</td>
<td>1.4</td>
<td>3.8</td>
<td>49</td>
<td>4.77</td>
</tr>
<tr>
<td>Switzerland</td>
<td>180</td>
<td>1.0</td>
<td>1.1</td>
<td>23</td>
<td>4.29</td>
</tr>
<tr>
<td>Spain</td>
<td>124</td>
<td>0.7</td>
<td>0.9</td>
<td>40</td>
<td>2.98</td>
</tr>
<tr>
<td>Italy</td>
<td>101</td>
<td>0.5</td>
<td>0.5</td>
<td>21</td>
<td>3.90</td>
</tr>
<tr>
<td>EU15 average</td>
<td>4,062</td>
<td>21.7</td>
<td>22.8</td>
<td>28</td>
<td>3.74</td>
</tr>
</tbody>
</table>

Note: The analysis uses application data from the European Patent Office for 1980–2000, which allows a citation window of 10 years (until 2010). Citations are from all patent systems (United States Patent and Trademark Office; European Patent Office). The patent impacts are measured by the amount of citations received per cited patent.

Source: Veugelers and others 2011.
In quantity, the United States dominates, producing a large volume of university patents and leaving the EU15 behind. But just 14 percent of U.S. academic patents are cited by the corporate sector, compared with 28 percent for the EU15 and 48 percent for Japan. These countries have fewer but more frequently

Figure 5.18: The United States has the largest market share for international students
(percentage of all foreign tertiary students, 2008)

Source: OECD 2010.

Figure 5.19: Switzerland, Scandinavia, and Germany are global innovation leaders
(EU27 and non-European states, percent, 2010) (index for individual European countries, 2010)

Source: European Commission 2011b.
cited university patents. When looking at the average number of citations received, conditional on being cited, the United States again leads the EU15 and Japan, as their university patents have a higher average impact.

The U.S. model of technical innovation is one of experimentation on a massive scale. U.S. universities generate a large volume of patents, but few are “used” in creating corporate technology. At the same time, this large volume provides fertile ground for university patents to turn into commercial “hits.” The biotech (pharmaceutical) field employs this experimentation process. The profile of Europe suggests more mediocrity: universities are much less active in generating patents, only bringing out ideas more likely to be used commercially. However, with less experimentation, European universities are less likely to register “high-impact” patents. In Europe, there is considerable heterogeneity, which can be traced back to IPR legislation and institutional set-up (Veugelers and others 2011). Japan’s university patents are the most likely to be cited by company patents, but—conditional on being cited—their average impact is not exceptionally high.

Moreover, the total share of corporate citations traced back to U.S. university patents is almost as high as the share of U.S. universities in the quantity of all patents produced. The higher probability of patent citations by U.S. companies suggests that U.S. universities provide more truly global knowledge, despite the predominance of local science-business links in all countries. The citation flow also shows that U.S. corporations are more likely to source knowledge globally, citing patents registered by non-U.S. universities. Not only does the United States have the strongest local science-business links of any country, it leads in globalizing these links, building on experience gained at home.

Europe’s lower success in attracting global scientific talent and students is the third consequence of its underperforming science and university complex. The United States dominates the market for international students (figure 5.18). In advanced U.S. research programs, close to a third of all students are international. Many of Europe’s most promising researchers are attracted to the United States by better remuneration packages (Salmi 2009), better teaching and research facilities, and the greater density of talented colleagues and students.

Europe’s innovation systems ranked and compared

The evidence surveyed so far points to four distinct country groups in Europe. First, there are the leading innovating countries, including the Nordics, Switzerland, and Germany. On many dimensions, this group either equals or outdoes the United States and Japan. Second, there are the continental economies, the United Kingdom, and Ireland, which are performing reasonably well, though not at the level of global leaders on most dimensions. Third, there are the Southern European economies, which have struggled to increase productivity, reflected in relatively weak innovation systems. And fourth, there are the emerging economies in Eastern Europe, including front-runners in the EU12, who have on most dimensions exceeded the south and economies where innovation does not appear to be a policy priority given general constraints to the business environment (Goldberg and others 2011).

We now summarize this evidence by using the European Commission’s IUS indicator—a composite indicator using some data in this report and a few additional
measures. On the aggregate IUS indicator, Europe as a whole performs poorly (figure 5.19, left panel). The United States has the highest IUS score, followed closely by Japan. The United States score in 2010 was 49 percent higher than that of the EU27. This gap persisted over 2006–10 (in 2006, the United States score was 46 percent higher). Relative to the main emerging market economies, Europe still has a considerable lead. But except for the Russian Federation, the BRIC countries—especially China—are catching up fast. This aggregate result confirms that Europe’s National Innovation Systems need updating.

Europe’s best are performing as well as the United States, while its least innovation-friendly economies are not different from emerging economies elsewhere, and may even lag the BRICs. The IUS for 33 European countries, covered by all 25 subindicators (essentially most of the EU27, the European Free Trade Association, and candidate countries), shows that Switzerland had an IUS score about 60 percent higher than the EU average (figure 5.19, right panel). Although the data are not strictly comparable since not all subindicators are available for non-European countries, Switzerland is arguably on par with the United States on most dimensions of its National Innovation System. Finland, Germany, Denmark, and Sweden also do well.

The weakest group includes mostly transition or EU candidate countries. The bottom seven are Latvia, Turkey, Bulgaria, Lithuania, the former Yugoslav Republic of Macedonia, Serbia, and Romania. But the innovation divide in Europe does not follow a simple transition divide. Among the innovation laggards are some older member states, notably Spain and Italy, while Estonia and Slovenia have already joined Europe’s more innovative half.

The rankings in figure 5.19 are thus consistent with the pattern observed by looking at the individual dimensions of the IUS score, as well as other rankings of innovation capacity within Europe, such as the World Competitiveness Indices. The rankings are also persistent over time—the top five countries in 2006 were the same as in 2010, though Sweden ranked ahead of Switzerland in the top spot. The bottom five did not change either.

**Achieving global leadership for Europe’s best**

The Nordic economies, Switzerland, and Germany are getting the innovation fundamentals right, combining public support for innovation with private incentives to profit from it. Is there something Europe’s other countries can learn from its leaders? Does Europe’s failure to specialize more in IBG sectors, and thus benefit from the spillovers that come from innovation-intensive activities, reflect an industrial policy failure, even among its leading countries? The answer to the first question is yes, but implementing public support for innovation is difficult and institutionally demanding. Failure abounds and caution is in order. The answer to the second question is no. Instead, Europe’s failure to achieve global leadership in IBG sectors has more to do with three factors: its segmented labor and services markets; the nature of incentives for innovation resulting from European antitrust legislation and the absence of an integrated public procurement market; and unnecessary transaction costs imposed by the absence of a single European patent or greater bundling of public funding for scientific research. This does not exclude a role for cultural or other
idiosyncracies that might have helped create technology clusters in the United States, such as Silicon Valley. But there is much that Europe can do at the policy level to encourage its own clusters to grow to a global scale, without appeal to good luck or good weather.

**An industrial policy for the 21st century?**

Finland is a top innovator in Europe. Its total investment in R&D was 3.9 percent of GDP in 2009 (European Commission 2011b), the highest in Europe and second-highest in the world. Finland has the second-highest registration of patents per euro of GDP in Europe, and the second-largest share of innovating companies cooperating with firms outside Europe. Over 1995-2009, Finland’s annual productivity growth was 1.5 percent and its rate of job creation 1.3 percent, making for one of the fastest GDP growth rates in Europe (chapter 4).

Finland’s innovation success is the result of conscious national policy. At the heart of this policy is public support for commercially targeted R&D through the National Technology Agency of Finland. This organization provides matching grants and subsidized and convertible loans geared to early-stage technological development. And, administering around a third of the public sector’s R&D spending ($1.9 billion in 2009, or slightly more than 1 percent of GDP), it is complemented by a publicly owned venture capital fund (SITRA). SITRA provides funding for preseed start-ups; a public applied research institute that, while publicly owned, obtains a third of its revenues from sales to the private sector; and basic research through the Academy of Sciences and universities. Political leadership is an important factor: the prime minister chairs a national research and innovation council. Yet, policy instruments have generally gone with the market by leveraging market incentives, rather than substituting for business decisions.

Finland is not alone in boosting innovation through active public support. Financial incentives, matching grants, targeted procurement policies, and other measures have helped boost innovation and venture capital from Silicon Valley to Singapore, and Tel Aviv to Bangalore. But many more times public interventions have failed. Lerner (2009) summarizes the evidence as a “boulevard of broken dreams.” Typical mistakes include public support programs that are of insufficient length and flexibility; that do not leverage an existing scientific and research base, disregarding agglomeration economies; that fail to let the market provide direction, setting national standards rather than following global best practices; that are either too large or too small and fail to pay sufficient attention to careful monitoring so that adjustments can be made; and that are not evaluated, so that policymakers and stakeholders do not learn from mistakes.

Successful public policies to support innovation often require governance structures unlike those usually found in the public sector. This conclusion echoes a more general point about industrial policy: where public interventions can catalyze or emulate competitive market selection, and where they can encourage experimentation despite imperfect information, they can lift an economy’s overall performance (Aghion and others 2011). Too often industrial policy tries instead to prevent competition, and another broken dream takes its place along the boulevard.
On the agenda: single market, competition, and public procurement

The demand for innovation investments is a function of market pressures and perceived opportunities. Because the commercial opportunities resulting from innovation are greater when markets are larger and denser, the degree of market integration (or “thickness”) matters. In this respect, Europe is disadvantaged for two reasons. First, companies in Europe operate within domestic borders, due largely to the incomplete realization of the single market—particularly in services—and to other EU policies. The incomplete realization reduces the incentive to innovate, as the market of potential consumers remains smaller and competition lower. Second, Europe’s labor is not as mobile as that in the United States (chapter 6). Mobile labor allows the U.S. economy to respond more rapidly to shifts in the technological frontier, realizing agglomeration benefits in newly emerging centers of excellence. By rapidly reallocating resources in line with new technologies, the U.S. economy has a higher capacity for shifting to new technologies and markets.

Pelkmans and Renda (2011) highlight a striking example of the lack of market integration in communication services, one of the IBG sectors identified earlier. Despite three packages of market liberalization, the European Union has failed to develop an integrated market for e-communications. In the European Union, the highest price for a wide range of e-communication services exceeds the lowest price by several multitudes (up to 1,300 percent in the case of fixed-line calls to Japan!). The average monthly spending of European businesses differs by as much as 270 percent (not counting outliers), whereas the difference between New York and California is close to zero. The same is true in residential telecom bills. Of perhaps greater economic significance, given the impact on the cost of information flows and thus the scope for productivity-enhancing decentralization (Bloom, Sadun, and Van Reenen 2007), the quality of broadband services differs greatly within the European Union—and not only because of differences in incomes and available infrastructure. Regulatory obstacles—traceable to the existence of national telecom regulators in each EU state and to the lack of a Europe-wide approach to promoting investment in network industries—are partly to blame. Research suggests that a single digital market in the European Union would noticeably boost Europe’s economy.

Tilford (2008) notes that Europe has been gradually losing its R&D leadership in pharmaceuticals to the United States. Between 1990 and 2005, the annual growth rate of pharmaceutical R&D in the United States was 4.6 percent, compared with just 2.8 percent in the European Union. One reason may be that national price regulation leads to market segmentation and free-riding by EU member states that are not hosts to large pharmaceutical companies. Prices in Southern Europe tend to be significantly lower than in Germany, the Netherlands, Scandinavia, and the United Kingdom, where most R&D in pharmaceuticals happens. Europe’s high-price markets, smaller than those in the United States, may limit incentives for companies to develop, test, and introduce new drugs in Europe. And the average price for patented drugs in the European Union was only half that in the United States. This may keep health costs down (chapter 7), but it is bad for innovation. Moreover, the arbitrage opportunities resulting from price differences in the European Union may lead
pharmaceutical companies to attempt to restrict sales in low-price markets to the detriment of patients.

Crescenzi, Rodríguez-Pose, and Storper (2007) estimate a so-called knowledge production function, which compares the number of patents registered to R&D investments in Europe (and a number of other factors at the regional level) with that in the United States. An insight from their analysis is that in the United States, knowledge production is more concentrated at the regional level, and there are fewer spillovers to other regions. In the European Union, R&D produced in one region helps generate patents in regions as far as several hundred kilometers away. This pattern may weaken incentives to create regional centers of excellence large enough to attract global leaders, risking the duplication of R&D across regions in Europe. In a nutshell, Europe’s most successful innovating economies are not big enough to allow innovators to grow to global leadership. A particularly prominent example for European fragmentation in innovation policy is the absence of a single Europe-wide patent. Leading European countries cannot agree on which languages to register the patent in. This is a case where overcoming national pride and prerogatives will be critical to create functioning Europe-wide innovation clusters.

It is not just barriers to the single market resulting from national regulations that may reduce incentives for innovation-based growth sectors to develop. EU policy may have a role too, important in competition policy and procurement. Mowery (2011) discusses the role of competition policy and IPR protection in the evolution of R&D in the United States. During the postwar years, antitrust legislation prevented established U.S. companies from acquiring new technologies through mergers and acquisitions, thus promoting the birth of small innovative companies in new technologies such as semiconductors and electronics. After 1980, U.S. policy became considerably more patent-friendly. With the Bayh-Dole Act, the United States tightened protection of IPR, leading to an explosion in patents and collaboration among firms to benefit from technology diffusion. The role of the Bayh-Dole Act in promoting business-relevant research by universities—and the greater role of patent revenues for universities—has led Denmark and Japan to emulate its provisions. There are, however, critics of tight IPR regimes—regimes that could lead to strategic use of patents to prevent new entry, with little value created in the process.

Tilford (2008) discusses the European Commission’s interpretation of its competition policy mandate with respect to network industries such as ICT, noting that an overly stringent interpretation of consumer risk from dominant market power may fall short. In industries where benefits to consumers may increase with the number of consumers, market dominance may not harm consumer interests. At the same time, companies anticipating antitrust action may hold back from innovation. The design of competition and IPR policies is an important element of a Europe-wide National Innovation System, though Mowery (2009) emphasizes that successful U.S. policies may not bring the same result in places with a different tradition of university-business collaboration.

Finally, the United States’ success in innovation-based growth sectors owes a good amount to an integrated national procurement policy, particularly in the military and defense sector. Access to early users willing to take up and co-develop innovations is critical for new firms entering new sectors. One early customer...
is the government. In many health and ICT sectors, history has shown U.S. public institutions to be an important early user, pivotal in leveraging further private markets through public procurement (Mowery 2009; Lerner 2009). In Europe, the use of public procurement as a policy tool to foster innovation and structural change is much less developed and far from integrated on a European scale (Monti 2010).

**America’s innovation machine versus Europe’s “Vorsprung durch Technik”**

As corporate emblems of their continents, it is not unfair to contrast Apple and Audi. Since its inception in 1976, Apple has revolutionized the computer industry, changed the way music is bought and heard, and made the telephone a smart device, capable at once of voice, visual, and data communications. In 35 years, the company has transformed three industries. It has rewarded its shareholders and grown big while still young. Indeed, in summer 2011, Apple briefly became the world’s largest company by market capitalization. Audi was founded more than a century ago, and its main innovation was to produce the first left-hand drive cars, making driving in traffic easier and safer. A luxury arm of the massive Volkswagen Group since 1965, it has been making cars safer and more reliable ever since.

Both Apple and Audi are global companies, sourcing parts from around the world and manufacturing products in countries where assembly is cheapest. But one is an emblem of unimaginable innovation, the other perhaps of persistence. One is a Yollie, having grown big while still young, and the other is an Ollie, becoming big only after it became old.

European leaders have long recognized Europe’s innovation deficit relative to the United States, Japan, and other countries in East Asia. The European Union even carved into its 2002 Lisbon Strategy the ambition to become the most competitive knowledge-based economy in the world. In the subsequent EU-2020 strategy and Innovation Union Flagship, it set a roadmap for sustainable and inclusive growth to be “smart” (for example, European Commission 2011a). European efforts focus on investment in R&D. An ambitious target of devoting 3 percent of GDP to R&D by 2010 was set in 2002. The same 3 percent was again targeted in the EU-2020 strategy. But reality has disappointed. R&D as a share of GDP has remained less than 2 percent in the EU15, and the gap between its R&D investments by the business sector and those of the United States—and even East Asia’s high-income countries such as Japan, the Republic of Korea, and Singapore—has been growing. It is increasingly apparent that such R&D targets are unrealistic; it may also be that they are not optimal.

Yet, as the analysis has shown, Europe is capable of creating successful National Innovation Systems, which stand toe-to-toe with the world’s leading innovation machine: the United States. This raises the question: What are the characteristics of successful innovation systems in Europe? In particular, are there any uniquely European features of effective systems?
One clue is that Europe’s leaders perform especially well where Europe lags as a whole. For example, Switzerland has revenues from international licenses and patents of 2.5 percent of GDP, 10 times the EU27 average and more than 3 times that of the United States. Sweden’s licensing and patent revenues were more than 1 percent of GDP in 2008, Finland and Denmark’s around 0.7 percent, about the same as that of the United States (European Commission 2011b). Finland’s population of 30–34-year-olds with tertiary education exceeds the level in the United States and is close to Japan’s; Finland’s business R&D was almost 3 percent—on par with the United States. Public-private co-publications were between three and six times larger in Europe’s innovation leaders than in the EU27 average, and much higher than in the United States.

So, how are these aggregate differences reflected at the enterprise level? Europe’s innovation deficit relative to the United States can be attributed in part to the lack of Yollies in innovation-based growth sectors. European companies in traditional sectors do not innovate less than their competitors in the United States. But Europe has far fewer Yollies and is much less specialized in sectors characterized by innovation and rapid productivity growth—such as ICT, biotech, and medical technologies and services. This finding comes with a caveat: to measure innovation at the firm level, the analysis relies on R&D investments. This is obviously not the only way to measure innovative behavior. But the list of major R&D spenders overlaps other rankings of the world’s most innovative companies. In short, while the United States has Apple, Google, Amazon, Microsoft, eBay, and Facebook, Europe has BMW, Mercedes Benz, Siemens, Vodafone, and Nokia.31

And what measures should European countries take to fix their innovation fundamentals? Three policy priorities emerge. First, speed up the integration of markets for business services and skilled labor to increase the thickness of markets for innovators, and shift resources rapidly to new, untested business opportunities. Doing so leads to more competition in IBG sectors, dominated by services. Second, improve incentives in scientific research and university education systems to generate ideas that can be business successes. Third, assess the role of venture capital in catalyzing the growth of Yollies, both in providing access to patient capital and ensuring attention to good management. Venture capital markets are integrated globally, and public policy to attract such financing is difficult to design, so the early focus should be on setting the table before launching into specific programs of public support.

These things are difficult to do, so this analysis has daunting implications for Europe’s policy agenda. The evidence suggests that policies aimed at raising R&D expenditure across all types of industries and firms do not address the roots of Europe’s innovation deficit. Policies need to address the barriers to developing new high R&D-intensity sectors and firms, as the evidence has shown how pivotal these sectors and firms are for tackling the deficit in Europe’s capacity to shift. These barriers have roots in poor access to early risk-financing, frontier research, specialized knowledge and skills, and risk-taking lead customers, including the government. Lacking this access, aspiring young innovators are hampered in their search for partners to develop, finance, produce, market, distribute, and sell their breakthrough innovations.

A general innovation policy for improving the risk-taking environment is needed. Yollies need to interact with other innovators, and innovators should not be impeded
Europe’s leading innovators in Scandinavia, Switzerland, and around the Baltic Sea have narrowed the gap with the United States in access to venture capital and in the quality of science and universities. But even they still depend on decisions in Brussels to address the weaknesses in the single market for modern services. Constraints are exacerbated by Europe’s sluggish labor markets, which slow the adoption of new technologies and the shift in effort from old and stagnant to new and growing sectors. How can these constraints be eased? Chapter 6 tries to answer this.

Answers to questions on page 245

- Europe’s innovation deficit matters most for the EU15, and so it also matters for the economies of emerging Europe because they are closely integrated.
- European enterprises do less R&D than American firms because they tend to be in sectors that are not as innovation-oriented.
- The most innovative European economies such as Switzerland spend a lot on R&D, but also share key attributes with the United States—tight business–university links, good management skills, and top universities.
- Measures to fully integrate the Single Market for Services will provide the scale, more privately funded universities will supply the skills, and regulations that foster competition will create the incentives for European enterprises to innovate.
Chapter 5: Annexes

Annex 5.1: Indicators used in the innovation union scoreboard

The Innovation Union Scoreboard (IUS) is a composite indicator composed of indicators capturing eight dimensions of innovation:

- Human resources.
- Research systems.
- Finance.
- Firm investment.
- Linkages and entrepreneurship.
- Intellectual property rights.
- Innovators.
- Economic effects.

Within Europe, the IUS covers 34 European countries over time: 27 EU Members (15 old member states and 12 new member states) and Switzerland, Norway, Turkey, Croatia, Iceland, Former Yugoslav Republic of Macedonia, and Serbia.

For the intra-European comparison, 25 indicators are used.

- Human resources: new doctorate graduates, population ages 30–34 with completed tertiary education, youth ages 20–24 with upper secondary level education.
- Research systems: international scientific co-publications, top 10 percent most-cited scientific publications worldwide, non-EU doctorate students.
- Finance and support: public R&D expenditures, venture capital.
- Firm investments: business R&D expenditures, non-R&D innovation expenditures.
- Linkages and entrepreneurship: small and medium enterprises innovating in-house, innovative small and medium enterprises collaborating with others, public-private scientific co-publications.
- Innovators: small and medium enterprises introducing product or process innovations, small and medium enterprises introducing marketing or organizational innovations.
- Economic effects: employment in knowledge-intensive activities, medium and high-tech manufacturing exports, knowledge-intensive services exports, sales of new-to-market and new-to-firm innovations, license and patent revenues from abroad.
Outside Europe, the comparison countries included the United States, Japan, and the BRIC countries (Brazil, the Russian Federation, India, and China).

Because of limited data availability, only 12 indicators from the 25 were used for comparing countries outside Europe. These indicators are for human resources: new doctorate graduates (ISCED 6) per 1,000 people ages 25–34, percentage of people ages 25–64 with completed tertiary education; for research systems: international scientific co-publications per million people, scientific publications among the top 10 percent most-cited publications worldwide as a percentage of total scientific publications of the country; for finance: public R&D expenditures as a percentage of GDP; for firm investment: business R&D expenditures as a percentage of GDP; for linkages and entrepreneurship: public-private co-publications per million people; for IPR: Patent Corporation Treaty patents applications per billion GDP in euro adjusted by the purchasing power standard (PPS€), Patent Corporation Treaty patent applications in societal challenges per billion GDP (in PPS€) (climate change mitigation, health); for innovations: none; for economic effects: medium- and high-tech product exports as a percentage of total product exports, knowledge-intensive services exports as a percentage of total service exports, license and patent revenues from abroad (as a percentage of GDP).

Annex 5.2: The dataset on leading innovators

We start with the firms belonging to the EU-1000 and non–EU-1000 largest R&D spenders in the 2008 edition of the EU Industrial R&D Investment Scoreboard. The dataset was augmented with information on the age of the firm’s creation. The information on the firm’s age allows the United States to distinguish between young and old leading innovators.

As the scoreboard database only records the largest R&D spenders, “young firms” are not small start-ups. Indeed, the average size for the young firms in our sample is 10,000 employees worldwide. Some top young firms in our sample (by R&D size) are Microsoft, Cisco, Amgen, Oracle, Google, and Sun. As it includes (almost) no firms with fewer than 250 employees, the scoreboard dataset is not suited for analyzing small and medium enterprises.

The young firms in our analysis managed on their own (without being taken over), in a short time since their birth (after 1975), to grow to a leading global position deploying substantial R&D resources. We will label them young leading innovators (Yollies) and old leading innovators (Ollies).

Besides the age of the firm’s foundation, the dataset contains information on the following variables: main industrial sector (according to the Industry Classification Benchmark), country of origin, net sales, number of employees, and R&D investment for each year over 2004–07. The geographic classification of firms is based on ownership, not on location of the activities. Due to missing data for some firms, the final sample includes 1,111 firms. Of our sample firms, 32 percent are from Europe, 38 percent from the United States, 19 percent from Japan, and 10 percent from the rest of the world.
Notes

1. The Estonian programmers were Jaan Tallinn, Ahti Heinla, Priit Kasesalu, and Toivo Annus. The company founders were Niklas Zennstroem (Sweden) and Janus Friis (Denmark).

2. This analysis presents productivity as GDP per hour worked, as is common in the literature (figure 5.3). If we were to use GDP per person employed, as in chapter 4, Europe’s leading economies would reach only around 83 percent of the United States peak in 1990. Moreover, the north would overtake the continental economies in labor productivity around 2003. The basic pattern that interests the United States in this chapter—the reversal of convergence in productivity between Europe and the United States after 1995—would remain.

3. Among technology followers, demand for a particular vintage of products is given. Market share declines with the number of competitors, reducing returns on moving into a new product vintage through adaptation. At the frontier, however, innovation creates new demand by offering new product types.

4. A general caveat: the measurement of productivity in services is fraught with problems. For instance, final prices for many services reflect both quality improvements and cost reductions, but quality improvements are often insufficiently captured. It is not clear whether such measurement issues affect cross-country comparisons of productivity growth in services. To the extent that they do, the conclusions drawn in the literature referenced in this chapter would also be affected.

5. See also Dewatripont and others (2010).

6. The Selected Indicators table A.9 reports selected data series that draw on the original source data quoted in the IUS. In some cases, data used in the IUS are not available for non-European countries, and alternative data series are reported. We have checked the robustness of the results in the IUS against alternative data series and indicate where results diverge. The main conclusions are not affected.

7. There are significant differences in the productivity of R&D. The transition economies of Europe and Central Asia, for instance, are characterized by much higher costs of R&D investment per patent registered than the EU15 or the United States (Goldberg and others 2011). By and large, countries that generate a lot of R&D, particularly in the business sector, have a larger output of innovations, as measured by patents and corresponding business applications.

8. The patent data in the bottom panel come from the IUS and refer only to patents registered under the Patent Cooperation Treaty. In the Selected Indicators, we also report the data on patent counts based on all patents registered under the Treaty, whether with national patent offices or under the European Patent Office. Countries such as Brazil, China, Japan, and the Russian Federation considerably improve their ranking against smaller European countries using this alternative measure. We prefer the IUS data given the data of international registration with the European Patent Office.

9. The data do not tell us what this spending is on. They are calculated as a residual from overall innovation spending minus R&D. The denominator is enterprise turnover. The data are obtained from enterprise surveys.

10. Goldberg and others (2011) examine collaboration of business across borders in patent registrations. Generally, data on collaboration show an upward trend, but in the past decade, the region has been falling behind such countries as China and India. For technology followers, collaboration across borders may be particularly important to absorb and adapt cutting edge technologies for domestic applications.

11. These are aggregate data based on a simple growth accounting framework, subtracting investment in physical capital and labor inputs, but do not account separately for ICT investments or structural shifts in the economy, as in van Ark, O’Mahony, and Timmer (2008). Data are also reported for the United States but not for a larger sample of countries. We therefore do not know whether the EU12 are outliers among emerging markets.

12. It would be preferable to link TFP growth to a measure of innovation at the start of the period. The Commonwealth of Independent States data are, however, only collected since 2006, and there is not much change in the cross-country distribution in the other two measures over time. The results should be seen as indicative, not conclusive.

13. Based on an analysis of the top 1,000 global firms in market capitalization, which were listed in Business Week in 1999, Cohen and Lorenz (2000) found that information technology was by far the most important sector in determining the difference in the total number of new giants between the two regions.

14. Using firm-level information from the scoreboard of largest R&D spenders, it is possible to trace the age and sectoral profile of the largest firms investing in R&D. As the number of observations quickly becomes low, however, particularly when age groups in sectors in regions have to be analyzed, the level of individual European countries cannot be used for analysis. Annexes 2 and 3 describe the scoreboard data and its caveats. Veugelers and Cincera (2010b) performed and reported a similar exercise for the EU27 countries.

15. Finland (four Yollies), Sweden (three), Spain (two), Italy (two), and Iceland, Denmark, Luxembourg, and Austria (each with one) complete the picture.

16. Veugelers and Cincera (2010a) perform a decomposition analysis to calculate the exact size of these effects. This analysis shows that the contribution of Ollies to the total deficit in R&D is small. The most important factors to explain Europe’s overall poor business R&D performance are that Europe has fewer Yollies and that the Yollies it has are less R&D-intensive. Having less R&D-intensive Yollies accounts for more than half the business R&D deficit with the United States.

17. This precludes any analysis at the country level, so only aggregate differences between Europe and the United States are reported.

18. For an interesting comparison of European and U.S. spending patterns on health care and the implications for innovation in the sector, see Cowen (2006).

19. Although the relationship between competition and innovation is not linear, firms well below the technological frontier may actually be discouraged from innovating if competition is too intense.

20. For examples, see the British Broadcasting Corporation’s Planet Earth series.

21. Because of significant year-on-year volatility, the ranking among countries changes quite a bit across years. But the United States is always the largest market for venture capital—both in absolute terms and as a share of GDP.

22. The data used in figure 5.15 come from IJASA/VIP. Data in the IUS indicate that the United States has a large advantage over Europe in the share of graduates in its population, but the IUS for the United States only reports graduate shares among people ages 25–64, thus reflecting cumulative investments in tertiary education, not recent investments.
The Shanghai Ranking ranks universities on a set of indicators measuring their research performance. The indicators include the number of alumni winning Nobel Prizes, the number of university faculty winning Nobel Prizes, the number of articles published in Nature and in Science, the number of articles published in ISI Web of Science journals, the number of highly cited researchers, and the size of universities.

The World Economic Forum reports qualitative measures of the business-research links, based on interviews with executives. Managers are asked to rank the quality of research institutions and the extent to which they collaborate with business. The United States, Switzerland, the United Kingdom, Germany, and Sweden come out on top. The transition economies are mostly at the bottom of the European ranking, but Italy and Greece rank worse than Turkey and Ukraine. The Czech Republic and Hungary score roughly the same as Austria and Luxembourg (Schwab 2011).

An ANCOVA confirms that country differences, as well as technology fields of the cited and citing patents, explain a considerable share of the observed variance in the share of cited university patents. In terms of impact, country effects prevail (Veugelers and others 2011).

Within the EU15, Belgium’s university patents hold a top position in 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 success of Belgian university patenting is due largely to the country’s Interuniversity Microelectronics Centre.

The aggregate score is based on 8 dimensions comprising 25 indicators. Each indicator is normalized, and the aggregate score is the unweighted average. For comparisons with non-European countries, only 12 indicators are available. See annex 1 for details.

Radosevic (2004) found similar results. In addition to a high-tech “north” cluster composed of four countries with the highest national innovation capacities in the European Union (Finland, Sweden, Denmark, and the United Kingdom), he obtained two other clusters comprising most of the catching-up member states, as well as some other member states. One cluster comprises the three cohesion states (Greece, Portugal, and Spain) and six less-advanced new member states (Bulgaria, Latvia, Lithuania, Poland, Romania, and the Slovak Republic). These nine states are characterized by weak national innovation capacities. The four more-advanced new member states (Czech Republic, Estonia, Hungary, and Slovenia), together with six old member states (Austria, Belgium, France, Germany, Ireland, and Italy), form a middle-level group of the European Union.

This short summary draws on Goldberg and others (2011). See also Roos, Fernström, and Gupta (2005).

For an example of how single market reforms in medical devices have promoted innovation in the industry, see Steg and Thumm (2001), who note the limitations imposed by national health systems and the incomplete harmonization in applying single market rules.

According to the Business Week ranking of the 50 most innovative companies in the world, only one European company—Nokia—made it into the top 10. Microsoft, Intel, and Google (all Yollies)—in the top 10 of the world’s largest R&D spending—are ranked 5th, 33rd, and 2nd among the most innovative companies. In Europe, Vodafone, BMW, Daimler, Siemens, and Audi rank among the most innovative companies and are among the largest R&D spenders. Only Vodafone is a Yollie.

While 25 indicators compose the Innovation Union Scoreboard, only 24 are currently computed, as the indicator on “high-growth innovative enterprises as a percentage of all enterprises” is not yet available.

The sources used for retrieving the age information are mainly company websites. This has been cross-checked with other databases (for example, the Amadeus database provided by Bureau van Dijk, and Véron 2008). To construct the firms’ ages, we used the first year of its creation (ex nihilo). In case of a merger and acquisition (14.9 percent of cases), we used the oldest age of the merged entities.

All activities of the firm are consolidated in the scoreboard. We have no information on the geographic or sectoral distribution of firms’ activities.

Europe includes the EU27 and countries in the European Free Trade Association. The rest of the world includes Canada (14 firms), China and Hong Kong SAR, China (10), India (12), Israel (8), the Republic of Korea (18), and Taiwan, China (33).
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