PART I

Chapter 1

Innovation in the crisis and beyond

This chapter provides an overview of the impact of the global financial and public debt crises on innovation. The global financial crisis negatively affected business innovation and R&D. Enterprise creation seems not to have recovered and business bankruptcies have increased significantly. The chapter shows substantial differences in performance across countries, sectors, businesses and types of innovation.

Future trends in innovation in most developed countries are uncertain. In particular, long-term damages to innovation systems occur when long-term skilled unemployment rises and public support of innovation is weakened.

Finally, many countries have implemented policies to respond to the crisis that include innovation, although budgetary constraints have put pressure on governmental support of innovation.

The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.

Key messages

1. **The economic crisis that started in 2008 has negatively affected business innovation and research and development (R&D) in all countries.** The size of the effect and the impact on business innovation has differed widely across countries, depending on their situation at the eve of the crisis and on the policies they subsequently implemented.
2. **Emerging countries in Asia, including Korea and China,** have used the opportunity to demonstrate their strengths in innovation. They continue to outperform developed countries, relying on structural strengths that helped them face the crisis. The crisis has also rewarded **large high-technology innovating firms**; markets for these innovations will continue to be strong.
3. **The crisis revealed the pre-crisis weaknesses of some countries** (*e.g.* Greece and some southern and eastern European countries), **sectors** (*e.g.* the automobile sector) and **types of innovations** (*e.g.* financial innovations). Future prospects for innovation in these countries and industries will greatly depend on broader economic restructuring, which does not place innovation at the top of the immediate policy agenda although innovation will have to play a role in driving growth in the future.
4. **Many OECD countries (northern Europe, Japan and the United States) have recovered somewhat**. Their future innovation performance remains uncertain; it will depend on macroeconomic conditions but also on their ability to maintain innovation as a policy priority.
5. To date there is no evidence of a reallocation of resources towards more innovative businesses. **While there have been more bankruptcies than before the crisis, new business entry has also been significantly depressed. Venture capital investment, which can help support entry of innovative firms, has yet to recover to its pre-crisis level.**
6. **Uncertainties over market conditions in the currently unstable global macroeconomic situation have inhibited investment in innovation.** Large companies and banks are engaged in a process of deleveraging and hoarding that is detrimental to all types of investment, including innovation. Financing constraints have also increased but are not the main explanation to date for the weakening of innovation activities.
7. Many countries have implemented policies in support of innovation during the crisis. This has given innovation new prominence on the policy agenda; government responses to the crisis **mainly focused on infrastructure investments for innovation and the provision of financial resources to businesses**. As the budgetary crisis has developed, a number of governments have more recently started reducing their expenditure on innovation.

Policy lessons

1. **Few innovation policies implemented in response to the crisis have addressed demand uncertainties effectively.** Most countries have relied on traditional infrastructure and financial support instruments, whereas instruments aimed at reducing demand uncertainties could have speeded up the recovery process. Experimenting further with these types of policy tools, notably in sectors where potential demand is high (*e.g.* health, ageing, etc.), would help improve innovation and growth prospects.
2. **The crisis has in many ways accentuated existing situations, including structural weaknesses in national innovation systems, and accelerated previous trends**. Recovery policies that supported failing sectors were likely mistaken: market forces will continue to weaken them and they will eventually face similar difficulties. Instead, resources should be provided to sectors with growth potential, in parallel to industrial policies that facilitate resource redeployment, *e.g.* retraining programmes and R&D and entrepreneurship programmes that reduce costs of such restructuring.
3. **Policies aimed at avoiding employment losses and supporting training are essential to avoid damage to innovation systems**. Such policies do not only matter from a social perspective. From the perspective of innovation *i)* the lack of enterprise creation to absorb unemployed workers, *ii)* the lower quality of matching skilled workers to adequate employment available during recessions as well as *iii)* the importance of employees' tacit knowledge for firms' innovation processes are the main arguments for employment support during downturns.

Introduction

The collapse of Lehman Brothers in September 2008 led to a major global economic crisis of a magnitude that had not been seen for at least half a century: world gross domestic production (GDP) and industrial production retracted, trade collapsed sharply, and unemployment increased in many of the world's major economies. A moderate short-lived recovery began by the end of 2009 and continued with some notable exceptions in 2010 and 2011. Market speculation regarding the sustainability of sovereign debt and the challenges of negotiating fiscal consolidation lowered expectations for a rapid, fully fledged recovery of the world economy. Some countries are now on a much more favourable trajectory. Because of the substantial impact on the output of the world's major economies, on global financial institutions (which play a central role as intermediaries for businesses and their innovation investments), and on public finances (which provide key support to innovation systems), the business cycle downturn has negatively affected innovation performance.

The chapter provides a first comprehensive overview of the effect of the global financial crisis and the subsequent public debt crisis on the world's innovation system and then considers potential future trends.[1] They had an overall negative effect on business R&D and innovation in 2008 in a wide range of countries. To date there is no evidence that they led to a reallocation of resources towards more innovative businesses. The impacts differed substantially across countries, types of businesses and types of innovation. The chapter identifies three different scenarios in terms of the impact on innovation. At one end of the spectrum, the evidence shows that emerging Asia, including Korea and India, has gained opportunities to demonstrate strengths in innovation, as have highly

innovative firms; at the other end of the spectrum, some countries were weakened and their performance remains fragile (*e.g.* Greece, some southern and eastern European countries). The majority of countries have recovered somewhat, but uncertainties remain as regards future developments.

The chapter also discusses the three main factors which have influenced innovation performance during the crises: *i)* uncertainties about trends in demand regarding the recovery, *ii)* access to finance and *iii)* governments' innovation policy responses. Uncertainties over market conditions in the currently unstable global macroeconomic situation have strongly inhibited innovation. Large companies and banks are engaged in a process of deleveraging and hoarding that is detrimental to all types of investment, including in innovation. Financing constraints also increased but are not the main explanation for the decline in innovation activities. Moreover, many countries have implemented policies to support innovation during the global financial crisis giving innovation new prominence in the policy agenda. However, budgetary pressures have risen significantly in many countries and will likely continue to put pressure on public support for innovation.

The remainder of the chapter focuses first on the impact of the crises on innovation and then looks at what happened to factors that likely drove the observed performance. This is followed by a discussion of policy responses and finally of future trends in public spending, likely longer-term challenges and geographical impact.

The crises and their impact on innovation

What to expect of innovation as a result of the crises?

Joseph Schumpeter famously argued that the process of "creative destruction", while painful, fosters innovation and progress by discarding the old and familiar for the new and better. From this perspective, the downturn may be a source of opportunities for innovators and innovation systems. Before turning to what to expect in this respect, Box 1.1 briefly discusses the three dimensions of the global financial and sovereign debt crises that are most important for innovation.

The global financial and sovereign debt crises described in Table 1.1 have had four types of effects on the private sector: *i)* reduction in the demand for products; *ii)* reduction in liquidities in the financial system; *iii)* increased uncertainties as to future developments; and *iv)* impacts due to changes in innovation policy. These can affect innovation performance and investments via several mechanisms, as described in column 2 of Table 1.1. Column 3 shows that the implications for innovation can both be positive and negative. With few exceptions (Nickell *et al.*, 2001; Francois and Lloyd-Ellis, 2008), the pro-cyclicality of R&D and innovation has been observed over various business cycles and for a variety of countries (*e.g.* Griliches, 1990; Broda and Weinstein, 2010; Barlevy, 2002, 2007; Comin and Gertler, 2006; Fatas, 2000; Francois and Lloyd-Ellis, 2008; Rafferty, 2003; Walde and Woitek, 2004).

The global financial crisis and even more the public debt crisis affected countries differently. The global financial crisis most severely hit European countries such as Iceland, Ireland and Italy but also Mexico. Not all countries had negative growth rates in 2009; the BRIC countries (Brazil, the Russian Federation, India, and the People's Republic of China), Argentina, Colombia and Korea continued to grow. Their innovation systems were therefore much less exposed. Public debt challenges were particularly severe for certain

Box 1.1. **Effects of the global financial and sovereign debt crises of relevance to innovation**

Three aspects of the present context suggest that confidence that the current downturn will have had merely "marginal" impacts on innovation may be unwarranted:

- First, innovative businesses in many developed economies have suffered from lower demand for their products and substantial uncertainties over future trends in consumption. The magnitude of the global financial crisis even exceeded some negative records established by the Great Depression (Almunia *et al.*, 2009; Reinhart and Rogoff, 2009). Innovators have suffered and high-technology companies saw their revenues decrease markedly with the drop in demand for higher-quality innovative products that tends to occur during recessions (Lien, 2010; Piva and Rossi-Lamastra, 2011). Following the crisis, the recovery in most developed economies has often been short-lived and incomplete. By mid-2011 prospects for a rapid recovery had dimmed as a result of increased concerns over sovereign debt and the deleveraging that limited opportunities for consumption to recover quickly. The historical evidence also points to a slow recovery process (Reinhart and Rogoff, 2009).
- Second, public support for innovation faces potential challenges given the priority attached to fiscal consolidation. Fiscal consolidation has been at the forefront of policy discussions in Europe, the United States and Japan. High levels of sovereign debt and market speculation about potential sovereign default restrict the scope for policy interventions. Moreover, population ageing will likely place further pressure on pension and health budgets in the medium term and challenge governments' abilities to invest strongly in long-term growth, including in factors that support innovation such as education, infrastructure and innovation projects.
- Third, the global financial crisis exposed the vulnerabilities of the global financial system (Reinhart, 2011). Fragilities in the banking sector affect innovative businesses' opportunities to obtain external financing. With markets speculating in sovereign default risks, moreover, the banking sector in Europe and beyond remains at risk (IMF, 2011a, 2011b). In China, the quick expansion of investment credit for 2009-10 led some to question the quality of some of the projects financed, thus adding to other challenges to the Chinese banking system (IMF, 2011a).

southern European countries. In most countries the recovery has been sluggish with a return to the modest growth rates that characterised the pre-crisis period. The differing impacts of innovation across countries are worth bearing in mind.

The analysis of innovation performance during the global financial and public debt crises points to three different scenarios across countries, industries, firms and framework conditions for innovation. These are described in Table 1.2 with examples and potential future trends:

- In a first scenario the global financial crisis had strong negative impacts on innovation and there has been limited or no recovery. Examples include entrepreneurship/firm creation, venture capital financing and Greece. These areas require structural reforms. Certain trends threaten to damage innovation in the long run (*e.g.* reduced public financing of R&D).
- In the second scenario, probably the most prevalent, the global financial crisis resulted in a temporary negative shock to innovation but led to a subsequent recovery. Examples include many European economies, big R&D firms and trademarks. Future trends will depend on whether or not any long-term risks for innovation arise (*e.g.* a sluggish evolution of demand).

Table 1.1. **Potential effects of various aspects of the global financial and public debt crises on R&D, innovation and entrepreneurship**

Direct effects	Mechanisms affecting innovation	Impact on innovation
Reduced demand for goods and services	• Demand effects: Ambiguous impact as the downturn likely reduces demand for innovative goods, which are often more expensive, and/or durable goods whose purchase can be more easily postponed. Downturns may also increase demand for innovative products that offer lower prices and/or respond better to altered demand during recessions.	*Innovation:* Negative for certain product innovation but positive for process innovations as well as product innovations that reduce costs/prices (*e.g.* low-cost airlines grew out of the recession in the early 1990s). *Entrepreneurship/firm dynamics:* Fewer market opportunities exist for young innovative firms except those with a business model aimed at responding to demand for lower-priced goods. High-potential entrepreneurs react more to the presence of good business opportunities than marginal entrepreneurs who are more likely to respond to labour market conditions. This will affect innovation performance (Koellinger and Thurik, 2011).
	• Competition effects: Competition may increase because gaining other firms' market shares is the only way to maintain sales levels. However, the shock may also force the exit of small firms and thus decrease competition faced by big businesses.	*Innovation:* Impact on innovation depends on the link between product market competition and innovation, the trade-off between rents from less competition and incentives for innovation to "escape" competition (Schumpeter, 1942; Nickell, 1996; Aghion *et al.*, 2005a). *Entrepreneurship/firm dynamics*: • Competition leads to "creative destruction" processes and the failure of less innovative incumbents. It can facilitate opportunities for entrepreneurship to improve aggregate innovation performance (Hall, 1991; Mortensen and Pissarides, 1994; Caballero and Hammour, 1994; 1996; Bailey *et al.*, 2001; Foster *et al.*, 1998). Disney, Microsoft, Hewlett-Packard, Oracle and Cisco were created during downturns. • Young firms with substantial innovation capacities may be forced to exit during recessions before they have fully developed their potential with loss of any set-up costs spent in building up firms' innovation systems (Ouyang, 2011).
	• Cash flow effects: Firms' cash flow may be reduced, making fewer internal resources available to cover operational expenses.	*Innovation:* Negative if external financing is not available. Small and young firms may lower their investments as they face greater risks of being forced to exit and face stronger financing constraints. *Entrepreneurship/firm dynamics:* • Exit of innovative businesses can result if external financing constraints exist (Barlevy, 2002; Nishimura *et al.*, 2005; Hallward-Driemeier and Rijkers, 2011). • However, layoffs and lower wages and/or forced firm exit reduce opportunity costs of entrepreneurship, increase individuals' willingness to take on greater risks and increase the availability of qualified labour during downturns (Koellinger, 2008; Audretsch, 1991, 1995).
	• Inter-temporal resource allocation effects: Firms' opportunity costs for investing in innovation rather than spend on the production of output are lower when demand is low (Caballero and Hammour, 1996; Cooper and Haltiwanger, 1993; Aghion and Saint-Paul, 1998), Private payoffs for innovations are higher when demand is at its peak (Barlevy, 2007).	*Innovation:* Firms spend more on innovation and less on production during the downturn to reap higher payoffs at the peak of the recovery but keep innovations for the future. The time lag between investment and private payoffs to innovation ultimately determines whether the recession has positive or negative effects on innovation. *Entrepreneurship/firm dynamics:* Entrepreneurs might postpone entry of innovations until markets recover and demand is higher.
Reduced liquidity in the financial system	• Reduction in loans due to deleveraging affects all types of investments, notably those of SMEs (which rely more on financing from loans than large firms). Market failure in credit markets may worsen as lower cash flows mean firms have less collateral (Bernanke and Gertler, 1995). • Investors have fewer resources to allocate across investment projects.	*Innovation:* Lack of financing negatively affects innovation during downturns (Aghion *et al.*, 2005b, 2008; Krozner *et al.*, 2007; Dell'Ariccia *et al.*, 2008). The volume of venture financing varies with the business cycle (Gompers and Lerner, 1998, 1999; Kaplan and Schoar, 2005). *Entrepreneurship /firm dynamics:* Reduced entry of innovative start-ups (Lerner, 2011). Negative firm dynamics due to insufficient entry (Caballero and Hammour, 1994; Parker, 2009). Lower financial capital lowers investments in riskier, potentially higher pay-off innovations (Nanda and Rhodes-Kropf, 2011).
Uncertainties affecting demand and finance	• Uncertainties can reduce the number of risky investments by investors, banks and firms, as sunk costs of such investments provide incentives to postpone them.	*Innovation:* Firms may be less willing to face uncertainties and risks associated with introducing new products and/or processes since their survival might be compromised if demand evolves unexpectedly (Fernandes and Paunov, 2011). *Entrepreneurship/firm dynamics:* Limited firm entry can be caused by uncertainties. Entrepreneurs prefer to wait until demand and financial markets have recovered.
Public budgetary situation	• Policy makers either do not address challenges posed by innovation, given other priorities and/or lower public resources, or they focus specifically on innovation. • Recovery packages *vs.* fiscal discipline affects public expenditure as it relates to innovation.	*Innovation* and *Entrepreneurship/firm dynamics:* To the extent that business innovation and R&D are positively linked to public R&D and support, they will move in the same direction.

- In a third scenario, the best possible outcome, the global financial crisis had no substantial impact and innovation performance continues and/or even grows. China is a country to which this applies; other examples are IT firms and public R&D spending. Current trends suggest a positive evolution for those cases.

The following sections discuss these situations and provide evidence on trends.

Table 1.2. **Stylised description of scenarios on the crises and innovation**

Scenarios	Examples of countries, industries and firms	Outlook
1. The crises had negative impacts on innovation and there was no or little recovery subsequently. The global financial crisis revealed structural shortcomings that already existed in the pre-crisis period	• Greece and Spain (Figures 1.8, 1.15). • Automobile industries in developed countries and other medium-technology sectors (Figure 1.4). • Venture capital and other markets for risk financing (Figure 1.9) and, to lesser extent, access to bank credit (Figure 1.10). • Some financial innovations (Figure 1.5). • Entrepreneurship/firm creation (Figure 1.6). • Some small and medium-sized and young companies.	• Long-term skilled unemployment might lead to depletion of human capital needed for innovation across firms and businesses (Figures 1.14, 1.15). • Reductions in public funding of R&D (Table 1.5) further raise longer-term risks for countries and businesses. • Changing global innovation landscape might threaten recovery processes in some countries (Figure 1.17). • Recovery will depend on structural reforms implemented.
2. The crises had negative impacts on innovation but there was a notable recovery. The crises were a temporary shock for innovation but structural strengths facilitated some recovery.	• Many European countries and the United States, although recovery profiles have been substantially different (Figure 1.1, Table 1.3 and Table 1.4). • Big R&D investing businesses (Figures 1.3, 1.4). • Trademarks (Figure 1.2).	• Two distinct recovery paths for firms and economies in this group: 1. Recovery path likely in the long term in cases of limited impact on long-term skilled unemployment, continued public funding and a more pronounced recovery in demand. 2. Recovery at threat in cases of reduced public funding, long-term unemployment and weak recovery of demand.
3. The crises had little impact on innovation and innovation performance continues to be strong. The crises did not affect innovation performance.	• China, Korea (Table 1.3, Figure 1.17). • Dynamic IT firms (Figures 1.4, 1.11). • Most countries' government budget appropriations or outlays for R&D (GBAORD) (Table 1.5). • Business enterprise researchers (Figure 1.16).	• Positive with limited evidence to date of slowdowns for firms and countries.

What happened to innovation?

Describing the impacts of the global financial and public debt crises requires timely and reliable statistics. However, several statistical series, including many official ones, are only available well after the reference period, sometimes several years. This is often necessary to ensure the quality of such statistics, but it reduces the list of indicators available for a timely analysis of the current context. The choice made here has been to use official statistics such as BERD and GBAORD where available, with estimates for some recent data points, along with more timely indicators, such as from *ad hoc* firm surveys conducted to assess the impacts of the global financial crisis, trademark filings, PCT patent applications and EU R&D Scoreboard data. Future work on the impacts of the crisis will make it possible to validate the evidence with more systematic official statistics.

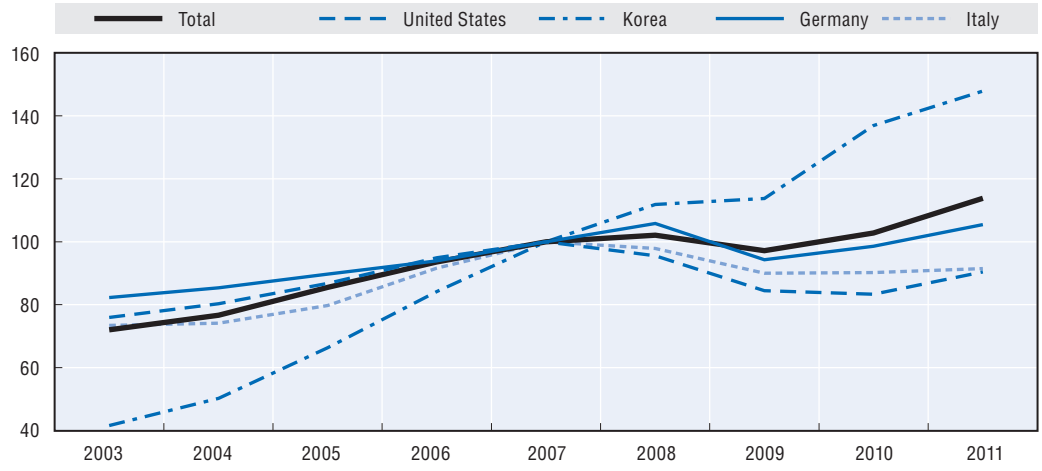
The available evidence on firms shows that innovation activities declined. Among 4 238 European firms, a large share decreased innovation spending at the onset of the global financial crisis compared to the pre-crisis period (26.7% *versus* 10.8%). However, more than half of the interviewed firms maintained their levels of innovation spending (Archibugi and Filippetti, 2011). Furthermore, evidence from the World Bank Financial

Crisis Survey for 2008-09 on firms in Bulgaria, Hungary, Latvia, Lithuania, Romania and Turkey shows that R&D investments were pro-cyclical during the global financial crisis (Männasoo and Meriküll, 2011). Also, among more than 1 500 Latin America firms, one in four stopped innovation investment projects in response to the crisis (Paunov, 2012). Kanerva and Hollanders found that 23% of innovative firms across 27 European countries decreased their innovation expenditures in response to the downturn. The same pattern is true for the world's top R&D investors; their R&D spending decreased by 1.9% in 2009. It recovered by 4% in 2010 to USD 563 billion (EUR 456 billion) (EC, 2011a).

Aggregate innovation performance indicators similarly reject the hypothesis that the downturn fostered innovation. Patenting activity based on trends in PCT filings declined considerably in 2009 compared to 2007. Figure 1.1 and Table 1.3 show worldwide trends

Figure 1.1. **Trends in the number of PCT patent filings for selected countries, 2003-11**

Index 2007 = 100



Source: WIPO Statistics Database, May 2012.

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Table 1.3. **Trends in the number of PCT patent filings for selected countries, 2003-11**

Index 2007 = 100

	2003	2004	2005	2006	2007	2008	2009	2010	2011
United States	76.0	80.3	86.7	94.9	100	95.6	84.4	83.3	90.4
Japan	62.8	73.1	89.6	97.4	100	103.7	107.4	115.9	140.1
Germany	82.3	85.4	89.7	93.9	100	105.8	94.3	98.6	105.4
China	23.8	31.3	45.9	72.3	100	112.2	144.8	225.4	300.7
Korea	41.6	50.2	66.3	84.2	100	111.8	113.7	136.9	147.9
France	78.9	79.0	87.5	95.4	100	107.8	110.3	110.5	113.4
United Kingdom	94.1	90.9	92.0	92.0	100	98.6	91.0	88.3	87.5
Switzerland	74.7	75.8	85.9	94.5	100	99.1	95.8	97.3	104.5
Sweden	71.3	78.0	78.9	91.3	100	113.2	97.6	90.7	94.7
Netherlands	101.0	96.6	101.5	102.7	100	98.4	100.7	91.7	79.0
Canada	78.8	73.0	80.4	89.4	100	103.4	87.8	93.7	100.3
Italy	73.5	74.1	79.7	91.6	100	97.9	90.0	90.2	91.5
Others	72.8	77.6	87.1	92.3	100	107.3	100.7	106.0	110.0
Total	**72.0**	**76.7**	**85.5**	**93.6**	**100**	**102.1**	**97.2**	**102.7**	**113.8**

Source: WIPO Statistics Database, May 2012.

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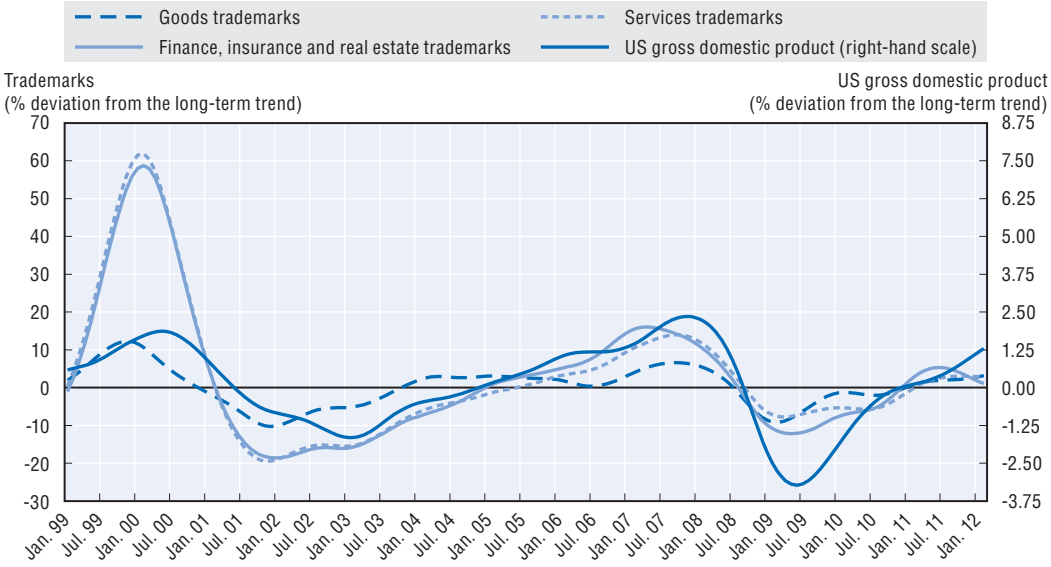
and trends for a selection of countries. The decline was particularly pronounced in Canada, Germany and the United States. In the United States, 2010 marked a further decrease relative to 2009, while Germany saw a recovery but did not attain 2007 levels until 2011. China and Korea, by contrast, continued to increase filings substantially in 2010. Statistics for 2011 indicate a continuing recovery, with the Netherlands, Italy, the United Kingdom and the United States as notable exceptions.[2] The global financial crisis also led to persistent below-trend trademark registrations (Figure 1.2). Similarly, businesses' R&D spending declined in 2009 compared to 2008 in some of the major economies (Figure 1.3). In the European Union business investment in R&D was more affected than public investment in 2009 (see below). In the EU's business sector, R&D expenditure decreased by 3.1% in nominal terms in 2009. This relatively limited decrease shows that business R&D expenditure has been relatively resilient (EC, 2011a).

Figure 1.2. **US gross domestic product and trademark applications at the USPTO, 1999-2012**

Comparing cycles, by type of trademarks, percentage deviation from the long-term trend



Note: Goods (resp. services) trademarks represent trademark applications designating only good (resp. services) classes; finance, insurance and real estate trademarks represent trademark applications designating class 036 of the Nice Classification. The US gross domestic product is based on the series of seasonally adjusted GDP, expenditure approach, in volume (chained volume estimates) contained in the OECD Quarterly National Accounts Database (June 2012). Raw GDP and trademark applications series were treated using the OECD's Composite Leading Indicators methodology. Monthly data were used for trademark applications and quarterly data for GDP, converted to a monthly frequency via linear interpolation and aligned with the mid-quarter month. This treatment removes seasonal patterns and trends (using the Hodrick-Prescott filter) in order to extract the cyclical pattern. The cyclical pattern presented on the graph is expressed as a percentage deviation from the long-term trend. Considering the filters applied, the remaining cycles are those with a period of between 18 months and 10 years. The analysis was performed on series from January 1990 to February 2012 for trademark applications and to January 2012 for GDP. For more information on the methodology, see OECD (2008), OECD System of Composite Leading Indicators, OECD, Paris, *www.oecd.org/dataoecd/26/39/41629509.pdf*. The graph shows a peak around 2004 for the trademark series which does not correspond to the economic activity. It corresponds to the accession of the United States to the Madrid Agreement in November 2003, which facilitated the filing procedure for foreign applications.

Source: USPTO, Trademark Electronic Search System (TESS), June 2012; OECD, Quarterly National Accounts Database, June 2012; based on OECD (2011), *OECD Science, Technology and Industry Scoreboard 2011, OECD, Paris.*

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However, in certain countries innovations aimed at improving efficiency have increased in response to the global financial crisis. Among respondents to a survey of about 1 500 Latin American firms, the number that introduced process innovations from 2008 to 2009 increased (Paunov, 2012). This may indicate that firms sought efficiency improvements in their production processes. Also, some respondents to a survey of 532 senior executives of large multinational enterprises said that while the crisis led to reductions in R&D it also led to efficiency improvements in the conduct of R&D. This included improved accountability for performance and spending, increased collaboration with outside R&D groups and the streamlining of core R&D processes (McKinsey, 2010).

Differential impacts across countries, industries and firms

The global financial crisis did not affect all countries to the same extent and recovery processes were very unequal. The intensity of the shock and the differences in countries' innovation systems also produced differential impacts on innovation performance. As Figure 1.3 shows, large R&D investors in the United States and Europe recovered substantially in terms of sales and, in consequence, increased their R&D investments in 2009-10. Evidence from leading R&D investors also suggests that the 2008 shock was greater for US companies than for European ones (EC, 2011a). With low rates of growth in R&D for the 2009/10 period, Japan did not show a corresponding recovery. The group of emerging countries was already much less affected in 2008/09.

Evidence on business R&D spending in Table 1.4 shows that the impacts varied. A group of countries suffered negative impacts, while others, among them many European countries, had weak performance up to 2010, while only a small group showed substantial performance, including several eastern European countries.

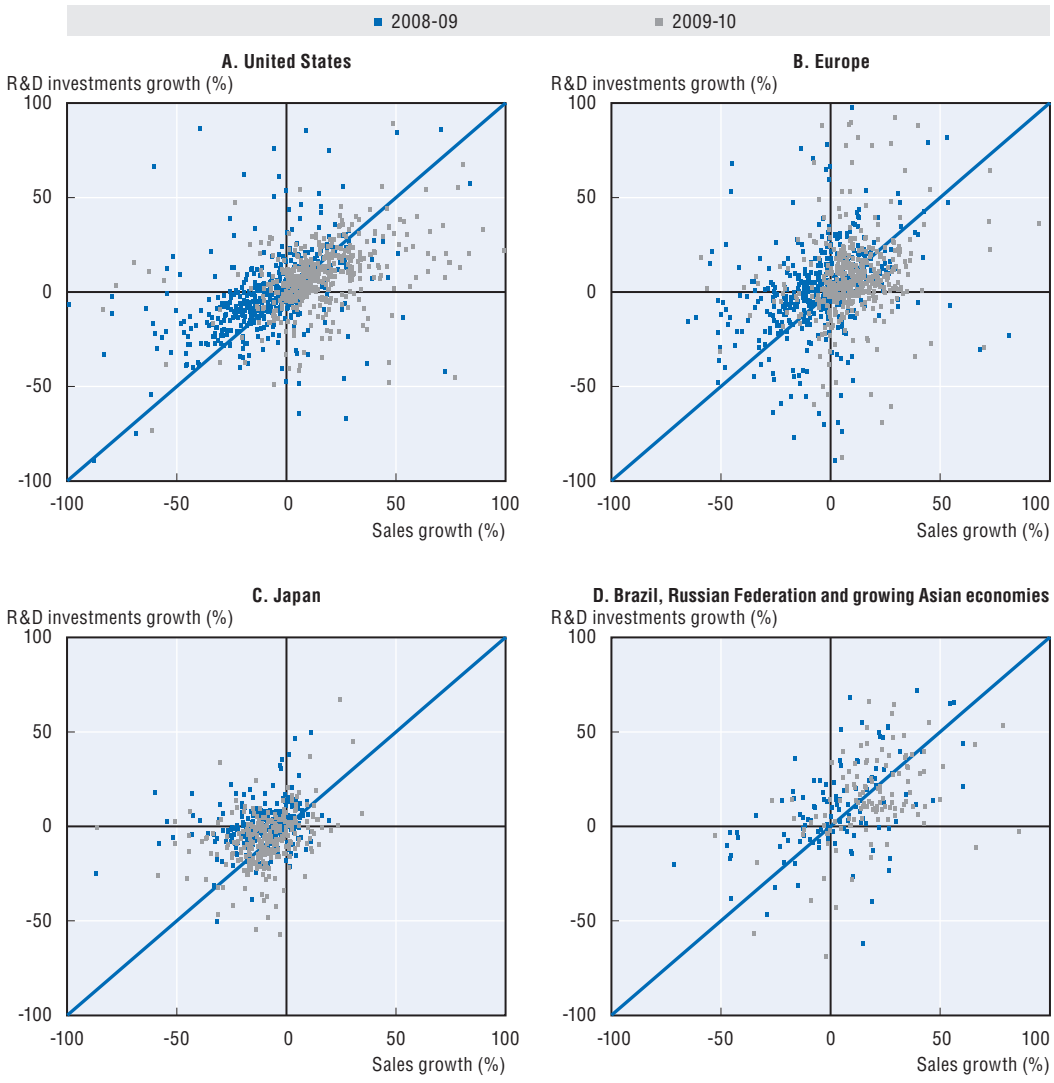
Not all industries were equally affected. While sales decreased for all segments, the medium-technology industry segment, which includes automobiles, was particularly hard hit. Among the top 1 400 R&D investors, sales dropped in 2008-09; declines in sales were much more modest for high-technology industries (*e.g.* aircraft, IT hardware, producers of medical instruments) and low-technology industries (including *e.g.* textile and food producers). In manufacturing, employment among top investors decreased exclusively in medium-technology industries, and this is the segment in which R&D took the largest hits (Figure 1.4). The health sector actually posted an increase in R&D investment in 2008/09 (EC, 2011a). Similarly, software companies raised R&D investments for 2008/09 (by 1.4%). This is also related to the fact that sales increased (by about 2.5%) over the period. For 2009/10 software firms reported sales and employment growth of 13.6% and 9.2%, respectively, along with R&D investments of 9.9% (EC, 2011a).

Evidence on European firms from the 2009 Innobarometer also points to substantial impacts on firms in the medium but also in the high innovation-intensive sectors (Kanerva and Hollanders, 2009). The differential effect of business cycles across industries has been previously observed. Sectoral data for 1975-2007 suggest their strong impacts on technology-intensive industries (such as business services, manufacture of electrical and optical equipment) (WIFO, 2011).

An interesting question that arises from the differences across industries is whether the shock of the global financial crisis affected types of innovation differently and may therefore produce a somewhat different mix of innovations (Figure 1.5). While it is necessarily a partial view, trademarks show somewhat different trends in the pre- and

Figure 1.3. **Top R&D firms' sales and R&D investment growth performance by countries and selected regions, 2008-09 and 2009-10**

Annual growth rate in percentage



Source: EC (2011), "Monitoring industrial research: the 2011 EU Industrial R&D investment Scoreboard", European Commission, Luxembourg.

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post-crisis period with a substantial upward trend in finance, insurance and real estate as well as services trademarks before 2008 while the post-2008 period shows a drop in finance, insurance and real estate trademarks which has persisted. Given the role of financial innovations in the build-up to the crisis this may suggest market corrections towards a different type of innovation in the post-crisis context.

Firms of different sizes and/or ages also differed substantially in terms of the effect of the global financial crisis on their innovation performance. Larger firms more readily accommodated shocks to sales because they have internal financial resources to rely on and larger access to external financial resources. Moreover, the evidence suggests that in 2011 European SMEs' profit margins continue to be more affected and they are more heavily engaged in deleveraging activities (ECB, 2011). Large firms used internal financial

Table 1.4. **Trends in business enterprise expenditure on R&D for a selection of countries, 2004-11**

Index 2007 = 100

	2004	2005	2006	2007	2008	2009	2010	2011
Business R&D is below pre-crisis (2007) levels in 2009								
Canada	99	99	101	100	94	88	85	86
Czech Republic	67	82	100	100	98	95	107	
Netherlands	98	97	102	100	94	88	92	
Israel	71	79	85	100	101	95	99	
Japan	83	90	95	100	100	88	90	
Luxembourg	92	91	102	100	93	91	86	
United Kingdom	87	90	94	100	99	95	93	
Sweden		97	108	100	110	97	95	
Business R&D is above pre-crisis (2007) level but weak								
Austria	78	90	94	100	106	102	106	
Belgium	90	89	95	100	103	100	100	
Denmark				100	110	108	109	
Finland	85	89	94	100	110	103	103	
France			99	100	101	103	103	
Germany	91	92	97	100	106	103	106	111
Italy	82	87	89	100	105	103	105	103
Norway	86	88	93	100	106	104	102	
Russian Federation	89	86	92	100	96	106	99	
United States	85	89	95	100	106	102		
Continued positive trends of business R&D throughout the crisis								
China	57	70	86	100	117	148	170	
Estonia	51	70	91	100	104	103	135	
Hungary	67	79	98	100	108	127	133	
Korea	73	79	90	100	106	111	124	
Ireland	82	87	93	100	108	124	125	
Poland	79	92	95	100	114	119	126	
Portugal	43	48	75	100	126	127	119	
Slovak Republic	108	116	104	100	118	109	153	
Turkey	35	60	69	100	108	109	125	

Notes: The following data points are provisional: Austria-2008-10, Belgium-2010, Canada-2010-2011, France-2010, Germany-2011, Israel-2009-2010, Italy-2010-2011, Luxembourg-2010, Portugal-2010, United Kingdom-2010. The following data points are based on national estimates or projections: Austria-2008-2010, Denmark-2010, Sweden-2008-2010, Portugal-2004-2006. Data points for Denmark, France and Sweden are excluded for years prior to 2007, 2006 and 2005, respectively, due to breaks in the series. Data for the United States exclude most or all capital expenditure and data for Israel exclude defence spending in all years.

Source: OECD, *Main Science and Technology Indicators (MSTI) Database*, June 2012.

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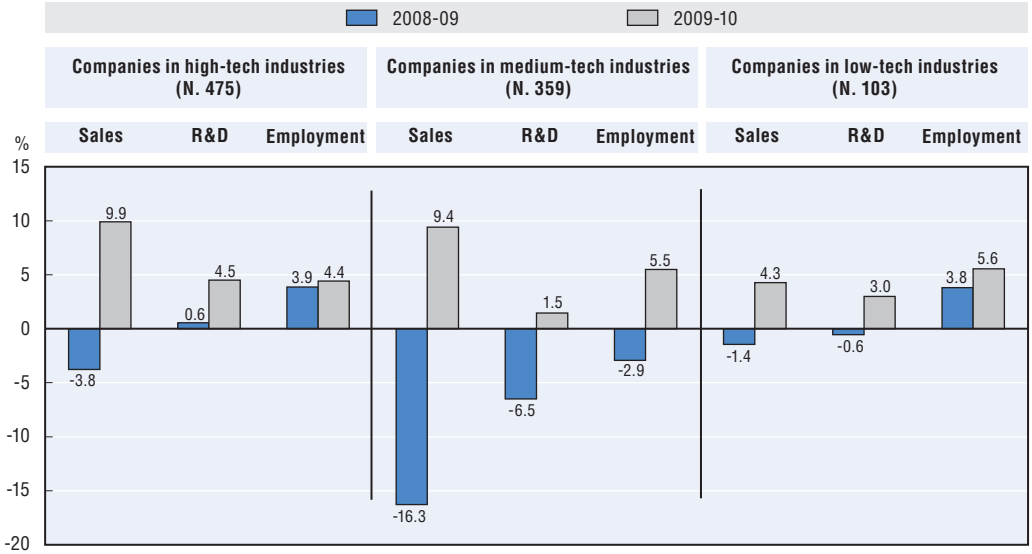
resources to make fewer cuts to innovation investments during the downturn and thus smooth their innovation investments over time. This is more efficient because discontinuing investments substantially involves costs: tacit capital embodied in human capital may be lost in case of project interruptions. Also, benefits will accrue over the over time after efficient working environments for innovation have matured.

The evidence suggests that large firms were less hard hit; while the top 1 400 R&D-investment firms reduced their R&D spending, it decreased much less than sales in firms headquartered both in the United States and in the EU (EC, 2011a). For small and young firms, Paunov (2012) finds that in a sample of Latin American firms small firms were not more likely to discontinue investment in innovation but younger firms were more at risk, likely because they have shorter credit histories and therefore difficulty accessing finance.

Figure 1.4. **Sales, R&D and employment growth for firms in high-technology, medium-technology and low-technology industries, 2008-09 and 2009-10**

Annual growth rate in percentage



Note: Firms are classified following the Eurostat/OECD taxonomy based on industries' R&D intensities.

Source: EC (2011), "Monitoring industrial research: the 2011 EU Industrial R&D investment Scoreboard", European Commission, Luxembourg.

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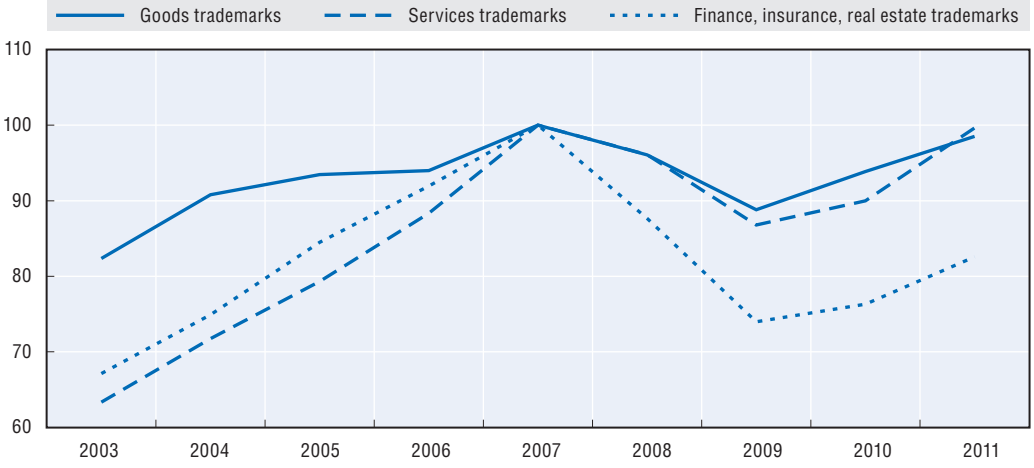
Figure 1.5. **Trends in trademarks by category, 2003-11**

Index 2007 = 100



Source: OECD, based on USPTO, Trademark Electronic Search System, June 2012.

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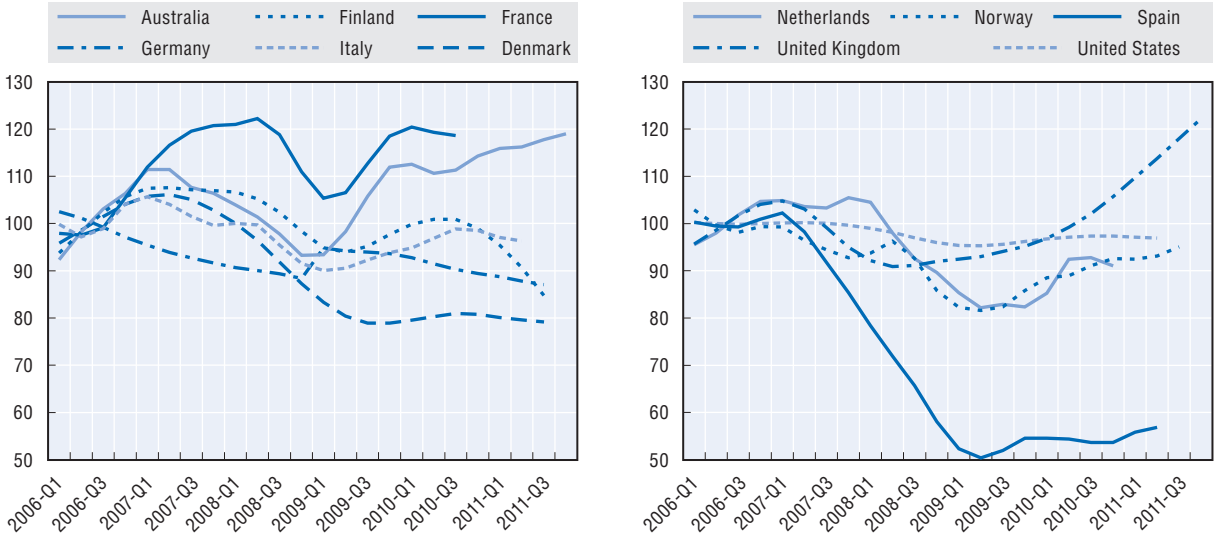
R&D trends suggest that small companies considerably reduced their R&D investments in many countries (EC, 2011a). On a more positive note, a survey of manufacturing companies in Austria, France, Germany, Hungary, Italy, Spain and the United Kingdom finds that innovative firms, independently of their size, saw a less substantial decline in sales (Békés *et al.*, 2011). This might have lowered to some extent negative impacts on innovation performance, including for smaller firms.

The global downturn and "creative destruction"

"Creative destruction" – the process whereby economic downturns force less innovative incumbents to exit and allow more innovative firms to enter – can play a powerful role in improving overall innovation performance (see Table 1.1) and therefore matters substantially for growth (Aghion and Howitt, 1992). The available evidence suggests that the "creative destruction" process broke down with the onset of the global financial crisis. Figures 1.6 and 1.7 provide information on enterprise creation and bankruptcies from official business registries for a selection of countries. They show a clear decrease in the rate of enterprise creation which tends to be most pronounced in the first half of 2009. The declines are larger in Australia, Denmark, France and Spain than in Finland, Germany, Italy and the United Kingdom. Only a few countries have managed to return to pre-crisis levels: the rate of enterprise creation is still below the 2006 rate in the United States and firm creation does not appear to have recovered in Denmark and Spain. Bankruptcies also increased substantially in some of the countries with weak firm entry; the United States and Denmark stand out as clear examples.

Figure 1.6. **Enterprise creation, quarterly data, 2006-11**

Index 2006 = 100



Notes: The data series on French enterprise creation which are taken from *OECD Entrepreneurship at a Glance 2010* in order to avoid a break in series in 2009Q1, showing a substantial increase in individual start-ups in response to the introduction of a simplified procedure. The substantial decrease from a historically high level in Norway from 2006 onwards followed changes to the tax code that sparked a wave of new firms in 2006.

Source: OECD (2010), *Entrepreneurship at a Glance, OECD, Paris;* OECD (2012), *Entrepreneurship at a Glance 2012*, OECD, Paris.

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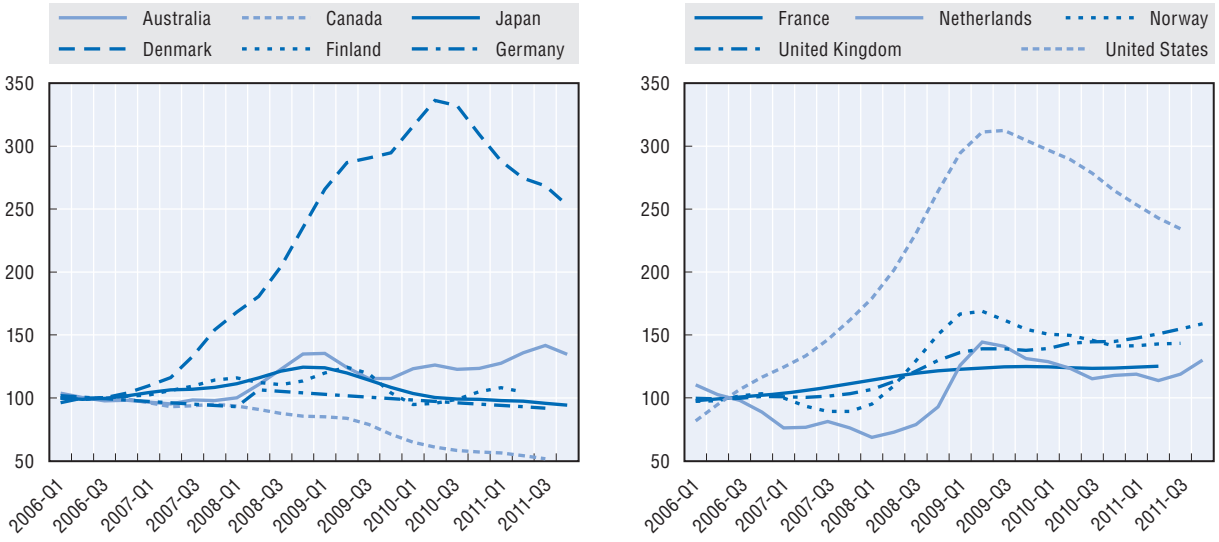
If large numbers of businesses exit, this will lead to unemployment unless other businesses, and notably new businesses, are created to re-employ those workers. Otherwise, high exit accompanied by low entry results in a substantial increase in unused resources, notably of labour. This represents a costly downside to recessions. The global financial crisis brought a rise in unemployment rates, and there are no or only partial or moderate returns to pre-crisis unemployment levels. Greece, Hungary, Ireland and Spain have had double-digit unemployment rates since mid-2009. Workers with tertiary education, who tend to be important for innovation, are affected in some countries. The

Figure 1.7. **Number of bankruptcies, quarterly data, 2006-11**

Index 2006 = 100



Source: OECD (2012), *OECD Entrepreneurship at a Glance 2012*, Paris, OECD.

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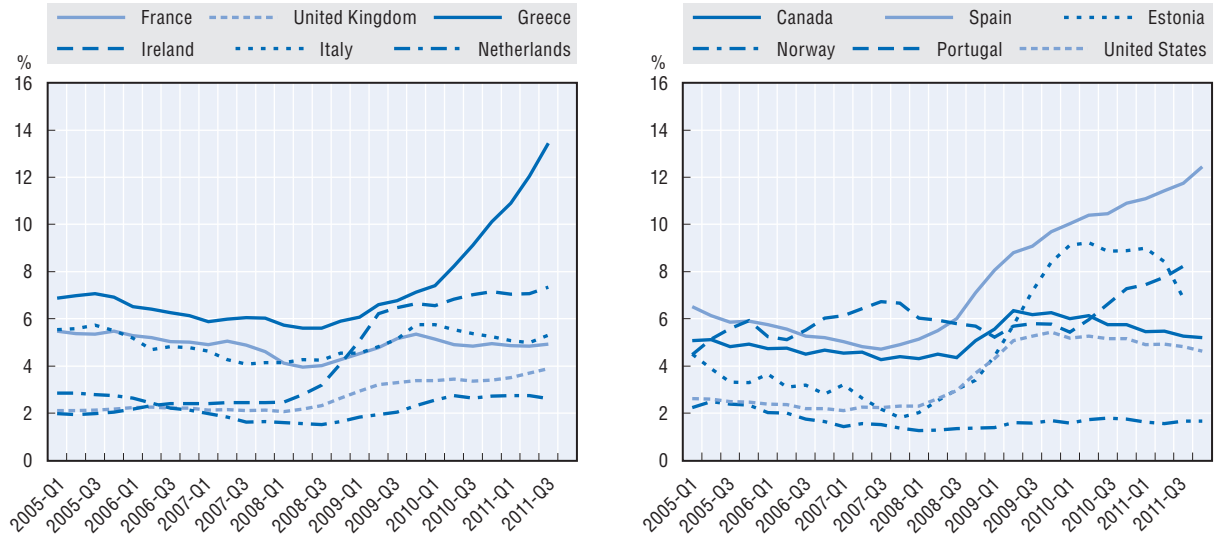
rise in unemployment of skilled workers was very substantial in Greece and Spain and relatively strong in Estonia, Ireland and Portugal. The Netherlands, Norway and the United Kingdom showed low increases, and there are small increases in the United States and Canada (Figure 1.8).

Figure 1.8. **Quarterly unemployment rate for highly-skilled workers for selected countries, 2005-11**

Percentage



Notes: Reported unemployment rates are smoothed using three-quarter centred moving averages for the age group 25-64. High-skilled is defined as ISCED 5/6. See source notes for further methodological detail.

Source: OECD estimates based on *OECD Main Economic Indicators Database* and national labour force surveys, March 2012.

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The impact on different factors relevant for innovation

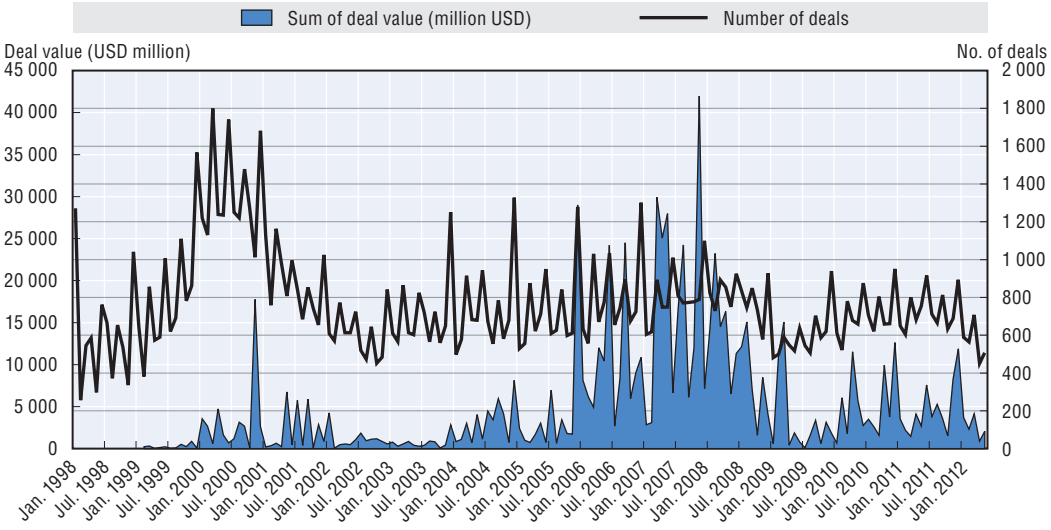
Impacts on the financing of innovation

A lack of available external resources to finance innovation activities, especially when cash flows decline, is one of the major reasons for pro-cyclical innovation investment patterns (Table 1.1). It is well known that it is more challenging to obtain external financing for innovation investments than for other business investments (see Hall and Lerner, 2009, for a comprehensive overview). Lerner (2011) suggests that the efficiency of venture capital investments would be improved if the reverse were true, since these investments appear to be deployed much less effectively during boom periods.

With regard to venture capital markets, Figure 1.9 shows a sharp decline in the number and value of venture capital deals with the onset of the global financial crisis, after what had been a very successful period of growth in venture capital markets. Venture capital investments have not fully recovered and Europe had only a slight rebound in 2010 and 2011 (Kraemer-Eis and Lang, 2011). Funding for new entrepreneurial endeavours from other sources during the credit crunch proved nearly impossible as a consequence of the collapse of financial markets, with pension funds, (university) endowments and wealthy individual investors reluctant to fund ventures. Moreover, increasingly risk-adverse investors hesitated to commit to new obligations (Lerner, 2011). While a recovery process had set in by the last quarter of 2009 the market has not returned to its 2008 performance levels. Data for the United States suggest that the pattern is similar in different industries.

Figure 1.9. **Venture capital investments: Number of deals and total value, January 1998 - March 2012**

Sum of deal value in million USD and number of deals



Source: Thomson ONE, May 2012.

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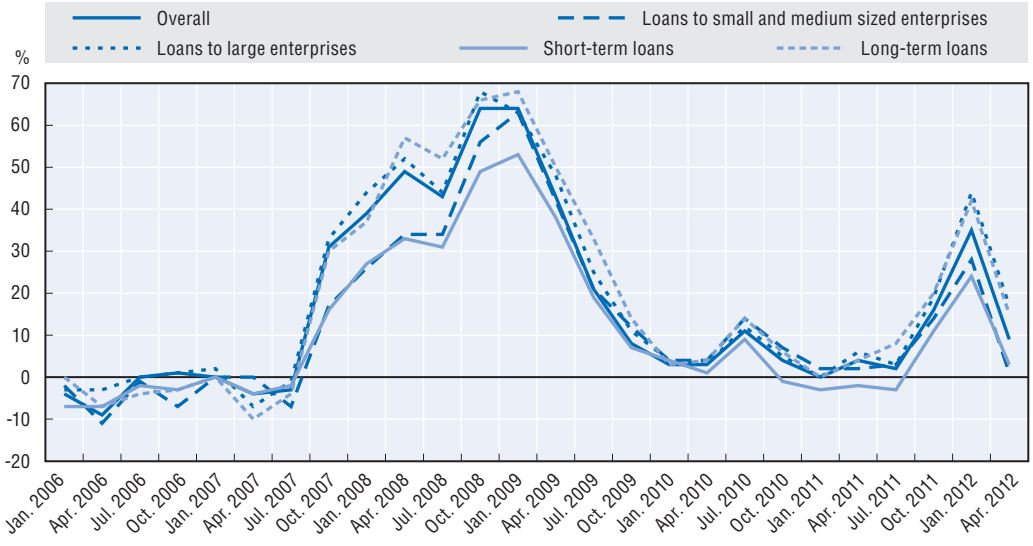
Banks' lending activities changed during the global financial crisis, and the October 2011 European Central Bank's (ECB) Bank Lending Survey indicates that banks' enterprise credit standards have tightened. The upward trend in the third quarter of 2011 (Figure 1.10) which was halted in the first quarter of 2012 is worth noting, as it will be important to understand the reasons for the changes in banks' lending behaviour when

designing policies to support innovation financing. The survey responses indicate that one reason is banks' liquidity position, as deleveraging continues to be important as banks build resilience to the potential continuing risk of sovereign default. New regulatory requirements under Basel III can also affect banks' credit offers. Uncertainties about the general economic situation play a role as well.

Figure 1.10. **Changes in credit standards applied to the approval of loans or credit lines to enterprises, January 2006-April 2012**

Net percentage of banks reporting tightening of credit standards



Source: European Central Bank, Bank Lending Surveys, April 2012.

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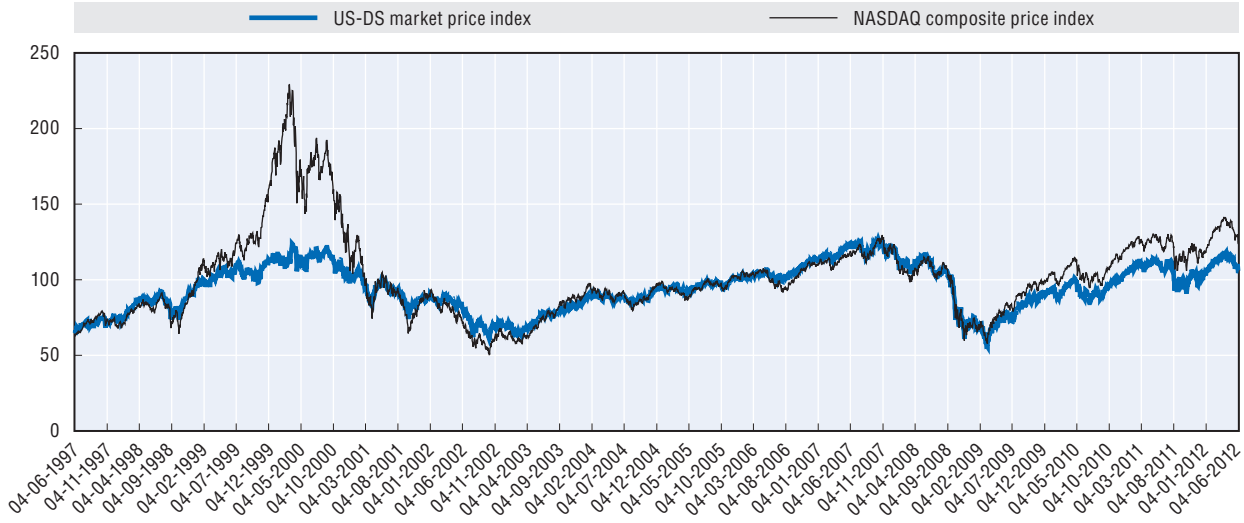
There is no evidence as yet on the impacts of financing constraints on innovation. To the extent that similar factors affected innovation and export performance, findings that US exports declined more in sectors with greater financing needs (Chor and Manova, 2011) support the hypothesis that financing constraints have played some role in constraining firms' activities.

Beyond questions of access to banking credit, uncertainty and volatility in stock markets in the current business cycle raise challenges for alternative financing opportunities as well. Using the NASDAQ as a proxy for the evolution of equity prices for technology companies, the evidence indicates that this market and the general market suffered in a similar way at the onset of the global financial crisis but that the shock was much smaller than for the dotcom bubble (Figure 1.11). Interestingly, the post-crisis recovery was stronger for NASDAQ firms than for the overall market, a sign of market confidence in at least some of the most dynamic large technology-based companies. The differential should, however, be interpreted with caution as a few dominant players may at some point in time have a significant impact on NASDAQ trends while the general indices include the financial industry which has suffered since the onset of the crisis.

Figure 1.11. **Equity price indices of the NASDAQ and the total US market, 4 June 1997-4 June 2012**

Price index 1/1/2006 = 100



Source: Datastream, June 2012.

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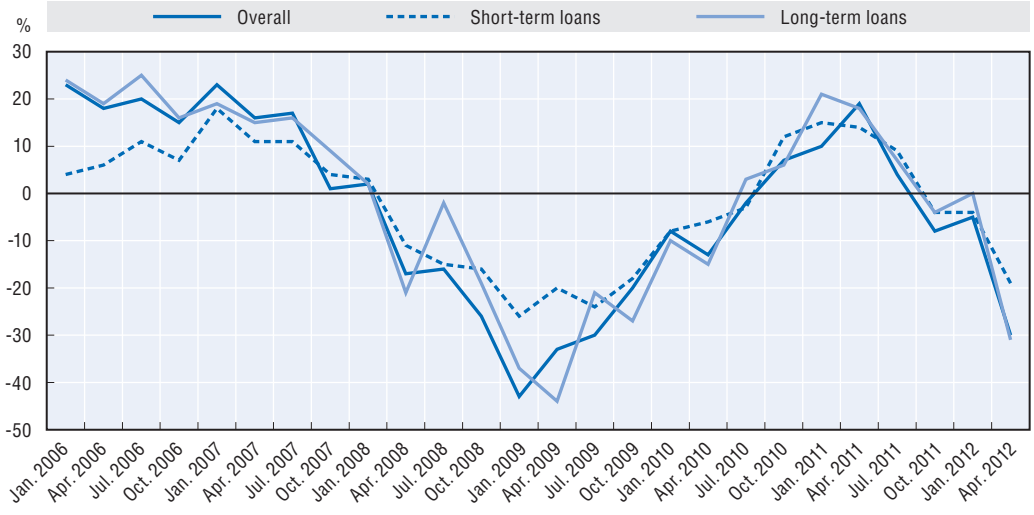
The role of depressed demand and substantial uncertainty

Declines in consumer demand and uncertainties as regards the recovery are probably significant reasons for weak innovation performance. Responses to the ECB's Bank Lending Survey suggest firms' demand for bank loans decreased substantially during the global financial crisis (Figure 1.12); the recovery in demand seems to have halted by end 2011/early 2012. Also, more than 70% of firms in each of the six eastern European countries (Bulgaria,

Figure 1.12. **Changes in demand for loans and credit lines to enterprises, January 2006-April 2012**

Net percentage of banks reporting positive loan demand



Source: European Central Bank, Bank Lending Surveys, April 2012.

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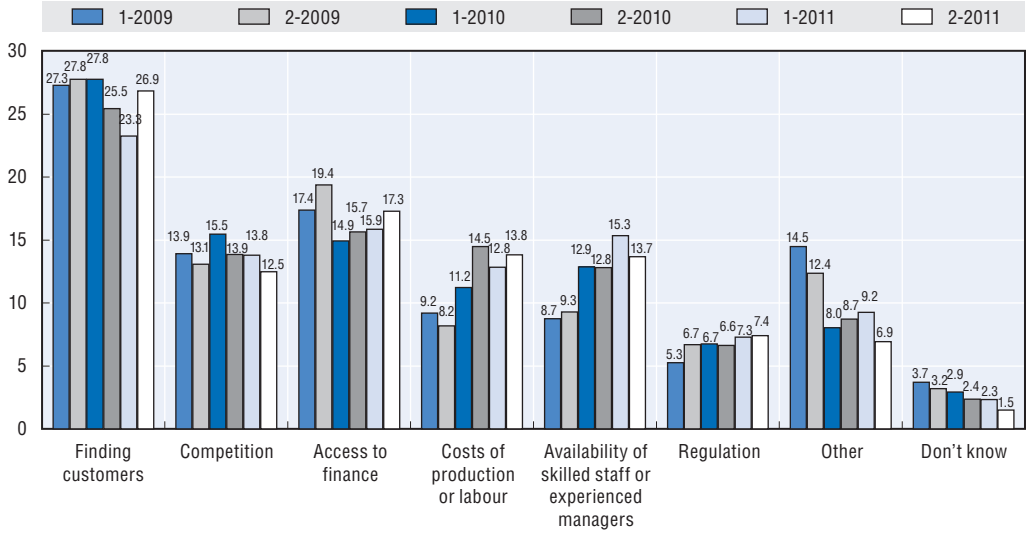
Hungary, Latvia, Lithuania, Romania and Turkey) interviewed for the World Bank's Financial Crisis survey said the primary impact of the crisis was a drop in demand for their products (Ramalho *et al.*, 2009). Finally, when asked about major challenges a larger percentage of firms was preoccupied about factors related to product markets – *i.e.* finding customers and competition – over access to finance. Evidence from a survey of US start-ups confirms this: for about two-thirds of these firms slow or lost sales and unpredictable business conditions were perceived to be the biggest challenges over 2008-10 (Robb and Reedy, 2012). Interestingly, a larger share of firms reported concern over business conditions in 2010 than in 2009. Figure 1.13 shows responses for SMEs; the evidence on large firms is similar on that dimension. In any case, access to finance appears to have been much more difficult as the global financial crisis unfolded. However, demand appears a much bigger challenge.

Figure 1.13. **Most pressing problem faced by SMEs in the euro area, 2009-11**

Percentages



Source: ECB, Surveys on the Access to Finance of Small and Medium-Sized Enterprises in the Euro Area, March 2012.

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Innovation policy responses to the global financial and public debt crises

Requirements and challenges for innovation policy

Innovation policies at present need to focus on two objectives: the first is to promote positive long-term trends in innovation performance. However, as described above, the downturn has affected innovation. The second objective, therefore, is to avoid possible long-term damage to innovation systems caused by the crises themselves. In fact, in the United States the slowdown in new business entry predates the global financial crisis (Haltiwanger, 2011). Across the OECD a productivity slowdowns set in well before (Dupont *et al.*, 2011). Again before the global financial crisis, economic performance in most EU countries was weaker than in the best-performing OECD countries in terms of GDP per capita (OECD, 2011c). Therefore, today's low economic growth may partly reflect deterioration in fundamentals and point to a need for structural support policies. Similarly, low growth in some southern European economies may reflect well-known weaknesses in prevalent innovation systems.

This chapter focuses specifically on crisis response policies that were closely related to innovation. However, it is worth noting that the global financial crisis, partly owing to efforts at fiscal consolidation, led to needed structural reforms. These notably included labour market reforms. For example, work-sharing arrangements were introduced or expanded as an immediate response but reforms were also introduced in retirement schemes, job protection, severance pay and wage bargaining systems. In some countries needed reforms were introduced to raise competition in previously protected sectors such as network industries and services. More generally, the worst-affected countries made efforts to remove barriers to entrepreneurship (OECD, 2012). These reforms obviously have impacts on innovation systems and should be considered in a full assessment of countries' responses to the crisis.

Trends in public spending on R&D and innovation

It is not easy to adopt policy tools to address these priorities for a variety of reasons. A first obvious challenge is the availability of public financial resources to invest in innovation. Recessions imply fewer tax receipts and prolonged recessions can require long-run support policies, so that such interventions lead to increasing levels of public debt and thus raise questions of sustainability. Trends in government budget appropriations or outlays for R&D (GBAORD) have shown considerable resilience to the global financial crisis (Table 1.5). By 2009, only Italy's spending had decreased relative to 2007. In spite of the increased fiscal pressure imposed by a lack of recovery, the evidence on spending in 2010 continues to show considerable resilience. This shows governments' firm commitment to public R&D support. Nonetheless, in 2010, in response to increased fiscal pressures, GBAORD in real terms was below the pre-crisis 2007 rate in Hungary, Ireland, Italy and the United Kingdom. This carried over to 2011. France and Slovenia decreased their 2009 spending rates. Responses from the *OECD Science, Technology and Industry Outlook 2012* policy questionnaire suggest that this also holds for Israel, in this case owing to a scaling back on temporary crisis-response measures with the end of the global financial crisis.

Innovation policies adopted in response to the crises

The impact of the global financial and public debt crises on innovation policies differs substantially across countries. In response, many governments announced recovery packages which often included substantial measures in support of innovation (OECD, 2009). Where recovery policies were implemented the response often consisted in supporting ongoing initiatives, responding strongly to financing constraints due to the global financial crisis (measures that would be phased out afterwards), and undertaking structural reforms that would not have an immediate impact. Table 1.A provides detailed information on policy responses to the crises based mainly on the *OECD Science, Technology and Industry Outlook 2012* policy questionnaire. Argentina, Austria, Belgium, Chile, Colombia and New Zealand report that they introduced few changes in response to the crises. In some cases, the economies were not severely affected and in others the governments did not believe changes were needed in innovation policy. In Estonia, Germany and Sweden the crisis mainly led to additional resources for existing programmes in support of innovation. Countries in which the crisis led to new innovation initiatives and projects include Greece and Spain but also Australia and Canada.

Table 1.5. **Trends in government budget appropriations or outlays for R&D (GBAORD), selected countries, 2008-11**

Index 2007 = 100

	2008	2009	2010	2011
Luxembourg	123	136	154	167
Slovak Republic	139	144	146	120
Portugal	115	119	134	132
Russian Federation	104	137	134	143
Korea	112	123	133	143
Estonia	127	119	126	130
Australia	103	117	123	122
Austria	110	118	123	127
Germany	104	109	120	121
Denmark	106	116	116	121
Slovenia	101	127	114	124
Finland	101	106	113	109
Sweden	100	109	112	109
Norway	101	109	112	106
Belgium	113	109	111	
Netherlands	103	109	111	107
France	117	120	111	113
Israel	108	109	109	
Czech Republic	98	108	108	122
Japan	103	103	106	110
Spain	103	106	101	
Ireland	104	106	96	95
United Kingdom	99	101	94	
Italy	98	94	91	87
Hungary	110	112	87	120
Romania	115	83	76	70

Notes: Data series for Israel exclude defence spending; for Australia, Austria and Japan only federal and central government is included; for Japan R&D in social sciences and humanities is excluded. All data for 2011 are provisional except for those of Finland, France, Italy, Japan, Korea, the Netherlands, the Russian Federation and Portugal. For UK-2010, they are based on national estimates or projections.

Source: OECD, *Main Science and Technology Indicators (MSTI) Database*, June 2012.

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Six main trends can be distinguished in the policy measures adopted:

- First, support for public research institutions and educational programmes were a clear priority in many countries. A non-exhaustive list includes Australia, Canada, China, Estonia, Greece, Hungary, Italy, Portugal, Switzerland and the United States. This shows that public authorities recognised the relevance of human capital and the contributions to knowledge of public institutions.
- Second, another priority was to help firms affected by lack of access to credit, particularly for riskier projects. Public authorities reacted by providing financial support and/or taking on risks by providing loan guarantees in Finland, Israel, the Netherlands, the Slovak Republic, Sweden, the United Kingdom and the United States, among others.
- Third, in several cases the types of tools used have undergone some adjustment; this includes the use of tax subsidy schemes. Extending tax breaks for firms, often related to their R&D spending, was a measure popular in Australia, Finland, France, Italy and the Netherlands. Other measures that involved less direct and more indirect spending were also adopted.

- Fourth, countries emphasised "smart specialisation" by focusing on sectors identified as central for national competitiveness and for welfare more generally. Sectors receiving wider support include health-related analysis as well as support for environmental innovations. Such sector orientation is also reflected in crisis responses in Belgium, Canada, China, France, Hungary, Japan, the Netherlands, Portugal and the United States.
- Fifth, many countries strengthened support for SMEs in recognition of the greater challenges they faced as the global financial crisis set in. This not only included support for SMEs to access to finance but also support for R&D and innovation projects, including the hiring of qualified staff to engage in such projects. Canada, Finland, France, Germany, Hungary, Italy and Slovenia adopted such measures.
- Sixth, more emphasis was placed on structural measures to address weaknesses of national innovation systems, including efforts to reform public research institutions in Italy and Greece, to enhance public-private collaboration projects in France, to reduce red tape for business in Spain, and to work towards more pay-off for public spending on R&D and innovation in the United Kingdom.

How successfully did innovation policy respond to the challenge posed by the global financial crisis?

A first policy challenge was a timely response to the global financial crisis, with the impact on employment a key priority. This poses considerable challenges for innovation policy as public projects in support of innovation often require long-term support before they have returns. The strategy adopted by many countries was to introduce clear short-term measures – notably providing credit or loan guarantees to firms directly affected by the crisis – jointly with longer-term reform measures. A strong focus on education and infrastructure is also related to addressing short- and long-term objectives, by offering short-term perspectives for laid-off workers while building a bigger stock of human capital for innovation.

A second policy challenge is that good projects often require long-term planning and were therefore not "shovel-ready" and able to be launched and have a rapid impact (OECD, 2011d). New projects implemented quickly have less chance of succeeding especially if there is too little time to prepare them optimally. This explains why many countries did not substantially alter their innovation policies. An approach widely adopted was to strengthen existing programmes and projects rather than launching altogether new ones. Where new programmes were launched, for example with new approaches to innovation, the time frame envisaged was much longer and the crisis served as a catalyst for reform.

A third policy challenge involved the private investments firms did not undertake because of uncertainties about the evolution of demand. The problem is that even if public support is provided for innovative projects, firms might not avail themselves of it, preferring to wait and see and thus prolonging a slow-growth period. One approach towards encouraging investment is public procurement of certain innovations (*e.g.* those serving environmental objectives) as a means to guarantee future markets for them. Canada, for example, combined recovery packages with commitments to environmentally friendly innovations. Another alternative is to offer prizes for innovations so as to potentially increase firms' investments in innovation (and possibly add public benefits to private ones) and signal the inherent value of innovation. There is less evidence of the use of such instruments, and the somewhat cautious recovery in some countries might point to future consideration of this issue.

A final appraisal of recovery policies will require evaluating how reforms affected innovation performance and welfare at large. Since many of these reforms were implemented recently, any judgements can only be preliminary and partial. Countries' own evaluations have rendered a positive verdict in terms of employment preservation: for instance, Canada's Economic Action Plan (CEAP) may have helped maintain roughly 220 000 jobs. Other outcomes have been improvements in digital infrastructure with the extension of the coverage of broadband in Portugal. Paunov (2012) and Kanerva and Hollanders (2009) also found that firms with access to public funding were less likely to cut innovation investments. A more thorough discussion of impacts will be provided in Guellec and Paunov (forthcoming).

Impacts on future innovation performance: Looking ahead

Is there a risk of long-term effects on innovation-based growth?

The costs of the global downturn will be much higher if innovation systems are more permanently affected. The sluggish recovery is likely to create substantial uncertainties about potential long-term consequences (referred to as hysteresis effects). The fact that downturns specifically related to financial crises can have long-term economic costs has been established in a variety of studies (*e.g.* Abiad *et al.*, 2009; Cerra and Saxena, 2008; Calvo *et al.*, 2006; Rafferty, 2003). Evolutionary approaches to the economics of innovation following Nelson and Winter (1982) describe the potentially substantial hysteresis effects of shocks (Metcalfe *et al.*, 2006; Dosi *et al.*, 2010).

Five factors have long-run effects on innovation systems: *i)* negative effects on human capital; *ii)* disruptions to investments that affect future innovation efforts; *iii)* negative impacts on technological leadership; *iv)* changes in attitudes towards innovation projects in financial markets; and *v)* permanent changes to public support systems for innovation. At present it is difficult to provide a verdict on the last two aspects since financial markets and public innovation policy are currently the subject of debate; potential implications for trends in innovation should be considered when policy decisions are taken.

First, in terms of negative long-run effects on skills – a central factor for innovation (OECD, 2010) – the crises have led to higher unemployment rates, including among the skilled workforce involved in innovation (in firms that decide to downsize innovation-related activities in addition to innovative businesses that are forced to exit). Longer-term innovation effects from lay-offs can arise in two ways:

- There may be less skilled human capital if capacities and "up-to-date" knowledge are lost, as occurs for the long-term unemployed. In fast-paced high-technology sectors such as biotechnology, aeronautics and information and communication technologies (ICTs) long spells of unemployment lower exposure to technology and therefore deplete workers' skills. High unemployment rates of college graduates also pose a challenge since early-career unemployment can permanently affect integration in the workforce along the entire career path.
- At the business level dismissals can lead to permanent "scars" for innovation processes at the concerned firms if laid-off employees hold tacit knowledge that is lost to firms as a result. There may then be a much slower recovery in innovation performance as new employees first need to acquire such knowledge, *i.e.* sunk costs have to be incurred before innovation activities can be taken up again.

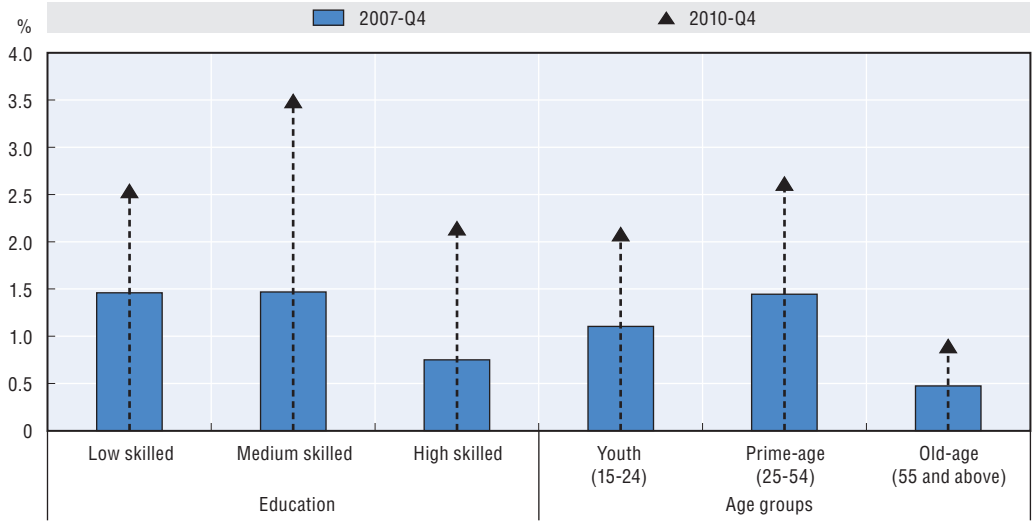
A factor that might act as a counter-weight is an increase in training for those unemployed.

Substantial uncertainties over recovery processes suggest that employment will not recover quickly; the potential risks for long-term effects due to unemployment are therefore important. In a survey of 532 senior executives some respondents worried that changes to R&D could weaken available talent for future R&D activities (McKinsey, 2010).

Long-term unemployment (LTU) rates for the OECD presented in Figure 1.14 show that while LTU tends to mainly affect low- and medium-skilled workers there was a substantial increase from pre-crisis levels for skilled workers as well. Difficulties also rose for young people, whose successful job entry matters for their entire employment careers as well (Oreopoulos *et al.*, 2012). Skilled LTU has increased up to the present in Estonia, Greece, Portugal and Spain and, to a much lower extent, in Ireland and the United States (Figure 1.15, A). Similar trends are observed for LTU of medium-skilled workers (Figure 1.15, B). Germany has opposite trends while in the majority of other OECD countries LTU of skilled workers was not substantially affected. It is worth noting, however, that this evidence may underestimate the depletion of skilled human capital due to the global financial crisis: this is because skilled workers who lost their jobs may have taken less skilled jobs because of limited employment opportunities during the global financial crisis in order to avoid unemployment. This would also lead to a depletion of the types of skills needed for innovation. Trends in the number of researchers (Figure 1.16) remain positive in that there is little evidence of a substantial decrease in their numbers in response to the crisis, and Korea stands out with a substantial increase.

Figure 1.14. **Long-term unemployment by education and age groups, 2007 and 2010**

Persons unemployed a year or longer as a share of the working-age population, OECD average



Notes: OECD is the weighted average of 27 OECD countries (excluding Australia, Chile, Israel, Japan, Mexico, New Zealand and Switzerland).

Source: OECD (2011), *OECD Employment Outlook 2011*, OECD, Paris.

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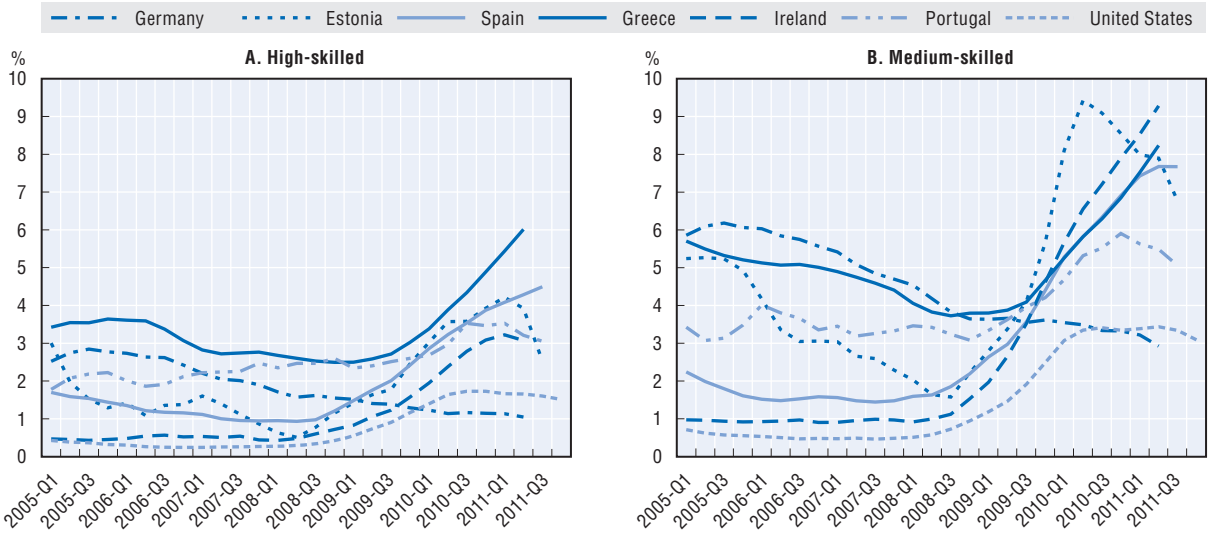
Figure 1.15. **Long-term unemployment rate by skills level, selected countries, quarterly data, January 2005-April 2011**

Persons unemployed a year or longer as a share of the population aged 25-64



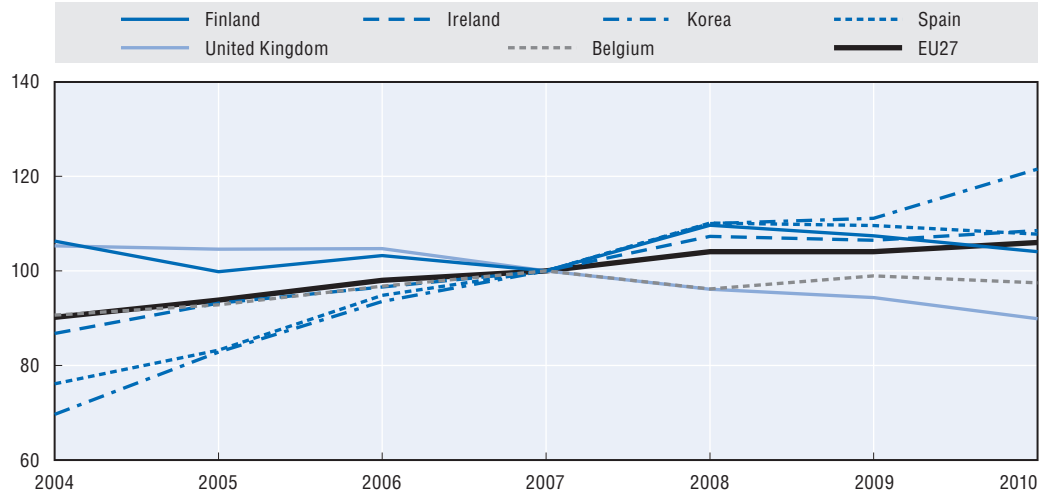
Notes: Reported long-term unemployemnt rates for age group 25-64. High-skilled is defined as ISCED 5/6 and medium-skilled as ISCED 3/4. Please refer to the notes for *OECD Main Economic Indicators Database* for further methodological detail.

Source: OECD estimates based on *OECD Main Economic Indicators Database* and national labour force surveys, February 2012.

StatLink http://dx.doi.org/10.1787/888932689598

Figure 1.16. **Business enterprise researchers (FTE), selected countries and EU27, 2004-10**

Index 2007 = 100



Source: OECD, *Main Science and Technology Indicators (MSTI) Database*, June 2012.

StatLink http://dx.doi.org/10.1787/888932689636

The current downturn may accelerate long-term trends towards more flexible employer-employee relationships. As has been widely noted, ICTs have altered work processes. Specifically, they increasingly allow segmenting production processes, including highly skilled tasks that can be executed through short-term assignments. An advantage of such processes is that if businesses do not face labour termination costs, they

may be much less hesitant to re-hire. The issue of the conditions under which such flexible employment relations support and/or weaken innovation needs to be tested.

Second, innovation investments not made in the present may have effects on innovation performance in the near future, as limited investments reduce the pool of opportunities for successful innovations: foregone innovations have a cumulative effect on innovation. Moreover, if businesses interrupt but later resume innovation investment projects they may face higher upfront costs. This can lead to a slower recovery in innovation investments. The loss of tacit knowledge and the costs involved in establishing new arrangements for innovation can also slow investments. At least for the world's leading R&D innovators, the substantial recovery of 2010 suggests that the shock of 2009 did not affect underlying innovation investment capacities (EC, 2011b). Yet the uncertainties of 2011-12 may create difficulties, particularly for smaller businesses. Finally, to the extent that some innovative firms exited, overall innovation investments may be lower, at least until comparable innovative businesses enter. This has not yet happened.

Third, technological leadership would be at risk if key businesses relocated abroad in response to prolonged low demand in local markets, difficult financing conditions and other challenges for operating their business. Such relocations might have an effect beyond the downturn if businesses do not find returning to their previous location advantageous even after the recovery. Private companies already seek to explore options to access growing Chinese and Asian markets, and the increasingly global nature of innovation and ICTs facilitate partial relocation. The crises may have accelerated these ongoing trends.

Fourth, another factor that will shape the magnitude and duration of the impacts relates to countries' policy responses. The fact that the large majority of countries affected by the global financial crisis decided to maintain their innovation investments and, in some cases, undertake additional projects has certainly been a boost, but for those that will struggle to keep spending in the future (as described below and in Table 1.6) there are further risks. While it is beyond the scope of this analysis to discuss regulation in the financial sector, it is important to note that decisions that affect firms' access to credit can also fundamentally shape innovation performance beyond the crisis.

Outlook for the global distribution of leadership in innovation

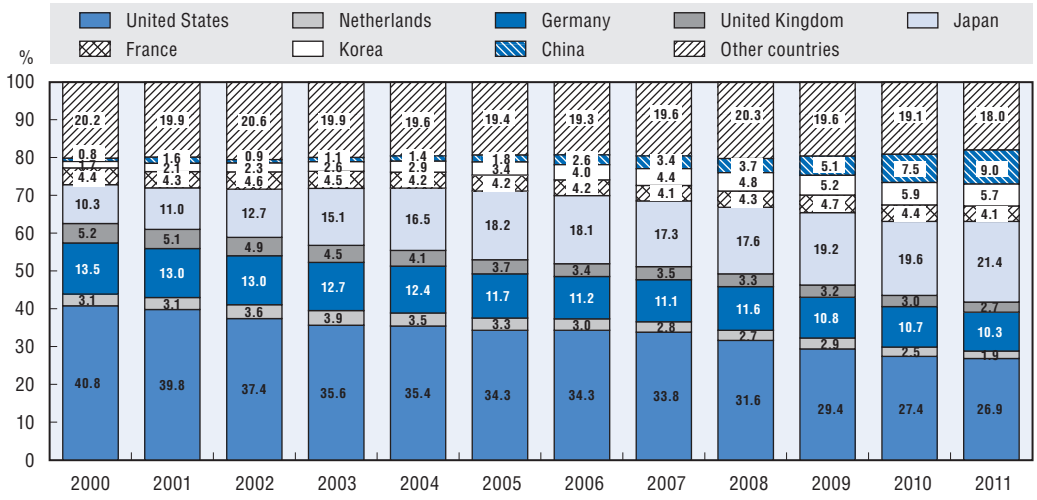
As described above, while the global financial crisis certainly had repercussions in developed and developing economies alike, Asian economies and countries such as Brazil continued to grow in 2009. The sovereign debt crisis had an even more pronounced effect on developed than on developing economies, with corresponding differences in the impacts on innovation systems. Moreover, OECD growth forecasts predict that Brazil, China, India and Indonesia will have much higher growth rates than the OECD area in 2011 and 2012 (OECD, 2011e). The differential in macroeconomic circumstances facilitates further catch-up, specifically in terms of the BRIICS' innovation performance. Indeed, the European Commission's Innovation Union Competitiveness Report concludes that: "The overall R&I [Research and Innovation] competitive position of the EU has been progressively declining in the last decade. This decline is mainly due to the sharp rise of Asia, a trend likely to continue given the ambitious R&D targets of South Korea, Japan or China; and the inability of the EU to address some important weaknesses of its R&D system" (EC, 2011b).

A comparison of the world's leading R&D investors shows that the 2010 recovery in R&D was highly unequal. Growth in R&D investments was much higher in China (29.5%), Korea (20.5%), India (20.5%) and Chinese Taipei (17.8%) than in the US (10%) and the EU (6.1%) (EC,

2011a). Moreover, while the statistics in Figure 1.17 should be interpreted with caution, they show evidence that China's and Korea's performance differs substantially from that of the United States which has seen a substantial decrease in its share of PCT filings from the onset of the global financial crisis. Evidence on triadic patents available until 2010 confirms this trend for China; while its share is still low (triadic patents are more selective than PCT patents in terms of novelty), it increased substantially (from 0.9% in 2007 to 1.8% in 2010). The strong performance of Japan is related to regulatory changes introduced in the late 1990s that led to very recent use of the PCT by Japanese firms.[3] Forecasts based on current trends suggest that by 2020 the shares of PCT patent applications may be 18% for the European Union, 15% for the United States and 55% for leading Asian countries (EC, 2011b).

Figure 1.17. **Country shares in total PCT filings, 2000-11**

Percentages



Source: WIPO Statistics Database, May 2012.

StatLink http://dx.doi.org/10.1787/888932689655

There is some evidence of catch-up in a few emerging Asian economies and strong performance and continued policy support for innovation in Latin America. For their part, several southern and eastern European countries that were hard hit by the global financial crisis have subsequently struggled to manage their public debt; this puts pressure not only on current but also on future public funding (see below). Based on firm data from the Innobarometer 2009 survey, Kanerva and Hollanders (2009) found that firms in European countries that had experienced the fastest rates of improvement in their innovation performance were most affected by the economic crisis. The impact on future public funding of R&D and innovation, on long-term unemployment of the skilled as well as on trends in their firms' innovation performance raises their risks of suffering longer-term scars from the global financial and public debt crises.

Moreover, at sub-national level the global financial crisis hurt many industries and regions that were already struggling before the crisis; one example is the US car manufacturing sector. The post-crisis period thus potentially intensified diverging performance trends within countries that might well intensify if public resources for support are limited (leaving aside the question whether such support is justified from an efficiency perspective).

Outlook for future public spending on R&D and innovation

As stimulus packages are phased out and countries pursue fiscal consolidation, there is a possibility that long-term public investment, a basis for future economic growth, will be sacrificed to short-term budgetary pressures. Indeed, several countries have specified that projects implemented during the global financial crisis will be phased out. Moreover, as Table 1.6 indicates, when asked about future public spending on R&D and innovation countries such as Greece, Ireland, the Slovak Republic, Slovenia and Spain foresee a possible decrease. By contrast, many countries, including those where the impacts of the global financial crisis were limited, such as Argentina and China, but also Denmark, Estonia and Sweden, plan to increase their spending in the near future. Therefore, the picture is not altogether negative. A question, however, is whether the different spending patterns in Europe will stall the catching up of eastern and southern Europe and, therefore, widen gaps within the European Union in terms of innovation performance. The Europe 2020 strategy adopted in 2010 responds to this challenge by setting out high-level policy objectives at EU level including the investment of 3% of the EU's GDP in R&D.

Table 1.6. **Forecasted changes in the overall levels of public R&D funding in coming years**

Spending will increase	
Argentina	Budget of the Ministry of Science, Technology and Productive Innovation increased from 2010 (USD 510 million, EUR 387 million) to 2012 (USD 732 million, EUR 527 million).
Austria	Planned increase.
Chile	Objective to increase spending on R&D in Chile from 0.4% to 0.8% of GDP; public budget for science, technology and innovation reaches USD 500 million.
China	12th Five-Year-Plan for S&T Development established an increase in government S&T appropriation over the next five years.
Colombia	Expected increase of GBAORD from USD 622 million (COP 807 billion) in 2012 to USD 917 million (COP 1 189 billion) in 2014 based on government targets established in the National Policy for STI, the National Development Plan 2010-14 and the strategic development programme "Visión 2019".
Denmark	Planned increase.
Estonia	Plans to raise R&D to 2% of GDP by 2015.
Germany	Plans to increase public R&D funding. Between 2010 and 2013 the federal government invests an additional USD 14.8 billion (EUR 12 billion) in key areas of education and research.
Luxembourg	Objective to reach 2.3%-2.6% of GDP by 2020.
Poland	Possible increase.
Russian Federation	2012 budget provides 10% increase in civil science spending for 2013 compared to previous budget, renewal of Russian armed forces likely increase in military-oriented R&D.
South Africa	Planned increase.
Sweden	Possible increase.
Turkey	Objective of increasing R&D intensity to 3% by 2023.
Spending levels will be maintained at their current level and increased in some domains	
Belgium	Federal government programme decided tax credit would not be subject to budget cuts of the coming years; Flanders budget for R&D to increase by USD 69 million (EUR 60 million) for 2012 and another USD 80.5 million (EUR 70 million) in 2013 as well as in 2014; Brussels Capital Region plans increase in coming years and of 9% for 2013.
Israel	Increase in budget for reform of higher education system, other budgets unchanged.
New Zealand	Additional budget for developing institutions to support business innovation and address science challenges, other funding unchanged.
Spending levels will be maintained at their current level	
France	Encouraging innovation remains a high priority for the government (*e.g.* R&D tax credit).
United Kingdom	Scientific research budget maintained and ring-fenced until 2014.
United States	National budget legislation (*Budget Control Act* of 2011) requires unchanged totals for most federal budget categories over the next decade; overall US federal R&D investments see possible decline from USD 147 billion (2010) to USD 140.8 billion (2013) with reduced funding for military spending) but US federal government support for basic and applied research possible increase from USD 59 billion (2008) to USD 65 billion (2013)

Table 1.6. **Forecasted changes in the overall levels of public R&D funding in coming years** *(cont.)*

Spending levels are likely to decrease	
Greece	Efforts to achieve more efficient use of resources (see Table 1.A on policies), European Union structural funds only possible source of increase of government funding for research.
Ireland	Investment in research likely to remain under severe pressure in years ahead due to budgetary constraints, objective to focus on investments in areas with higher medium-term pay-off opportunities.
Slovak Republic	Possible negative impact on public innovation support due to fiscal consolidation measures.
Slovenia	Drastic cuts in budget expected in 2012 and subsequent years with expected decrease in GBAORD from USD 343.2 million (EUR 216.2 million) in 2011 to USD 326.6 million EUR 202.5 million in 2012.
Spain	Measures adopted to manage public deficits include preliminary decrease of USD 845.1 million (EUR 600 million) for R&D activities for 2011 possibly also for 2012.
The evolution of spending is still uncertain	
Australia	The uptake of the R&D tax incentive is demand-driven and total business investment in R&D is difficult to foresee. "Powering Ideas", the government's innovation agenda 2009-20 highlights the importance of public research programmes. Recent trends show that support for public research programmes has increased with some decrease in direct business assistance programmes.
Canada	Science, technology and innovation features prominently in the 2012 federal budget, with corresponding budgetary commitments. The government will also streamline and improve the Scientific Research and Experimental Development tax incentive programme with savings expected to be directed towards direct R&D programmes. Other STI budgets are expected to remain steady although some may be affected by a government-wide effort to return to balanced budgets.

Note: The table is mainly based on country responses to the question: "How are public R&D budgets forecasted to change in the coming years?"

Source: Country responses to the *OECD Science, Technology and Industry Outlook 2012* policy questionnaire.

Conclusion

The global financial crisis which started in 2008 has negatively affected business innovation and R&D in all countries, and to date there is no evidence of a reallocation of resources towards more innovative businesses. The effects of the crisis differed substantially across countries, sectors, businesses and types of innovation. Emerging Asia, including Korea and China, have shown their dynamism as players in the international innovation system. They continue to outperform developed countries and are likely to continue to do so in the future. The crisis has also rewarded large high-technology innovating firms for which markets will continue to be strong.

By contrast, the global financial crisis has revealed pre-crisis weaknesses in some countries (*e.g.* Greece and some southern and eastern European countries), sectors (*e.g.* the automobile sector) and types of innovation (*e.g.* financial innovations). Future prospects for innovation in these countries and industries will depend on broader economic restructuring, which does not place innovation at the top of the immediate policy agenda although innovation will have to play a role in driving growth in the future. The majority of developed countries (northern Europe, Japan and the United States) have recovered somewhat. Their future innovation performance and future global innovation trends remain uncertain. Important factors include macroeconomic conditions, public innovation support policies, and the ability to maintain innovation as a priority. Avoiding long-term impacts of the crisis on innovation should have high priority; this requires ensuring limited long-term skilled unemployment and strong public support of innovation.

Finally, many countries have implemented policies to respond to the crisis that put substantial emphasis on innovation. Innovation-related responses to the crisis have mainly focused on infrastructure investments for innovation and the provision of financial resources to businesses. However, budgetary pressures have in several countries led to a public debt crisis and will likely continue to put pressure on public support for innovation.

Notes

1. It draws on a variety of sources: the OECD Thematic Workshop on Financing R&D and Innovation in the Current Macroeconomic Context held in December 2011; and responses to the *OECD Science, Technology and Industry Outlook 2012* policy questionnaire. It also builds on the OECD's "Policy Responses to the Economic Crisis: Investing in Innovation for Long-Term Growth" (OECD, 2009).
2. Triadic patent statistics reported until 2010 in the OECD MSTI Database 2012/1 confirm the trends described above, notably the slowdown in 2008 and 2009 and the weak recovery paths in several countries including the United States, the Netherlands and the United Kingdom.
3. The evidence on pre-crisis years shows that the decline of the United States pre-dates the downturn. However, it remains to be seen whether the crisis effectively facilitated China's positioning. China's specialisation in lower-quality production helped reduce the negative impacts of the global downturn, but this might cause more substantial losses during the recovery (Berthou and Emlinger, 2010). This potential negative demand shock on Chinese goods might (due to the mechanisms described in Table 1.1) then have negative effects on innovation in China.

References

Abiad, A., R. Balakrishnan, P.K. Brooks, D. Leigh and I. Tytell (2009), "What's the Damage? Medium-term Output Dynamics after Banking Crises", *IMF Working Paper* 09/245.

Aghion, P. and P. Howitt (1992), "A Model of Growth through Creative Destruction", *Econometrica*, Vol. 60(2), pp. 323-352.

Aghion, P., P. Askenazy, N. Berman, G. Cette and L. Eymard (2008), "Credit constraints and the cyclicality of R&D investment: Evidence from France", *Banque de France Working Paper No. 198*.

Aghion, P., N. Bloom, R. Blundell, R. Griffith and P. Howitt (2005a), "Competition and Innovation: An Inverted-U Relationship", *Quarterly Journal of Economics*, Vol. 120(2), pp. 701-728.

Aghion, P., G.-M. Angeletos, A. Banerjee and K. Manova (2005b), "Volatility and Growth: Credit Constraints and Productivity-Enhancing Investment", *NBER Working Paper* 11349.

Aghion, P. and G. Saint-Paul (1998), "Virtues of Bad Times: Interaction between Productivity Growth and Economic Fluctuations", *Macroeconomic Dynamics*, Vol. 2:3 pp. 322-344.

Almunia, M., A. Bénétrix, B. Eichengreen, K. O'Rourke and G. Rua (2009), "From Great Depression to Great Credit Crisis: Similarities, Differences and Lessons", *NBER Working Paper* 15524.

Archibugi, D. and A. Filippetti (2011), "Innovation in times of crisis: National systems of innovation, structure, and demand", *Research Policy*, Vol. 40, pp. 179-192.

Audretsch, D. (1995), "Innovation, growth and survival", *International Journal of Industrial Organization*, Vol. 13, pp. 441-457.

Audretsch, D. (1991), "New firm survival and the technological regime", *Review of Economics and Statistics*, Vol. 73, pp. 441-450.

Baily, M., Bartelsman, E. and J. Haltiwanger (2001), "Labor Productivity: Structural Change and Cyclical Dynamics", *The Review of Economics and Statistics*, Vol. 83(3), pp. 420-433.

Barlevy, G. (2007), "On the Cyclicality of Research and Development", *The American Economic Review*, Vol. 97(4), pp. 1131-1164.

Barlevy, G. (2002), "The Sullying Effect of Recessions", *Review of Economic Studies*, Vol. 69, pp. 65-96.

Békés, G, L. Halpern, M. Koren and B. Muraközy (2011), "Still standing: how European firms weathered the crisis", The third EFIGE policy report, Bruegel, 22 December 2011.

Bernanke, B. and M. Gertler (1995), "*Inside the Black Box: The Credit Channel of Monetary Policy Transmission*", *Journal of Economic Perspectives*, Vol. 9(4), pp. 27-48.

Berthou, A. and C. Emlinger (2010), "Crises and the Collapse of World Trade: The Shift to Lower Quality", *CEPII Document de Travail* No. 2010-07.

Broda, C. and D. Weinstein (2010), "Product Creation and Destruction: Evidence and Price Implications", *American Economic Review*, Vol. 100, pp. 691-723.

Caballero, R. and M. Hammour (1994), "The Cleansing Effect of Recessions", *American Economic Review*, Vol. 84, pp. 1350-1368.

Caballero, R. and M. Hammour (1996), "On the Timing and Efficiency of Creative Destruction", *The Quarterly Journal of Economics*, Vol. 111 (3), pp. 805-852.

Calvo, G., A. Izquierdo and E. Talvi (2006), "Phoenix Miracles in Emerging Markets: Recovering without Credit from Systemic Financial Crises", *NBER Working Paper* 12101.

Cerra, V. and S. Saxena (2008), "Growth Dynamics: The Myth of Economic Recovery", *American Economic Review*, Vol. 98(1), pp. 439-457.

Chor, D. and K. Manova (2011), "Off the cliff and back? Credit conditions and international trade during the global financial crisis", *Journal of International Economics*, Vol. 87:1, 117-133.

Comin, D. and M. Gertler (2006), "Medium-Term Business Cycles", *American Economic Review*, Vol. 96:3, 523-551.

Cooper, R. and J. Haltiwanger (1993), "The aggregate implications of machine replacement: theory and evidence", *American Economic Review*, Vol. 83, pp. 181-186.

Dell'Ariccia, G., E. Detragiache and R. Rajan (2008), "The real effect of banking crises", *Journal of Financial Intermediation*, Vol. 17, pp. 89-112.

Dosi, G., S. Lechevalier and A. Secchi (2010), "Introduction: interfirm heterogeneity – nature, sources and consequences for industrial dynamics", *Industrial and Corporate Change*, Vol. 19 (6), pp. 1867-1890.

Dupont, J., D. Guellec and J. Oliveira Martins (2011), "OECD Productivity Growth in the 2000s: A Descriptive Analysis of the Impact of Sectoral Effects on Innovation", *OECD Journal: Economic Studies*, Vol. 1, pp. 1-23.

Eslava, M, A. Galindo, M. Hofstetter and A. Izquierdo (2010), "Scarring Recessions and Credit Constraints: Evidence from Colombian Firm Dynamics", Universidad de los Andes, *Documentos CEDE*, September.

European Central Bank (ECB) (2011), Survey on the Access to Finance of Small and Medium-Sized Enterprises in the Euro Area, April to September 2011.

European Commission (EC) (2011a), "Monitoring industrial research: the 2011 EU Industrial R&D investment Scoreboard", European Commission, Luxembourg.

European Commission (EC) (2011b), *Innovation Union Competitiveness Report 2011*, Brussels.

Fatas, A. (2000), "Do Business Cycles Cast Long Shadows? Short-Run Persistence and Economic Growth", *Journal of Economic Growth*, Vol. 5(2), pp. 147-162.

Fernandes, A. and C. Paunov (2011), "The risks of innovation: Are innovating firms less likely to die?", Unpublished manuscript.

Foster, L., Haltiwanger, J. and C. J. Krizan (1998), "Aggregate Productivity Growth: Lessons from Microeconomic Evidence", *NBER Working Paper* No. 6803 (1998).

Francois, P. and H. Lloyd-Ellis (2008), "Implementation Cycles, Investment and Growth", *International Economic Review*, Vol. 49(3), pp. 901-942.

Gompers, P.A. and J. Lerner (1998), "What Drives Venture Fundraising?", Brookings Papers on Economic Activity: Microeconomics 1998, pp. 149-192.

Gompers, P.A. and J. Lerner (1999), "An Analysis of Compensation in the US Venture Capital Partnership", *Journal of Financial Economics*, Vol. 51(1), pp. 3-44.

Griliches, Z. (1990), "Patent Statistics as Economic Indicators: A Survey", *Journal of Economic Literature*, Vol. 28, pp. 1661-1707.

Guellec, D. and C. Paunov (forthcoming), "What are the implications of the crises for innovation?", *STI Working Paper Series*.

Hall, R. (1991), "Labor Demand, Labor Supply and Employment Volatility", in *NBER Macroeconomics Annual*, The MIT Press, Cambridge, MA.

Hall, B. and J. Lerner (2009), "The financing of R&D and innovation", *NBER Working Paper* 15325.

Hallward-Driemeier, M. and B. Rijkers (2011), "Do Crises Catalyze Creative Destruction? Firm-level Evidence from Indonesia", *World Bank Policy Research Working Paper* 5869, November.

Haltiwanger, J. (2011), "Firm Dynamics and Productivity Growth", Presentation at the European Investment Bank Conference on Productivity and Long-term Growth Potential in Europe, Luxembourg, October.

IMF (2011a), *World Economic Outlook: Slowing Growth, Rising Risks*, IMF, Washington, DC.

IMF (2011b), *Global Financial Stability Report*, IMF, Washington, DC.

Kanerva, M. and H. Hollanders (2009), "The Impact of the Economic Crisis on Innovation, Analysis based on the Innobarometer 2009 survey", *InnoMetrics*.

Kaplan, S. and A. Schoar (2005), "Private Equity Performance: Returns, Persistence, and Capital Flows", The Journal of Finance, *Vol. 60 (4),* pp. 1791-1823.

Koellinger, P. and A. Thurik (2011), "Entrepreneurship and the Business Cycle", *Review of Economics and Statistics*, forthcoming.

Koellinger, P. (2008), "Why are some entrepreneurs more innovative than others?", *Small Business Economics*, Vol. 31, pp. 21-37.

Kraemer-Eis, H. and F. Lang (2011), "European Small Business Finance Outlook", *European Investment Fund Working Paper* 2/2011.

Krozner, R., Laeven, L. and D. Klingebiel (2007), Banking Crises, Financial Dependence, and Growth, Journal of Financial Economics, 84: 187-228.

Lerner, J. (2011), "Innovation, Entrepreneurship and Financial Market Cycles", *OECD Science, Technology and Industry Working Papers* 2010/03.

Lien, L. (2010), "Recessions across Industries: A Survey", *Institute for Research in Economics and Business Administration Working Paper* No 16/10.

Männasoo, K. and J. Meriküll (2011), "R&D in Boom and Bust: Evidence from the World Bank Financial Crisis Survey", *Working Papers of Eesti Pank*, No 7/2011.

Metcalfe, S., J. Foster and R. Ramlogan (2006), "Adaptive economic growth", *Cambridge Journal of Economics*, Vol. 30 (1), pp. 7-32.

Mortensen, D. and C. Pissarides (1994), "Job Creation and Job Destruction in the Theory of Unemployment", *Review of Economic Studies*, Vol. 61, pp. 397-415.

McKinsey and Company (2010), "McKinsey Global Survey Results: R&D after the Crisis", McKinsey Quarterly.

Nanda, R. and M. Rhodes-Kropf (2011), "Investment Cycles and Startup Innovation", Harvard Business School, Boston, MA, October.

Nelson, R. and S. Winter (1982), *An evolutionary theory of economic change*, Harvard University Press, Cambridge, MA.

Nickell, S., D. Nicolitsas and M. Patterson (2001), "Does Doing Badly Encourage Management Innovation?", *Oxford Bulletin of Economics and Statistics*, Department of Economics, University of Oxford, Vol. 63(1), pp. 5-28.

Nickell, S. (1996), "Competition and Corporate Performance", *Journal of Political Economy,* Vol. 104(4), pp. 724-746.

Nishimura, K.G., T. Nakajima and K. Kiyota (2005), "Does the natural selection mechanism still work in severe recessions? Examination of the Japanese economy in the 1990s", *Journal of Economic Behavior and Organization*, Vol. 58(1), pp. 53-78.

OECD (2009), *Policy responses to the economic crisis: investing in innovation for long-term growth*, OECD, Paris.

OECD (2010), *The OECD Innovation Strategy: Getting a Head Start on Tomorrow*, OECD, Paris.

OECD (2011a), *Science, Technology and Industry Scoreboard 2011*, OECD, Paris.

OECD (2011b), *Entrepreneurship at a Glance 2011*, OECD, Paris.

OECD (2011c), *OECD Economic Survey 2011*, OECD, Paris.

OECD (2011d), *Making the Most of Public Investment in a Tight Fiscal Environment: Multi-Level Governance Lessons from the Crisis*, OECD, Paris.

OECD (2011e), *OECD Economic Outlook*, OECD, Paris.

OECD (2012), "Structural Reforms in Times of Crisis", Chapter 1, *Going for Growth*, OECD, Paris.

Oreopoulos, P, T. Von Wachter and A. Heiz (2012), "The Short- and Long-term Career Effects of Graduating in a Recession", *American Economic Journal: Applied Economics*, Vol. 4(1), pp. 1-29.

Ouyang, M. (2011), "On the Cyclicality of R&D", *The Review of Economics and Statistics*, Vol. 93(2), pp. 542-553.

Parker, S. (2009), *The Economics of Entrepreneurship*, Cambridge University Press, Cambridge.

Paunov, C. (2012), "The global crisis and firms' investments in innovation", *Research Policy*, Vol. 41, pp. 24-35.

Piva, E. and C. Rossi-Lamastra (2011), "Does participation by a venture capital investor moderate the relationship between sales and employment changes? The case of the current global crisis", unpublished manuscript.

Rafferty, M. (2003), "Do Business Cycles Influence Long-Run Growth? The Effects of Aggregate Demand on Firm-financed R&D Expenditures", *Eastern Economic Journal*, pp. 607-618.

Ramalho, R., J. Rodríguez-Meza and J. Yang (2009), "How are firms in Eastern and Central Europe reacting to the financial crisis?", *Enterprise Surveys, Enterprise Note* No. 8.

Reinhart, C. and K. Rogoff (2009), *This Time is Different*, Princeton University Press, Princeton, NJ.

Reinhart, V. (2011), "A Year of Living Dangerously: The Management of the Financial Crisis in 2008", *Journal of Economic Perspectives*, Vol. 25(1), pp. 71-90.

Robb, A. and E.J. Reedy (2012), "An Overview of the Kauffman Firm Survey: Results from 2010 Business Activities", May.

Schumpeter, J. (1942), *Capitalism, Socialism, and Democracy*, Harper, New York.

Walde, K. and U. Woitek (2004), "R&D Expenditure in G7 Countries and the Implications for Endogenous Fluctuations and Growth", *Economics Letters*, Vol. 82:1, pp. 91-97.

WIFO (2011), Structural Change and the Competitiveness of EU Member States, Vienna.

ANNEX 1.A

The economic crisis and STI policy: National policy examples

Table 1.A. **The economic crisis and STI policy: national policy examples**

Argentina	Innovation support was maintained in spite of the 2008 crisis.
Australia	Nation Building and Jobs Plan announced in February 2009 with a budget of USD 29 billion (AUD 42 billion) is key component of the "National Building – Economic Stimulus Plan" and included funding for investment in education, infrastructure and energy efficiency with innovation-related measures including: ● USD 566.8 million (AUD 821.8 million) to secondary schools for the building or refurbishing of science and/or language-learning facilities among other infrastructure investments within the USD 11.2 billion (AUD 16.2 billion) Building the Education Revolution Package. ● Additional USD 1.9 billion (AUD 2.7 billion) temporary tax break to small and other businesses buying eligible assets as *e.g.* tangible capital used in R&D. ● Support for Australia's business innovators included USD 57.2 million (AUD 83 million) for the Innovation Investment Follow-on Fund to foster early-stage companies' research activities and efforts at commercialisation in spite of lack of available capital due to global crisis.
Austria	No immediate response with respect to innovation policy.
Belgium	No new measures taken at federal level in 2010-11 except for annual growth in tax credits but commitment to maintain R&D/GDP rate. Global financial crisis raised focus on innovation policies for smart specialisation in Flanders (White Paper on New Industrial Policy [Witboek Nieuw Industrieel Beleid]) with impact on new policy initiatives such as the Transformation and Innovation Acceleration (TINA) Fund established in December 2010 with capital of USD 232.6 million (EUR 200 million) to support projects by groups of enterprises (jointly with investors, knowledge-based institutions, research and/or technology partners) and the Spin-Off Financing Instrument (SOFI) established in 2011 with USD 11.5 million (EUR 10 million) to support spin-offs.
Brazil	Minor impacts on national STI policies, credit volume for private R&D operated by national financing agency FINEP doubled in 2009 partly as a crisis response.
Canada	In 2009, the Government of Canada put in place a two-year economic stimulus package: Canada's Economic Action Plan (CEAP). The CEAP included USD 4.1 billion (CAD 4.9 billion) for science, technology and innovation including: ● The Knowledge Infrastructure Program (KIP) with USD 1.7 billion (CAD 2 billion) for university and college infrastructure projects, including repair, maintenance and construction. ● The Canada Foundation for Innovation (CFI) with additional funding of USD 625 million (CAD 750 million) to accelerate investment in state-of the art research facilities and equipment. ● Almost USD 208.3 million (CAD 250 million) allocated to upgrade and modernise federal laboratories doing research in a wide array of fields, including health, safety, security, transport, environmental protection, and heritage. ● A USD 662.5 million (CAD 795 million) Clean Energy Fund to support clean energy R&D and demonstration projects. The CEAP also included an additional USD 72.9 million (CAD 87.5 million) over three years, starting in 2009-10 to the federal granting councils to expand temporarily the Canada Graduate Scholarships programme, which supports Canada's top graduate students. This included USD 29.2 million (CAD 35 million) each for the Natural Sciences and Engineering Research Council of Canada and the Canadian Institutes of Health Research, and USD 14.6 million (CAD 17.5 million) for the Social Sciences and Humanities Research Council. In addition, Industry Canada received USD 187.5 million (CAD 225 million) over three years to develop and implement a strategy to extend broadband coverage to as many unserved and underserved households as possible. In 2009, the Canadian government also launched the Canada Skills and Transition Strategy which included: USD 1.6 billion (CAD 1.9 billion) to strengthen benefits to give workers more time to find the right job and get training, to give companies using work-sharing arrangements more time to restructure and better position themselves to emerge from the economic downturn, and to better protect workers' wages and severance packages in the event of their employer's bankruptcy; USD 1.6 billion (CAD 1.9 billion) were provided to enhance the availability of training by providing unprecedented levels of short- and long-term skills upgrading opportunities for workers in all sectors of the Canadian economy, including investments in the long-term potential of under-represented groups.
Chile	No changes of national STI policies in response to the global financial crisis.

Table 1.A. **The economic crisis and STI policy: national policy examples** *(cont.)*

China	Economic Recovery Plan of USD 1.0 trillion (CNY 4 trillion) (including USD 392.7 billion, CNY 1.5 trillion, for infrastructure) in response to 2008 financial crisis focused on investments in fixed infrastructures and human capital in ten industries including machinery-manufacturing, electronics and information industries, as well as light industries and petrochemical sectors. State Council of February 2009 proposed by the Ministry of Science and Technology decided to strengthen science, technology and innovation (STI) in response to the global financial crisis. In the following two years, the central and local governments invest USD 26.6 billion (CNY 100 billion) to strengthen STI infrastructure including development of high-technology clusters, support of firms' innovation capacities and university support of private innovation. Chinese Academy of Sciences' Scientific and Technological Innovation Action Plan to address the global financial crisis included building pilot programmes (such as a broadband wireless media network) and commercial application of major S&T results (*e.g.* laser display technology).
Colombia	No substantial changes in national STI policies in response to the global financial crisis.
Estonia	Spending on R&D funding instruments (targeted, grant and base-line financing) decreased by 4% and general budget of the Ministry of Education and Research reduced by 8.4% in 2009; further reductions in STI support policies in 2010 (*i.e.* grant financing: 9.1%, targeted financing: 3.6%, base-line financing: 7.4%, infrastructure subsidies: 3%). No changes in 2011-12. TULE programme offered opportunity to around 800 people who previously interrupted university education programmes to return to such programmes in 2010-13.
Finland	2009 stimulus package of USD 6.56 billion (EUR 5.97 billion) included measures aimed at supporting transport and broadband infrastructure, education and training (including notably raising the availability of vocational training and education for adults) and R&D. About USD 159.3 million (EUR 145 million) for R&D, education, infrastructure as well as firm and energy support. Main tools consisted in tax cuts and related measures rather than increased public spending. Finnish Funding Agency for Technology and Innovation (Tekes) received additional resources to allocate for research, development and innovation and lowered temporarily share of company funding required in public research projects. Finnvera started to grant counter-cyclical loans and guarantees at the beginning of March 2009; the government raised ceilings on Finnvera's outstanding financial commitments twice during 2009. 2012-13 STI policies affected by consolidation of public finance, continued support of R&D and innovation but changes in targets of support. Finnvera introduced as part of recovery strategy counter-cyclical loans and guarantees to finance working capital of small enterprises whose profitability or liquidity declined because of crisis, loans continued until end 2011.
France	Firms could request immediate refunding of their Research Tax Credit in 2009 and 2010, only true for micro enterprises and SMEs from 2011. Injection of funds into OSEO Garantie to provide guarantees, co-financing, direct loans (October-December 2009), government increased eligibility for firms with more employees and coverage of guarantee to 90% among other measures strengthening capacity for intervention by USD 11.5 billion (EUR 10 billion) and guaranteed loans increased 64%; OSEO estimates impact equivalent to 30 000 jobs saved in France as a result of these crisis response measures. Investments in the Investments for the Future Programme (Programme des investissements d'avenir) of USD 40 billion (EUR 35 billion) over 2011-13, in response to the economic crisis aimed at strengthening national innovation capacities with investments across nine programmes including: centres of excellence (USD 13.8 billion – EUR 12 billion); knowledge transfer to industry (*valorisation de la recherche*) (USD 4 billion – EUR 3.4 billion); health and biotechnologies (USD 2.8 billion – EUR 2.4 billion); digital economy (USD 5.2 billion – EUR 4.5 million); and enterprise funding (USD 3.6 billion – EUR 3.1 billion).
Germany	No major impact on German STI policy but short-term measure with Central Innovation Program for SMEs (ZIM) receiving additional support of USD 1.1 billion (EUR 900 million) for 2010/11.
Greece	In early 2012 new strategic framework law under public consultation by National Council and General Secretariat of Research and Technology to set out a long-term vision for the Greek R&D system, including objectives setting and associated milestones. Preparation and implementation of Business Friendly Action Plan aimed at identifying and removing barriers to entrepreneurship plus policy shift from direct funding of business R&D to tax relief for R&D considered with need of appropriate policy design beforehand. Adoption of measures to avoid brain drain: starting grants for young research (USD 169 million, EUR 120 million, for 2012-15) and new scheme for employing young researchers in successful Greek businesses (USD 21 million, EUR 15 million, for 2012). Other initiatives include stronger focus on supporting bilateral and international collaboration, efforts aimed at re-organisation of fragmented public research centres to achieve critical mass with a disciplinary and/or geographical focus and strengthening linkages between research and innovation.
Hungary	Crisis management programme with little emphasis on innovation, mainly focused on defining R&D spending targets, identifying strategic sectors and the disbursement of the Research and Technological Innovation Fund. Funding programme in 2009-10 for projects to facilitate the development of human resources for R&D by creating jobs at SMEs, publicly financed or non-profit R&D organisations as well as by employing highly qualified personnel whose jobs at medium-sized and large industrial enterprises were lost due to the global financial crisis.
Ireland	Innovation support has broadly been maintained in spite of the crisis.
Israel	MANOF Fund, series of joint investment funds established by government and institutional investors, introduced to counter credit crunch of the global financial crisis with government taking most of the risk. A downside-protection programme aimed at attracting institutional investors to invest in high-technology companies, through the venture capital industry and other mechanisms, offering investors downside protection of up to 25% in case of loss, programme promoted knowledge-based industries and was intended to deal with the entire production chain (from academic concept stage all the way through transitioning start-ups to large companies with government risk-taking).

Table 1.A. **The economic crisis and STI policy: national policy examples** *(cont.)*

Italy	2008/09: introduction of an anti-crisis export promotion plan, with USD 237 million (EUR 185 million) in 2009, managed by the Institute for Foreign Trade (ICE); new tax benefits to enterprises including for contracts aimed at boosting productivity with USD 3.7 billion (EUR 2.9 billion) for 2009/11; in January 2009 a refinancing of the Central Guarantee Fund for SMEs was put in place (USD 2.1 billion, EUR 1.6 billion) until 2012, and State guarantee as a last-resort guarantee provided; measure helped about 50 000 firms providing more than USD 6.7 billion (EUR 5.2 billion) guarantees for USD 11.7 billion (EUR 9.1 billion) worth of loans; no cuts in public R&D expenditure and business support, but a slowdown in the launch and implementation of some instruments and programmes. One-year debt moratorium for SMEs allowed firms (with no bad debts, restructured loans or ongoing foreclosures) to suspend repayment of the bank loan principal to obtain an extension of the duration of loans for credit advances; by December 2010, 200 000 applications had been accepted, and USD 16 billion (EUR 13 billion) worth of debts rolled over. In 2010 and 2011: reductions in public administrations' spending do not affect universities and diverse research bodies, but regulation facilitating temporary hires at universities of researchers, USD 500 million (EUR 400 million) must be dedicated to support public universities and USD 25 million (EUR 20 million) private ones recognised by the state and an increase of USD 187.5 million (EUR 150 million) in the fund dedicated to fellowships and prizes for excellent students; tax credit of 90% for activities developed by enterprises working in joint ventures with universities and public research institutions.
Japan	Supplementary budget about USD 487.8 billion (JPY 57 trillion) to address the global financial crisis in 2008 with over USD 8.6 billion (JPY 1 trillion) was allocated to S&T. 4th S&T Basic Plan shows policy shift from discipline-oriented to issue-driven approach and towards recovery after the devastating tsunami in March 2011. 2011 budget introduced budgetary reductions excluding for budgetary lines related to science and research, Ministry of Education, Culture, Sports, Science and Technology, whose overall budget decreased by 0.9%, the budget for science increased by 3.3%.
Korea	No substantial impact on innovation policies but continued public support for R&D activities.
Luxembourg	No changes of national STI policies in response to the global financial crisis.
Mexico	No major changes to national STI policies in the immediate aftermath of the global financial crisis, STI budgets were mostly maintained in spite of budgetary constraints. Overall recovery packages included several measures with implications for innovation such as programmes in support of SMEs and infrastructure investments.
Netherlands	Programme of USD 214 million (EUR 180 million) aimed at supporting about 2 000 researchers employed by the private sector at potential risk of job loss by providing financing for secondments to public research institutes. Existing R&D tax credit enlarged in 2009 and 2010 by USD 179 million (EUR 150 million). Growth Facility offered banks and private equity enterprises a 50% guarantee on newly issues equity or mezzanine loans, extended during the crisis allowing up to USD 29.8 million (EUR 25 million) in equity per enterprise to be guaranteed; also Guarantee for Entrepreneurial Finance launched in March 2009 provided banks with a 50% guarantee on new bank loans ranging from USD 1.8 million (EUR 1.5 million) to USD 179 million (EUR 150 million).
New Zealand	No public initiatives were explicitly created to target STI as a result of the financial crisis.
Norway	No substantial long-term impact on innovation policies. Continued support for R&D activities.
Portugal	Investment and Employment Initiative (Iniciativa Para o Investimento e Emprego) introduced in December 2008 of USD 3.4 billion (EUR 2.2 billion) involves improvements of the education system (public investments of USD 781 million, EUR 500 million, in 2009); renewable energy sources and energy efficiency (public investments of USD 391 million, EUR 250 million in 2009); broadband infrastructure (tax expenditure of USD 78.1 million, EUR 50 million in 2009). New stimulus package in December 2010, Initiative for Competitiveness and Employment (Iniciativa para a Competitividade e Emprego) with priority to education systems and STI. 50 measures were approved and developed in five fundamental areas including focus on competitiveness and support for export trade; administrative simplification and reduction of red tape for business enterprises and labour market reforms. 2012 budgetary consolidation efforts with no cutback on former spending on STI and increased government budget appropriations for advanced training and scientific employment (jointly 34% in 2012 compared to 31% in 2011) and support for scientific employment. Government prioritised support of the automobile industry via proposal to scrap light vehicles older than 8 to 13 years and buy new ones and prepared a new stimulus to introduce electric vehicles on the market by 2010, project of USD 313 million (EUR 200 million); energy investments encouraged in the anti-crisis package in support of innovation and sustainability.
Russian Federation	A short-term negative impact on the overall budget effort but no substantial impact on STI policy; over last years civil science funding has increased 3.8 times which has reduced negative influence of crisis on the industrial sector and compensated for the decrease in funding from extra budgetary sources.
Slovak Republic	Government loan guarantees available to banks and financial institutions increased temporarily by 21% to USD 429 million (EUR 219 million) in 2009, direct loans from state-owned banks more than doubled.
Slovenia	Significant strategic reorientation in national STI system introduced in response to the financial crisis, in many cases the crisis was the catalyst that fostered shifts and new instruments. Stimulus package included several R&D support measures as reflected in the 2009 revised budget representing 2.1% of GDP including co-financing of SMEs, support for start-ups, provision of loan guarantees, co-funding of firm R&D and investment projects and support for research among other measures.
South Africa	No major policy changes to the national STI policy; Framework for South Africa's Response to the International Economic Crisis re-emphasised some aspects of the national challenges that required scientific and technological input such as energy security, food security and new industrial development and led to some refinements in the implementation plan of the National Industrial Policy Framework adopted in 2008.

Table 1.A. **The economic crisis and STI policy: national policy examples** *(cont.)*

Spain	Plan to Stimulate the Economy and Employment of 2009 included USD 690 million (EUR 490 million) directly related to R&D and innovation (representing more than 16% of total budget). Strategy for a Sustainable Economy (November 2009) introduced new regulatory framework to promote innovation through the development of a new Law on Science, Technology and Innovation (June 2011) and the State Innovation Strategy E2i (July 2010) which includes budget actions undertaken by the General Secretariat for Innovation of the former Ministry of Science and Innovation of USD 4.3 billion (EUR 3.2 billion) in 2010 (an increase of 48% from 2009). Centre for the Development of Industrial Technology (CDTI) reorganised structure and operation in 2008-11, increased the amount of its direct aids to companies by 75.4% and improved temporarily (until March 2012, depending on budget availability) financial conditions of its business R&D support (*e.g.* reduction of guarantees for small companies, increase of support coverage for R&D projects from 75% to 85% of the budget and increase of the advance of the payment of aid for SME from 25% to 30%). State Fund for Employment and Local Sustainability of 2010 with USD 6.8 billion (EUR 5 billion) did not include a specific fund for R&D but USD 742.2 million (EUR 549.2 million) allocated by municipalities to innovative projects aimed at fostering local employment.
Sweden	Increase in university budget by 25% with 1/3 of free funding, 1/3 target areas identified as of particular interest to industry and society, 1/3 to research infrastructure and to industry-related research. Fouriertransform AB, a venture capital firm in the automobile industry, established in late 2009 with USD 335 million (SEK 3 billion) of capital to invest in viable R&D projects in the vehicle cluster. A capital injection by the government of the Swedish Development Bank (ALMI) increased lending capacity in 2009 compared to 2008, combined with allowing a higher share of co-financing, lending volume back to normal in 2010 (about 65% of the 2009 level and 120% of the 2008 level).
Switzerland	Recovery package of additional expenditures of USD 461 million (CHF 705 million) with about USD 31 million (CHF 48 million) on research and innovation: ● Swiss National Science Foundation (SNSF) responsible for basic research funding increased by USD 6.9 million (CHF 10.5 million) (= 28 additional R&D projects). ● Budget of federal universities and research institutions (ETH) increased by USD 8.8 million (CHF 13.5 million). ● Innovation policy promotion budget increased by USD 13.7 million (CHF 21 million) with: an increase in the budget of the Commission for Technology and Innovation (KTI/CTI), the main funding agency for applied research, by USD 12.7 million (CHF 19.5 million); a pilot scheme with innovation cheques that intends to encourage SMEs to engage in technology transfer has been launched with USD 0.64 million (CHF 1 million); and USD 0.3 million (CHF 0.5 million) information campaign targeted at the academic and private sectors on the subject of funding opportunities offered by the KTI/CTI.
Turkey	Precautionary measures related to R&D and innovation to address global financial crisis included shift towards direct public financial support via the additional allocation of USD 217.4 million (TRY 200 million) to the Scientific and Technological Research Council of Turkey.
United Kingdom	Spending Review of 2010 aimed to prioritise the capital investments that support long-term economic growth: USD 7 billion (GBP 4.6 billion) scientific research budget was maintained and ring-fenced until 2014, represents a cut in real terms of around 10% (given inflation). Commitment to increase the efficiency of the science budget by saving USD 491 million (GBP 324 million) a year by 2014/15 reinvesting these efficiency savings in science. Enterprise Finance Guarantee Scheme, introduced in January 2009, assisted enterprises affected by credit crunch, upper limit for loans of USD 1.5 million (GBP 1 million) providing assistance to enterprises with a turnover of up to USD 38.5 million (GBP 25 million), *i.e.* a three-fold increase in volume of guaranteed loans in 2009 compared to 2007/08 with previous scheme.
United States	Recovery and Reinvestment Act of 2009 implemented to provide short-term economic stimulus for research and for research infrastructure and strengthen knowledge base for future economic growth in areas of clean energy, biomedicine, and new industrial technologies. It approved USD 18 billion for new discoveries in energy, climate and future technologies. Within the Department of Health and Human Services (HHS), the National Institutes of Health (NIH) received USD 10 billion for biomedical research and laboratory renovation and construction. USD 1 billion was included for comparative effectiveness research at NIH and the Agency for Healthcare Research and Quality. USD 5.2 billion investment in key science agencies, including: USD 3.0 billion at National Science Foundation for basic research, education and human resources, research facilities construction, and research instrumentation; USD 1.6 billion at DOE's Office of Science for energy frontier research collaborations, and infrastructure investments at the national laboratories; and USD 580 million at the Department of Commerce's National Institute of Standards and Technology (NIST) for standards research, advanced measurement equipment, and construction of NIST research facilities. This investment by itself is an almost 50% increase for these programmes over the 2008 enacted level and represents a significant down payment toward the President's plan to double the funding for these agencies over a decade. National Aeronautics and Space Administration (NASA) received USD 1 billion for activities such as an acceleration of Earth science climate research missions, and development of the next-generation air transport system. National Oceanic and Atmospheric Administration (NOAA) received USD 170 million for climate modelling, and USD 660 million that includes support for maintenance and construction of research vessels and facilities. US Geological Survey received USD 140 million for facility renovation and construction and for seismic and volcanic monitoring systems. American Recovery and Reinvestment Act also allowed the government to temporarily increase its loan guarantee to 90% and reduce or eliminate processing fees for these loans. US Small Business Administration (USSBA) received USD 730 million to finance these measures, additional funding of USD 125 million provided subsequently extending assistance until February 2010. US Treasury intends to increase SME lending by providing low-cost capital to community banks, and President Obama in his State of the Union address pledged USD 30 billion for this purpose. This measure was incorporated into the "jobs" bill for SMEs that intended to give USD 12 billion in tax breaks, as well as expanding existing lending programmes (the law passed in September 2010).

Source: Country responses to the *OECD Science, Technology and Industry Outlook* policy questionnaires 2012, 2010 and 2008; *OECD SME and Entrepreneurship Financing Scoreboard 2012*; OECD Economic Survey; EU Erawatch country reports; EU country TrendChart reports; and national sources.