R&D and other investments in innovation

Investments in R&D and in innovation undertaken by firms are crucial inputs for success: they not only provide critical knowledge-based assets for these companies but also strengthen their absorptive capacities. Evidence confirms the positive effects of these investments on firms' innovation and productivity performance. The evidence points to substantial differences in business investments in R&D across countries; other investments in innovation, including investments in intangibles, are equally important. Downturns have negative impacts on these investments. Investments in R&D and innovation substantially depend on access to finance, IP systems and the state of competition. Effective access to labour, a well-developed interface with universities and PRIs, and technology co-operation between firms can also provide key incentives for investing in R&D and innovation. Public policy can help innovative businesses by providing them with a variety of direct and indirect support mechanisms for R&D and other innovation investments.

What are R&D and other investments in innovation?

This theme refers to R&D and non-R&D investments in assets by firms, as these are crucial inputs for innovative activities. It includes investments in knowledge-based capital (KBC), where three types of KBC can be distinguished: computerised information (software and databases), innovative property (patents, copyrights, designs, trademarks) and economic competencies (including brand equity, firm-specific human capital, networks joining people and institutions, and organisational know-how that increases enterprise efficiency). The term KBC is sometimes used interchangeably with other terms, such as "intellectual assets", "intellectual capital", and "intangibles".

How do R&D and other investments in innovation affect innovative businesses?

R&D and other investments in innovation are a key input for innovation, which may lead to greater sales in innovative products and services, and to revenues generated by the trading of intellectual assets (e.g. by providing others with licensing opportunities). They are particularly important for innovative companies, where knowledge is a key asset and an exclusive process that cannot be codified.

R&D investments can also contribute to improving firms' absorptive capacity i.e. the "ability to recognize the value of new information, assimilate it, and apply it to commercial ends" (Cohen and Levinthal, 1990). For instance, R&D investments can improve the ability of firms to learn about advances in leading edge technologies and to understand and assimilate the discoveries of others, thereby increasing the return on current R&D investment. Thus, new ventures can be disadvantaged when competing with established firms that have a longer history of R&D investment and a larger knowledge-based capital stock.

Evidence on the importance of R&D and other investments in innovation for the success of innovative businesses

Impacts on innovation

Evidence indicates strong positive relations between R&D investments and patents, which might be one proxy for innovation outcomes (though they technically are inventions). For example, analysis has shown that industry-financed R&D expenditures and the number of triadic patent families are positively correlated (OECD, 2007). The proportion of a country's firms engaging in innovation spending is also found to be closely correlated with the proportion of its successful innovators. A study using firm-level data from 21 countries (OECD, 2009a) shows that investing in innovation is associated with an increase in sales from product innovation in all sampled countries except Switzerland. The correlation with sales is greater than 40% in Australia, New Zealand and Norway, and ranges from 14% to 35% in the other countries. Firms spending more on innovation also earn greater returns from innovation than other firms. Innovation investments per employee are positively associated with innovation sales per employee. The elasticity range is between 0.1% and

0.3% for most sampled countries.

Impacts on productivity

Evidence suggests that innovation inputs determine innovation outputs, which in turn affect productivity. A study conducted in OECD countries shows that sales from product innovation per employee are strongly associated with labour productivity in all countries except Switzerland (OECD, 2009a). The magnitude of the coefficients of sales from innovations in the productivity equation ranges from 0.3% to 0.7%. The largest estimated effects are in Korea, where a 1% increase in innovation sales per employee is associated with an estimated 0.69% increase in labour productivity, and in New Zealand (0.68%) and Brazil (0.64%). On average, a 1% increase in firms' innovation sales per employee is associated with a productivity increase of 0.5%.

Effects of investment characteristics on innovation investments' productivity

There is some evidence to indicate that non-R&D expenditures are sometimes more important for innovation than R&D. Results from innovation surveys show that more than a quarter of innovating firms in most countries introduced new products or processes without performing R&D (OECD, 2010a). This is influenced by the major role that the services sector, which for many activities has lower R&D intensity compared to manufacturing, plays in most OECD economies. For example, nearly 30% of surveyed businesses in Australia that described themselves as innovation-active reported no expenditures on developing innovation. Moreover, SMEs were more likely than large businesses to have no such expenditures. Acquisition of machinery, equipment or technology, and training and marketing activities related to innovation, were the most highly reported types of expenditures (OECD, 2011a).

What is the evidence on R&D and innovation for innovative entrepreneurship?

The effects of innovative investments on innovation outputs depend on multiple firm characteristics, such as size, domain expertise, scope and organizational structure (Ahuja et al., 2008; Cohen, 2010 for literature reviews). However, the effects of firm size are unclear. Some studies find that firm size and R&D investments have a positive effect on innovative productivity (Lieberman, 1987; Schwartzman, 1976), while others find negative or no effects (Chakrabarti, 1991; Graves & Langowitz, 1993; Halperin & Chakrabarti, 1987). Moreover, innovative SMEs and start-ups are key players and drivers of innovation, especially in certain high-tech sectors (e.g. semiconductors, biotechnology), emerging sectors (green industries) and creative industries (e.g. film production, publishing, etc.), largely based on their combination of intangibles, new technologies and design skills. Even in traditional sectors, SMEs in OECD countries represent between 33-50% of innovative firms (OECD, 2011c).

What is the evidence on R&D and other investments in innovation and innovative businesses?

In several OECD countries, firms invest as much or more in knowledge-based capital and intangible assets, as in physical capital. For example, total annual investment in intellectual assets by US businesses in the late 1990s was estimated to account for 12% of GDP, which is roughly the same as tangible investments (Corrado et al., 2005, 2006). The problem is that these assets, which include not just R&D, patents and trademarks, but also human resources and capabilities, organizational competencies (such as databases and routines), and "relational" capital (such as customer and supplier networks), are difficult to measure and most do not appear in firm-level or national accounts (OECD, 2008).

A recent attempt at measuring investments in intangible assets, however, shows that this is increasingly important in many OECD countries and even exceeds investments in physical capital in Finland, Netherlands, Sweden, the United Kingdom and the United States. In some countries, investments in intangibles helps explain multi-factor productivity, which is the part of growth left unexplained by increased investments in capital and labour, and which is often used as proxy for efficiency in the economy (Figure 1).

In 2010, business enterprise expenditure on research and development (BERD) was around 1.6% of OECD GDP. Factors shaping BERD intensity and variations across countries include industrial specialization and business demographics.

BERD intensity is also much more affected by the business cycle than by government or publicly funded R&D. Innovation investments tend to be pro-cyclical and decrease significantly during recessions (OECD, 2009b; OECD, 2012). One reason is that as demand declines, firms formulate low demand expectations and demand uncertainty increases. Engaging in an innovation project may, therefore, no longer be profitable. Another explanation is that firms' financing constraints may be more acute, as negative demand reduces internal revenues and access to external credit becomes more difficult. During the global financial crisis, the available evidence on firms shows that innovation activities declined. Among more than 4,000 European firms, a large share decreased their innovation spending at the onset of the global financial crisis compared to the pre-crisis period (26.7% vs. 10.8%). However, more than half of the interviewed firms maintained their levels of innovation spending (Archibugi and Filippetti, 2011). Among more than 1,500 Latin American firms, a quarter stopped innovation investment projects in response to the crisis (Paunov, 2012).

What is specific evidence on R&D and other investments for innovative entrepreneurship?

Small firms tend to invest less in R&D than other businesses. However, SMEs are still important players. Firms with fewer than 250 employees account for more than half of business R&D in New Zealand (73%), Estonia (71%), Chile (63%), Greece (60%), Spain (54%) and Norway (51%). In New Zealand, Chile, Spain, Greece, Canada, Hungary and Norway, more than 20% of business R&D is performed in firms with fewer than 50 employees (Figure 2).

Besides, during the global financial crisis, evidence suggests that small and young firms were not more likely to discontinue investments in innovation, but younger firms were more at risk, likely because they had shorter credit histories and therefore difficulty accessing finance (Paunov, 2012). Overall R&D trends suggest that small companies considerably reduced their R&D investments in many countries (EC, 2011).

Figure 1. Investments on machinery and equipment, % of GDP

Figure 2. Investments on intangible fixed assets, % of GDP

What other topics relate to R&D and other investments in innovation and innovative businesses?

Intellectual property rights for innovative entrepreneurship [1]. Effective IP systems contribute to the protection of firms' intellectual assets and prevent other firms from using them. They therefore help firms to recoup their innovation investments and, consequently, provide an incentive for investing in innovation. In addition, effective IP systems facilitate access to knowledge markets, enabling firms to buy and sell intellectual assets (e.g. through licensing), which may encourage R&D investments.

Interface with universities and public research institutes [2] and **Technological co-operation between firms** [3]. Co-operation is strongly correlated with innovation expenditures. Moreover, the level of R&D investments of partnering organizations is likely to influence the results

of collaborations, with a greater investment of resources yielding better results. Similarly, a university system with incentives for faculty to collaborate with the business sector can also favour business R&D investments, especially in industries that make more use of scientific knowledge.

State of competition [4]. On the one hand, competition may foster innovation investments by giving firms an incentive to develop innovations in order to be more effective and to survive. On the other hand, competition may also negatively affect innovation investments by reducing the monopoly rents that induce a firm to invest in innovation.

Access to labour for innovative entrepreneurship [5] and **Firms' access to labour for innovation** [6]. Costs of hiring and firing may affect investments in R&D, since labour costs often represent a substantial share of the total R&D spending. Better access to labour, particularly skilled labour, can also positively influence the return on R&D investments and other investments in innovation, thereby increasing the incentive for innovative companies to perform such investments. Yet the contribution of labour to the success of these investments depends on how labour is complemented by investments in capital to generate innovations.

Firms' access to finance for innovation [7] and access to finance for innovative entrepreneurship **[7]** . Lack of access to finance negatively affects all types of investments, including innovation investments. Moreover, obtaining external financing for innovation investments is typically more challenging than obtaining external financing for other business investments (Hall and Lerner, 2009), since the outcomes of innovation investments are more uncertain and the problems caused by asymmetric information tend to be exacerbated.

What policies relate to R&D and other investments in innovation and innovative businesses?

Public policy can influence R&D investments and other investments in innovation by:

- **Providing a range of direct and indirect support to firms' innovation investments** . Direct support to innovation investments (for instance, through grants or direct procurement) has the advantage of being focused on activities and actors that are of greatest interest in meeting public policy goals and that may have the highest social returns. However, precisely because direct support can be more focused, it also raises the problematic prospect of governments "picking winners". They also result in relatively high information and administrative costs. Indirect support through fiscal incentives can also contribute to increasing innovative entrepreneurs' innovation investments; their impacts will, however, depend on how they are designed, as this influences which firms benefit from those support mechanisms.

- **Considering not only support to R&D investments but also support to other investments in innovation.** The emphasis of public policies is often on R&D inputs to the innovation process, although a key barrier to stronger innovation performance does not so much appear to be a lack of knowledge, but a lack of take-up in the market and commercialization. Public policies should therefore complement their support for R&D investments with support for other investments in innovation, such as those targeting the exploitation of R&D and non-R&D-based types of innovation.

Table 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-Knopf, 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.	→ *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.
	• Recovery packages *vs.* fiscal discipline affects public expenditure as it relates to innovation	

Source: OECD (2012), Science, Technology and Industry Outlook 2012, OECD, Paris.

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