CHAPTER 2

FISCAL POLICIES FOR INNOVATION AND GROWTH

Against a backdrop of mediocre medium-term growth prospects, identifying policies that could lift productivity growth by promoting innovation is critical. Fiscal policy can play an important role in stimulating innovation through its effects on research and development (R&D), entrepreneurship, and technology transfer.

New analysis in this chapter identifies areas in which fiscal policy should do more and others where it should do better or less. The key messages are the following:

- ***Do more*** to encourage R&D. In advanced economies, private firms should invest 40 percent more in R&D, on average, to account for the positive knowledge spillovers they create to the wider economy. This investment in R&D could lift GDP in the long term in those countries by 5 percent—and by even more globally as a result of international technology spillovers. Advanced economies can achieve this dividend through well-designed policies that include fiscal R&D incentives and complementary public investments in basic research. R&D can also contribute to productivity growth in emerging market and middle-income economies, provided that they have a sufficiently strong human capital base.
- ***Do better*** by designing fiscal stabilization policies, which are shown to play an important role in supporting R&D investment, particularly during recessions. In advanced economies, fiscal R&D incentives can often be designed better to increase their cost-effectiveness. In emerging market and developing economies, investment in education and infrastructure strengthens their capacity to absorb technologies from abroad. Moreover, adopting a simplified tax regime for small businesses can facilitate firm entry and reduce informality, which can raise productivity.
- ***Do less*** by scaling back or ending ineffective tax incentives. Preferential tax treatment of small companies is too blunt an instrument to foster entrepreneurial activity efficiently. It may actually hurt them by creating a "small business trap" that keeps businesses at a smaller size so as to remain eligible for this special treatment. In emerging market and developing economies, commonly used tax incentives aimed at attracting foreign direct investment should be scaled back because they are largely ineffective and costly.

Using Fiscal Policies to Spur Innovation

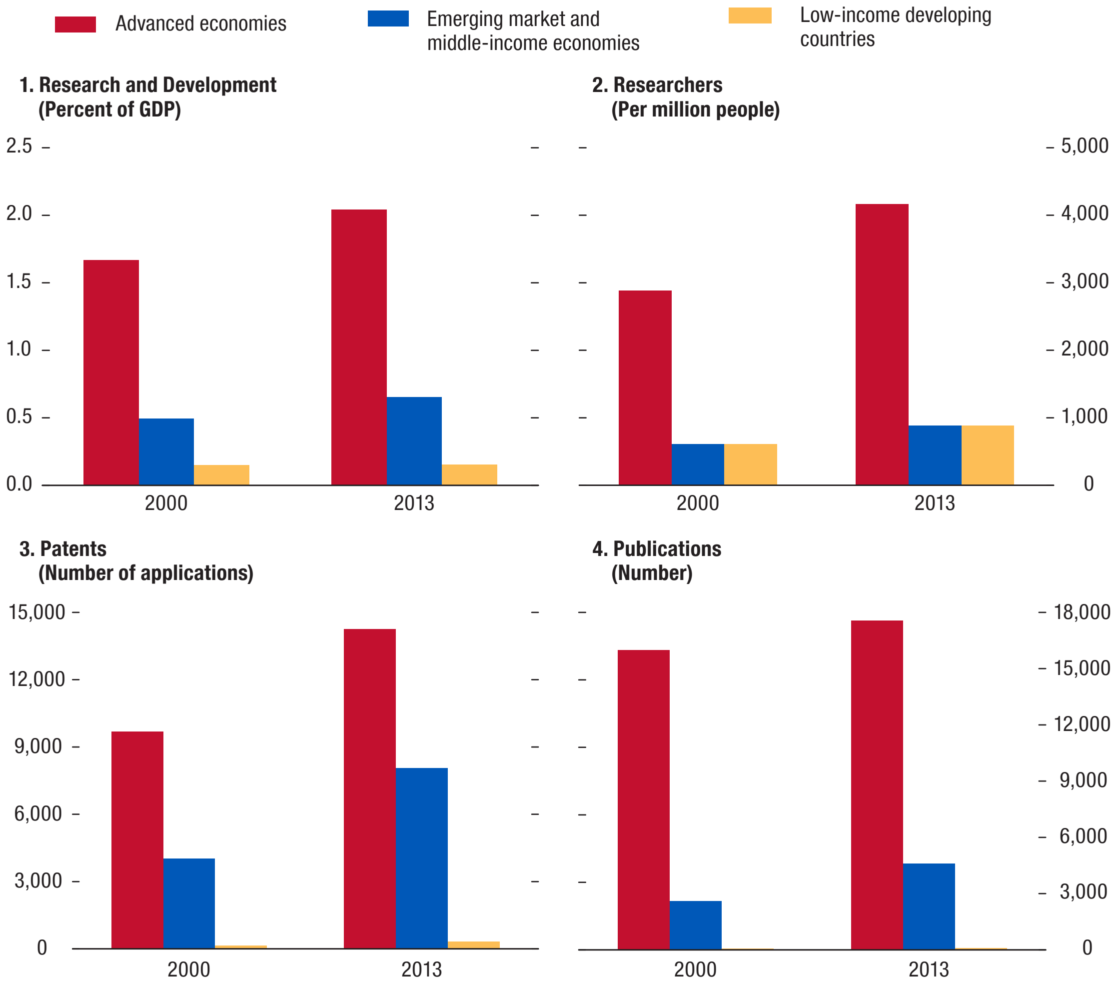
The recovery from the 2008–09 global financial crisis continues to be uneven and slow, raising concerns that the global economy may be trapped in an era of mediocre growth. The slow growth in total factor productivity (TFP) is particularly worrisome; it explains a significant part of the overall decline in potential growth since the early 2000s in advanced economies, and more recently in emerging market economies (see the April 2015 *World Economic Outlook*). This has sparked heightened interest in how governments can effectively promote TFP growth. Structural reform of labor and product markets is certainly one important avenue (see Chapter 3 of the April 2016 *World Economic Outlook*).[1] This chapter delves into the question of how fiscal policy can promote TFP growth by stimulating innovation.

Innovation is a key driver of long-term productivity growth. The inventions of the late nineteenth century, such as electricity and combustion engines, laid the foundation for a golden age of productivity growth in the mid-twentieth century. Breakthroughs in information technology have driven productivity increases in recent decades. Anticipated technologies such as three-dimensional printing, big data, driverless cars, and artificial intelligence might induce a dramatic growth spurt in the years to come, some observers believe (Brynjolfsson and McAfee 2014). Others, however, argue that the boost to TFP growth from these innovations is likely to be modest (Gordon 2016).

[1] Structural reform of tax and expenditure policies could lift medium- to long-term annual growth by ¾ percentage point in advanced economies and by even more in emerging market and developing economies (IMF 2015).

Figure 2.1. Quantitative Indicators of Innovation, 2000 and 2013

Advanced economies perform better on all innovation indicators, and the difference with other groups of economies has grown. During the past decade, emerging market and middle-income economies have improved on the number of patents and publications. Low-income developing countries have improved to some extent on the number of researchers, but they lag in research and development, patents, and publications.



Source: World Bank, *World Development Indicators*.
Note: For a list of countries in each group of economies, see Table A in the Methodological and Statistical Appendix.

The role of innovation in driving growth is difficult to analyze because of conceptual and data limitations. Most empirical work concentrates on the process of technological change, for which quantitative indicators are available, both as inputs (such as R&D investment and the number of researchers) and outputs (such as the number of patents and publications) (Figure 2.1).[2] However, these indicators capture only limited aspects of innovation, which is a broader process that refers not only to the creation of new and improved products and processes, but also to organizational change, improved marketing concepts, and new business models (such as e-commerce or the sharing economy). Moreover, economic statistics may not fully capture the social benefits of technological progress, such as the effects on mitigating climate change.

The course and speed of technological progress depends in important ways on institutions and government policies. Many advanced and emerging market and middle-income economies have adopted comprehensive

[2] Patents have limitations as a measure of technology output because many inventions are never patented, a significant portion of technological knowledge remains tacit, and only a small number of patents account for most of the value.

policy frameworks to stimulate the process of innovation and the diffusion of knowledge through various channels. First, innovation builds on a strong human capital base and institutions that foster new discoveries. This requirement for a human capital foundation calls for appropriate investments in higher education, basic scientific research, and partnerships between universities and private companies. Second, the business environment should provide adequate incentives for innovation. Policies to facilitate such an enabling environment include the protection of intellectual property rights; fiscal incentives; and broader policies related to trade, competition, labor market regulation, and bankruptcy laws. Third, macroeconomic policies that foster high and sustainable economic growth are important because growth allows firms to more quickly recoup their sunk costs and thus encourages R&D investment. This chapter focuses on the fiscal component of the second and third channels—that is, on micro and macro fiscal policies to foster innovation in the private sector.[3] Selected issues that are highly topical in current policy debates, such as the role of countercyclical fiscal policy and fiscal incentives in promoting innovation, receive special attention.

Fiscal policies for innovation should be considered in conjunction with other policies and objectives. For instance, by providing incentives for innovation, patents may reduce the need for fiscal incentives (Box 2.1). However, patents can hamper technology diffusion; hence they could also be complemented by R&D subsidies and tax incentives. More generally, an assessment of fiscal incentives needs to take into account not only their impact on innovation, but also their implications for other objectives, such as the government budget and the income distribution. Thus, the challenge for governments is to find the appropriate policy mix that balances various government objectives.

This chapter presents insights from the extensive literature and provides new empirical evidence on how fiscal policy affects the following three pillars of innovation.

- Research and development, which includes both basic and applied research
- Technology transfer, which includes international diffusion of technology and knowledge
- Entrepreneurial innovation, which involves experimentation with new products and processes by new businesses.

[3] A discussion of nonfiscal policies and education policies is beyond the scope of this chapter.

The three pillars of innovation matter to varying degrees across countries. In particular, R&D policies are relatively more important for advanced economies (which are closer to the global technology frontier). Policies to facilitate technology diffusion and entrepreneurship are also important for emerging market and developing economies. The chapter also draws on international experiences to discuss how fiscal policies can be designed effectively and efficiently to promote innovation.

Supporting Research and Development

Countries vary considerably in their total expenditure on R&D as a percentage of GDP (Figure 2.2). The average share is typically much higher in advanced economies (2 percent of GDP) than in emerging market and middle-income economies (0.65 percent of GDP) or in low-income developing countries (0.15 percent of GDP).

A useful distinction can be made between private (or business), public (or government), and university R&D (which can be either private or public). Private R&D and university R&D are much higher as a share of GDP in advanced economies than in emerging market and developing economies (Figure 2.3). Public R&D is similar in the two groups. Public R&D has been relatively flat during the past 15 years, while private R&D has gradually increased.

R&D expenditures are widely seen as a key driver of TFP growth. To promote these expenditures, governments can either invest directly in R&D (through public universities, government research institutes, and defense-related research) or design policies that encourage firms to undertake more private R&D.

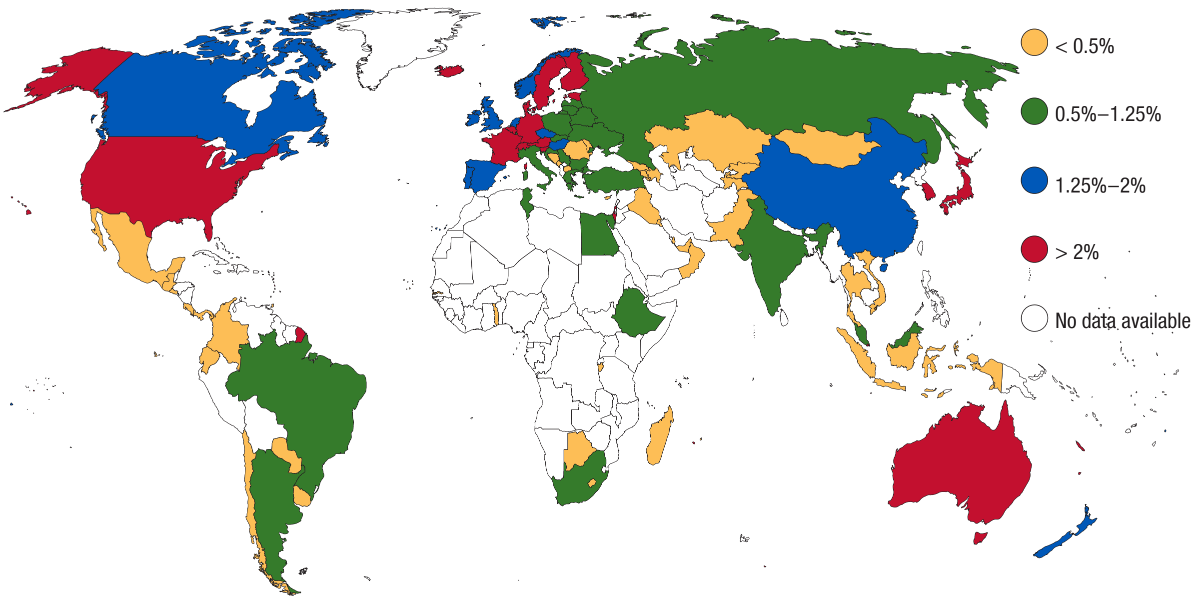
- *Public R&D* often focuses on basic scientific research, which can be critical for innovation, but which firms are unlikely to undertake.[4] Public R&D programs often yield positive and sometimes high rates of return, averaging about 20 percent (Georghiou 2015). This average is somewhat lower than the rates of return to most private R&D.[5] Still, public R&D programs can be more cost-effective if they also advance firms' research activities. A positive

[4] Between 1980 and 2007, large U.S. firms shifted away from doing basic scientific research and toward more applied R&D (Arora, Belenzon, and Patacconi 2015).

[5] There are methodological difficulties in measuring returns to basic scientific research in light of the long time lags and data limitations, especially at the macro level (Van Elk and others 2015).

Figure 2.2. Total Research and Development Spending, 2011–15
(Percent of GDP)

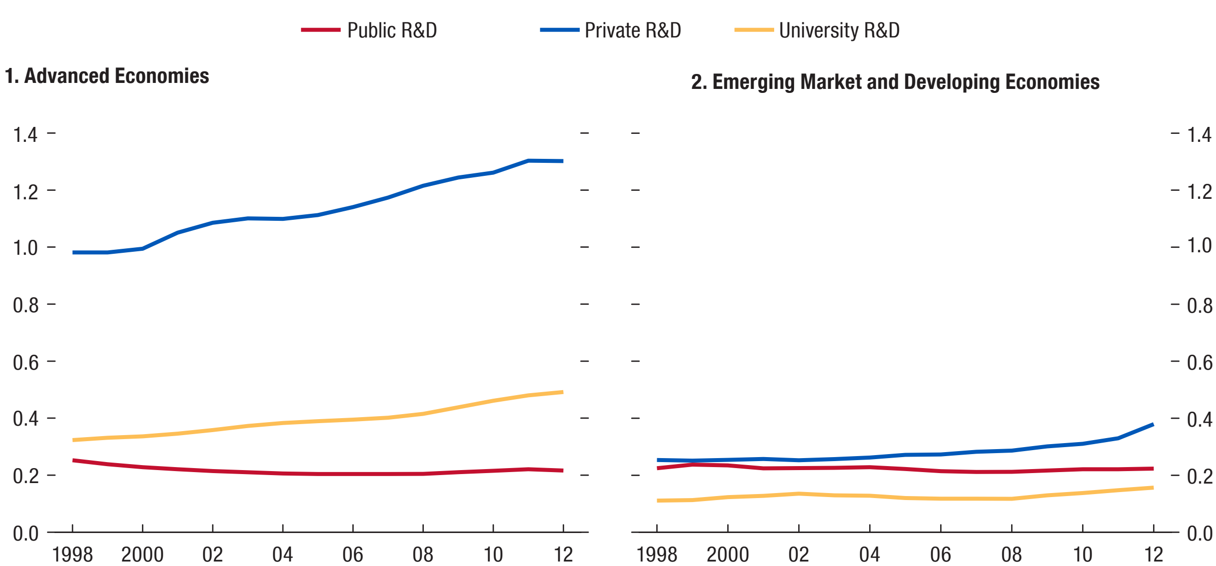
Research and development expenditures are concentrated mostly in advanced economies and China, followed by the large emerging market and middle-income economies.



Sources: World Bank; and IMF staff calculations.

Figure 2.3. Research and Development (R&D) Expenditures, 1998–2012
(Percent of GDP)

Private R&D and university R&D expenditures are significantly higher in advanced economies than in emerging market and developing economies. R&D expenditure is also increasing more rapidly in advanced economies. Public R&D expenditure is similar across groups of economies.



Source: United Nations.
Note: Emerging market and developing economies include emerging market and middle-income economies as well as low-income developing countries. For a list of countries in each group of economies, see Table A in the Methodological and Statistical Appendix.

relationship (complementarity) between public and private R&D seems to be prevalent (for a survey of recent empirical evidence, see Becker 2014) (Figure 2.4). Some forms of government R&D actively seek to support this complementarity, for example, support for research collaboration between universities and private firms.

- *Private R&D* investments chosen by individual firms might be lower than the socially efficient level because of two important market failures: credit constraints and externalities. The rest of this section focuses on how fiscal policies can help address these market failures.

Using Fiscal Stabilization to Promote R&D in Bad Times

Fiscal stabilization policies can promote R&D investments by helping dampen recessions. Firms may encounter difficulties in obtaining funding for R&D investments because R&D often involves a high level of risk, significant fixed costs, and returns that materialize only in the medium to long term. Firms' ability to borrow can be especially impaired during recessions, when liquidity risks are more prevalent. By reducing business cycle volatility, a more countercyclical fiscal policy can pave the way for greater private R&D expenditures and higher structural productivity growth.

These theoretical predictions find empirical support in new analysis in Annex 2.1, based on industry-level data. The results suggest that higher fiscal countercyclicality increases R&D expenditure significantly more in industries that are highly dependent on external finance.[6] The differential effect appears to be large: moving a country from the 25th percentile of the distribution of fiscal stabilization to the 75th percentile increases private R&D by between 10 percent and 16 percent more in industries that depend more on external finance. Higher fiscal countercyclicality also raises average TFP growth in these industries by 6 percent more, the analysis finds.

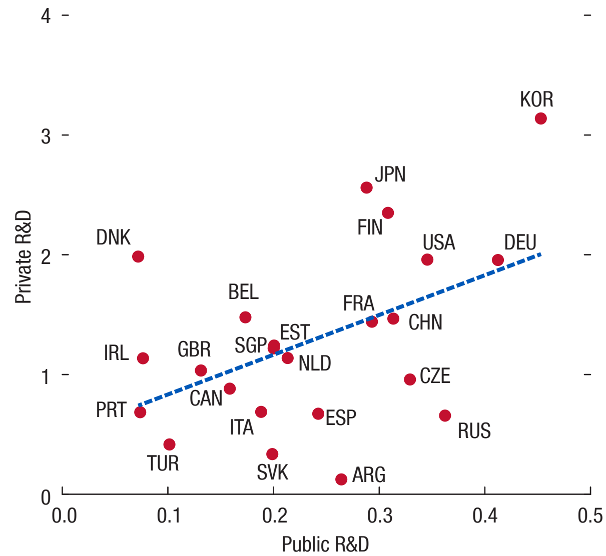
Correcting the Structural Underinvestment in R&D

The *private rate of return to business R&D*—that is, a firm's extra income from a dollar invested in R&D—

[6] Fiscal policy countercyclicality is measured by how responsive the overall government fiscal balance is to the output gap or GDP growth. See the April 2015 *Fiscal Monitor*.

Figure 2.4. Public and Private Research and Development (R&D), 2012
(Percent of GDP)

There is a positive relationship between public and private R&D, which reflects their complementarity.



Source: Organisation for Economic Co-operation and Development.
Note: Data labels in the figure use International Organization for Standardization (ISO) country codes.

is quite high, typically ranging between 20 and 30 percent (Wieser 2005; Hall, Mairesse, and Mohnen 2010). This return is higher than rates of return to physical capital, partly reflecting R&D's higher risk premiums. Most of the evidence is for advanced economies.

Returns to private R&D vary by country, depending on how effectively knowledge is created, commercialized, and diffused. A recent study finds that R&D returns in emerging market and developing economies are on average smaller than in advanced economies (Goni and Maloney 2014). However, returns depend critically on the human capital base of countries, which determines their capacity to absorb—that is, recognize, assimilate, and apply—technologies developed elsewhere. Studies for advanced economies also indicate that the rate of return tends to be larger for countries further away from the technological frontier (Griffith, Redding, and van Reenen 2004). Both of these factors suggest that R&D in emerging market and middle-income economies can potentially yield high returns, provided there is a sufficiently educated work force. R&D returns in China, for instance, are estimated to be as large as for advanced economies (Goh, Li, and Xu 2015).

Private R&D undertaken by one firm may increase productivity in other firms through knowledge spillovers.[7] Spillovers can occur both within the same industry and to other industries. Thus, domestic *social rates of return to private R&D* are generally estimated to be two to three times the private return (Sveikauskas 2007; Bloom, Schankerman, and van Reenen 2013). These positive externalities imply that market forces will lead to an underinvestment in R&D compared with the level that is socially efficient.[8]

This underinvestment can be addressed by corrective fiscal instruments that provide incentives for private R&D. Fiscal incentives such as tax credits and direct subsidies can lower the private cost of R&D so that firms are inclined to invest more, which is socially desirable because other firms will benefit, too. If the external benefits from private R&D are as large as the private benefit—as empirical studies suggest—then the socially efficient correction should reduce the marginal cost of R&D by 50 percent. That is, the cost for a firm investing in extra R&D should be reduced by 50 cents per dollar. Today, actual effective subsidy rates in most countries are much lower;[9] the average for a group of 36 advanced and emerging market economies was 12 percent in 2015. Increasing subsidy rates to the socially efficient level could increase private R&D expenditures by almost 40 percent (Annex 2.2).[10]

Increasing private R&D could generate a significant growth dividend. Based on a comprehensive meta-analysis containing 329 macro estimates (Donselaar and Koopmans 2016),[11] an increase of 10 percent in private R&D in an average advanced economy would boost the level of GDP by about 1.3 percent in the long term. Expanding R&D by nearly 40 percent could thus raise GDP by approximately 5 percent in a representative advanced economy. The fiscal cost would be about 0.4 percent of GDP per year—assuming that those costs rise proportionately with current spending on fiscal R&D support.[12]

International R&D spillovers are also important. R&D undertaken in the Group of Seven (G7) countries yields productivity gains in other countries of approximately 25 percent of the G7's own return (Coe and Helpman 1995; Coe, Helpman, and Hoffmaister 1997, 2009). Taking these spillovers into account, achieving a globally efficient level of R&D could thus raise global GDP by almost 8 percent in the long term (Annex 2.2).

Given the potentially large growth dividend from expanded R&D, the case for supportive fiscal policy is strong. Recognizing this, several countries have put in place policies to increase R&D spending. For example, the European Union has an ambitious goal of raising private R&D from its current level of about 1.3 percent of GDP to 2 percent of GDP in 2020, an increase of more than 50 percent.

Designing Fiscal Incentives to Get the Best Value for Money

Addressing the underinvestment in private R&D will require a comprehensive mix of policies, including well-designed fiscal incentives. Two key corrective incentives that reduce the private cost of R&D are direct R&D subsidies and R&D tax incentives, such as tax credits, enhanced allowances, accelerated depreciation, and special deductions for labor taxes or social security contributions. In 2013, advanced economies spent approximately 0.15 percent of GDP on these forms of fiscal R&D support. A little more than half this amount was in the form of direct subsidies, although the mix varies by country (Figure 2.5).

R&D tax incentives differ from R&D subsidies in important ways. Tax incentives are usually available to all firms that invest in R&D—although they can be designed to target specific groups of firms. This

[7] R&D may also exert negative externalities, such as duplication externalities (multiple firms running parallel research programs in a patent race) or creative destruction externalities (reductions in the value of existing technologies). On net, however, positive externalities from R&D far exceed the negative ones (Jones and Williams 1998).

[8] The market for technology (in which spillover benefits to other firms would be priced through the sale and licensing of intellectual property) is small relative to the overall size of the estimated spillover effects from R&D. This differential reflects high transaction costs in the technology market. Most of the spillovers are thus not accounted for in the private decisions of firms.

[9] The "subsidy rate" expresses the governments' contribution to the firms' last dollar of R&D investment as a percentage of the user cost of R&D (Jaumotte and Pain 2005).

[10] These calculations rely on a number of simplifying assumptions and should be interpreted with caution.

[11] The meta study draws on 15 papers, 14 of which are published in refereed journals.

[12] These calculations do not represent a full cost-benefit analysis, which would also discount for time lags and risk, and account for tax distortions, administrative and compliance costs, and benefits not captured by GDP. A permanent increase in annual R&D expenditures will gradually expand the stock of R&D, which determines the long-term productivity effect. In most models, a new steady state equilibrium is achieved after approximately 20 years.

market-based approach is attractive because it provides a level playing field; all private R&D activities get equal treatment. The drawback, however, is that private sector R&D decisions may not adequately address the complex knowledge spillovers associated with R&D.

Subsidies, in contrast, often take the form of specific support to targeted R&D projects. Thus, they are more often of a discretionary nature and largely designed by the government. If the government is able to target them well based on appropriate information about the size and nature of the spillovers, subsidies can be more efficient than tax incentives. They can also account for nonmarket benefits, such as a cleaner environment (Box 2.2).

New analysis in Annex 2.1—based on firm-level and industry-level data—finds that both tax incentives and direct subsidies increase TFP growth in advanced economies. The effects of the two instruments vary across industries and firms. For example, higher R&D subsidies increase TFP growth more in industries that are highly dependent on external finance (where R&D cannot be accommodated by current cash flow) and in the information technology sector. R&D tax incentives have a larger effect in industries characterized by high R&D intensity and for small firms (those with fewer than 50 employees).

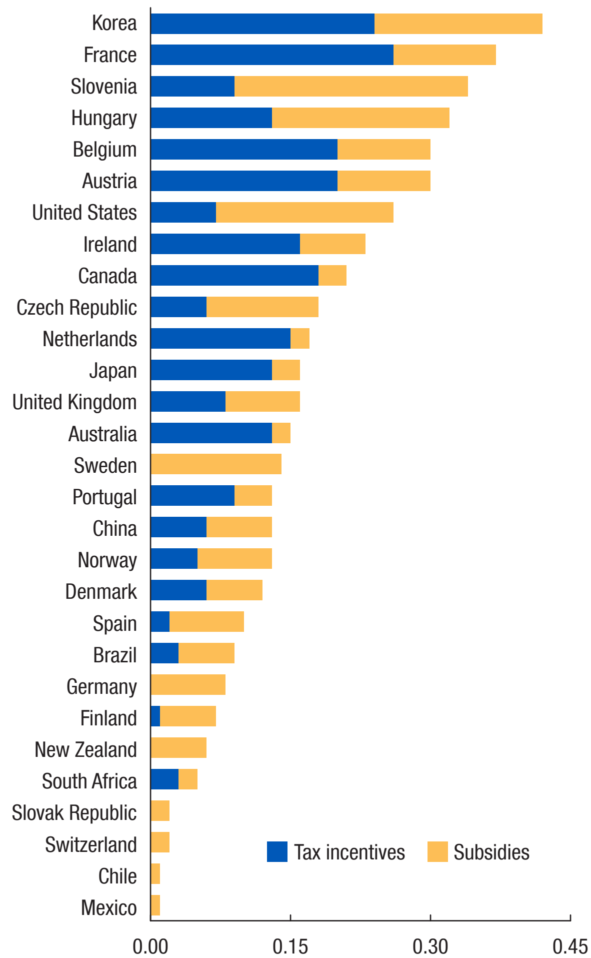
These variations make it difficult to conclude in general terms which instrument more effectively fosters innovation and productivity. In fact, it seems that subsidies and tax incentives each have their own strengths and can therefore usefully complement each other. Subsidies are especially useful for supporting the research component of R&D—the early phase of the innovation process in which knowledge spillovers tend to be larger (Zuniga-Vincente and others 2014). Tax incentives can complement these subsidies by providing across-the-board incentives to all firms investing in R&D.

During the past few years, many countries have increased their fiscal support for private R&D (Figure 2.6). Tax incentives, in particular, have gained popularity and are now used by most advanced economies and many emerging market economies (including Brazil, China, India, and South Africa). This wide use makes a discussion of how these R&D tax incentives can be designed to yield the best value for money particularly relevant. Evaluation studies offer the following lessons:

- *Targeting to small and new firms.* In Canada, the Netherlands, Norway, and the United Kingdom, R&D tax incentives for small firms are two to three times more effective in promoting R&D investments than for an average size firm. This effect might occur because small firms (and especially those that are new) find it harder to obtain finance—for example, because lenders may have less information about them and because new firms may face a higher risk of failure. Nine advanced economies provide more generous R&D tax incentives to small firms (Figure 2.7). Belgium, France, Italy, the Netherlands, and Portugal have more generous tax incentives for new firms.

Figure 2.5. Fiscal Support to Private Research and Development (R&D), 2013
(Percent of GDP)

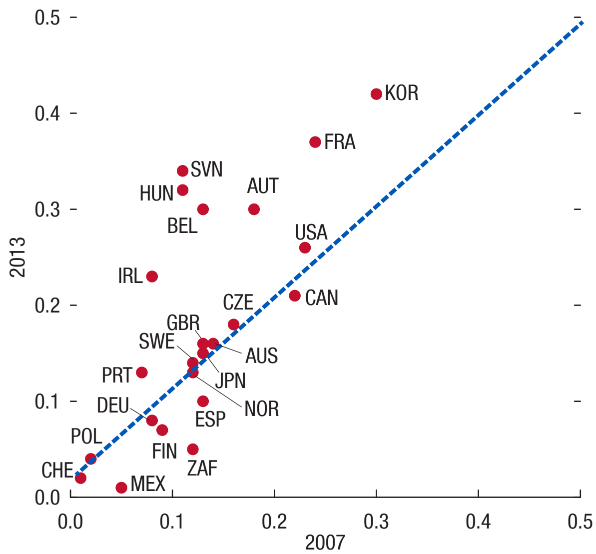
The level of fiscal R&D support and the mix between R&D subsidies and tax incentives vary across countries.



Source: Organisation for Economic Co-operation and Development.
Note: Data for R&D tax incentives in Israel and Poland were not available and are excluded from the figure.

Figure 2.6. Fiscal Support to Private Research and Development, 2007 and 2013
(Percent of GDP)

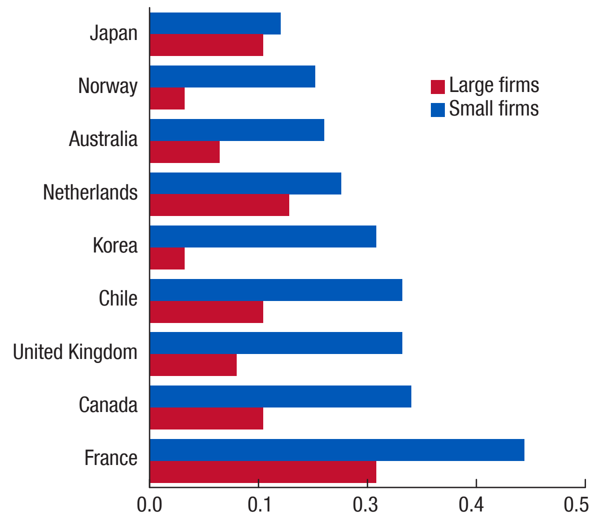
Fiscal support to private research and development has increased in most countries.



Source: Organisation for Economic Co-operation and Development.
Note: Data labels in the figure use International Organization for Standardization (ISO) country codes.

Figure 2.7. Research and Development Tax Incentives for Small and Large Firms, 2013
(Tax subsidy rate as a percentage of user cost of research and development)

Nine countries offer more generous research and development tax incentives to small firms than to large firms.



Source: Organisation for Economic Co-operation and Development.

- *Refundable tax credits.* New firms in their start-up phase often have negative profits. Thus, they would not immediately benefit from tax credits that can only be used against a positive tax liability. A tax credit that is refunded if there is a negative tax liability would be more effective for them. Thirteen advanced economies use refundable R&D tax incentives—sometimes only for small and medium-sized enterprises. R&D tax incentives can also be used to provide relief from labor taxes, such as payroll taxes or employer social contributions. Firms still benefit from those incentives, even if they do not report positive taxable income. Belgium, France, Hungary, the Netherlands, and Spain provide such tax relief.
- *Targeting incremental R&D* (above some baseline amount). Compared with tax incentives that apply to all R&D expenses, incremental incentives are cheaper because they avoid a windfall gain for existing R&D below the baseline. Such incremental schemes are used by Italy, Japan, Korea, Portugal, Spain, and the United States. However, incremental incentives can be more complex and may influence the timing of R&D investments. They also have higher compliance costs as a percentage of total support, which can reduce take-up. Some countries have therefore moved away from incremental schemes or have simplified them.
- *Intellectual property (IP) box regimes* (which provide for lower effective tax rates on income from intangible assets) are often less cost-effective in promoting innovation (Box 2.3).
- *Gradually expanding R&D tax incentives.* A gradual expansion of incentives can be preferable to a large immediate increase. Large increases might simply raise the wages of researchers, who tend to be in fixed supply in the short term. This also highlights the need for appropriate spending on higher education to accommodate the higher demand for researchers.
- *Effective administration* is critical to avoid abuse of R&D tax incentives. For instance, firms may try to relabel ordinary expenditures as R&D to qualify for the incentive. To prevent this subterfuge, support from other government agencies with specialized technical knowledge is often needed, which can raise administrative costs. At the same time, governments should try to minimize compli-

ance costs for firms—which one study estimates at 15 cents per dollar of tax relief for small firms in Canada (Parsons and Phillips 2007). High compliance costs can reduce take-up rates and make the incentive less effective. Most countries allow online application and offer a "one-stop-shop" process to minimize these costs.

Fostering Technology Transfer

Most technology creation occurs in a small number of advanced economies: more than 60 percent of global R&D is undertaken in the G7 countries. These new technologies are then disseminated to the rest of the world through imitation and absorption. Technology transfer from one country to another is critical for productivity growth, especially in emerging market and developing economies.

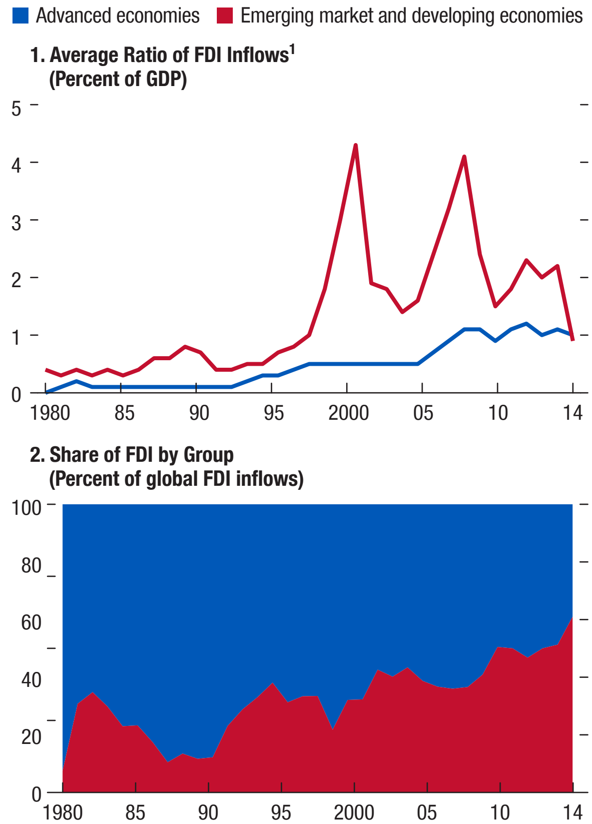
Identifying Technology Transfer Channels

Technology transfers take place through two main channels: international trade and foreign direct investment (Keller 2009).

- *International trade.* Firms can acquire technological knowledge by importing intermediate goods and capital equipment that embody foreign technology. Firms can also "learn by exporting" through direct interactions with their foreign customers—although these effects are weaker than those associated with imports.
- *Foreign direct investment (FDI).* The extent and speed of technology diffusion can depend on firm ownership and the linkages among firms. Multinational firms usually transfer technologies to their affiliates abroad through FDI to realize the full gains from their inventions (Chen and Dauchy, forthcoming). In the receiving country, inbound FDI may generate positive productivity spillovers to other firms through interactions between the multinational affiliate and local firms, worker turnover, or improved organization and management practices. FDI is therefore widely considered to be important for economic growth in emerging market and developing economies. Global FDI flows have increased significantly during the past few decades. The share of the world's total FDI that flows to emerging market and developing economies has also grown, from between 20 and 30 percent in the 1980s to about 50 percent today (Figure 2.8).

Figure 2.8. Trends in Foreign Direct Investment (FDI) Inflows by Country Group, 1980–2014

Emerging market and developing economies receive more FDI (as a share of their GDP) than advanced economies. The share of global FDI that flows to emerging market and developing economies has increased over time to more than 50 percent in recent years.

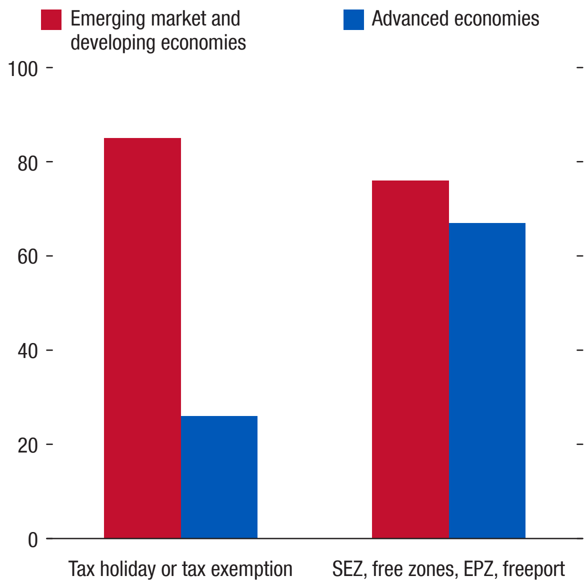


Sources: IMF staff estimates.
Note: Emerging market and developing economies include emerging market and middle-income economies as well as low-income developing countries. For a list of countries in each group of economies, see Table A in the Methodological and Statistical Appendix.
[1]GDP weights are used to compute the average.

Technology diffusion through trade and investment is not automatic. Productivity spillovers from FDI are more prevalent in countries with higher human capital (Havranek and Irsova 2013). In addition, trade and investment often require an adequate level of infrastructure, such as well-developed ground transportation and shipping ports. Government investment in human and physical capital is therefore essential to reaping the productivity gains associated with innovation. Some emerging market and middle-income economies have successfully created well-trained pools of scientists and engineers, which is facilitating technology adoption and innovation (Box 2.4).

Figure 2.9. Prevalence of Tax Incentives
(Percent of countries per income category)

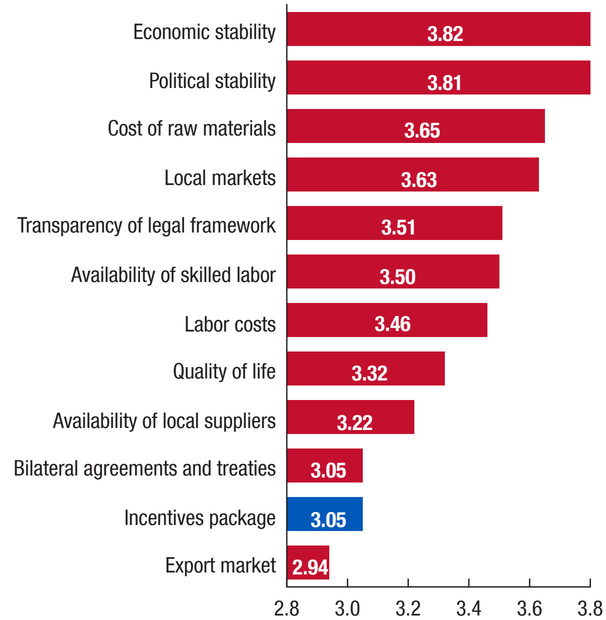
Tax holidays and special economic zones are prevalent in emerging market and developing economies.



Source: IMF and others 2015.
Note: Emerging market and developing economies include emerging market and middle-income economies as well as low-income developing countries. For a list of countries in each group of economies, see Table A in the Methodological and Statistical Appendix. EPZ = export processing zone; SEZ = special economic zone.

Figure 2.10. Importance of Investment Factors for Africa, 2011
(Average rank)

Tax incentive packages rank low in importance of investment factors. Economic and political stability and the transparency of the legal framework rank high.



Source: United Nations Industrial Development Organization.
Note: The figure shows average rankings of 12 location factors according to a business survey among 7,000 companies in 19 sub-Saharan African countries.

Tailoring Tax Policy to Attract Foreign Direct Investment

Countries face a dilemma in determining tax policies to maximize the benefits of FDI (such as productivity gains, high-quality jobs, and stable funding for greenfield investment). Emerging market and developing economies often implement tax holidays or tax exemptions in special economic zones to attract more FDI (Figure 2.9). However, these incentives erode tax bases, most notably of the corporate income tax (CIT). Should emerging market and developing economies reduce the CIT burden through tax incentives or should they maintain their CIT and use the proceeds to invest in education and infrastructure?

To answer this question, both the costs and benefits of FDI tax incentives must be assessed. In many emerging market and developing economies, the costs of tax incentives are unknown because governments do not provide reliable periodic estimations of their tax expenditures. Estimates for a group of 15 Latin American countries—which undertake tax expenditure reviews on a regular basis—suggest revenue losses from CIT incentives of almost 1 percent of GDP on average (CIAT 2011). On the benefit side, studies for advanced economies show that lower CIT rates attract inbound FDI. However, almost no evidence is available for emerging market and developing economies. New analysis in Annex 2.3 aims to fill this gap. The analysis finds that the effects of CIT rates on FDI in emerging market and developing economies are negative—as expected—but that the size of the effect is less than half of that for advanced economies.[13] This is consistent with business surveys conducted in Africa, Asia, and Latin America, which suggest that tax incentives very often have no impact on the investment decisions of multinationals (IMF and others 2015).

Another factor seems to matter more for FDI in emerging market and developing economies, the analysis finds: institutional quality. Also, business surveys rank institutional factors much higher than taxation for FDI location decisions (Figure 2.10). These findings suggest

[13] Similar results are found based on average effective tax rates for a smaller set of countries (Abbas and Klemm 2013).

that tax incentives alone are unlikely to be a cost-effective way to attract FDI. To enjoy the productivity gains from new technologies, countries would do better to invest in institutions, knowledge, and infrastructure.

Repeal of tax incentives might be difficult, however, especially in the short term. Still, governments can do much to improve the design, transparency, and implementation of FDI tax incentives. IMF and others 2015 provides guidelines for these improvements. Regional coordination can also help curb the negative spillover effects from tax incentive policies as a form of mutually damaging tax competition.

Promoting Entrepreneurship

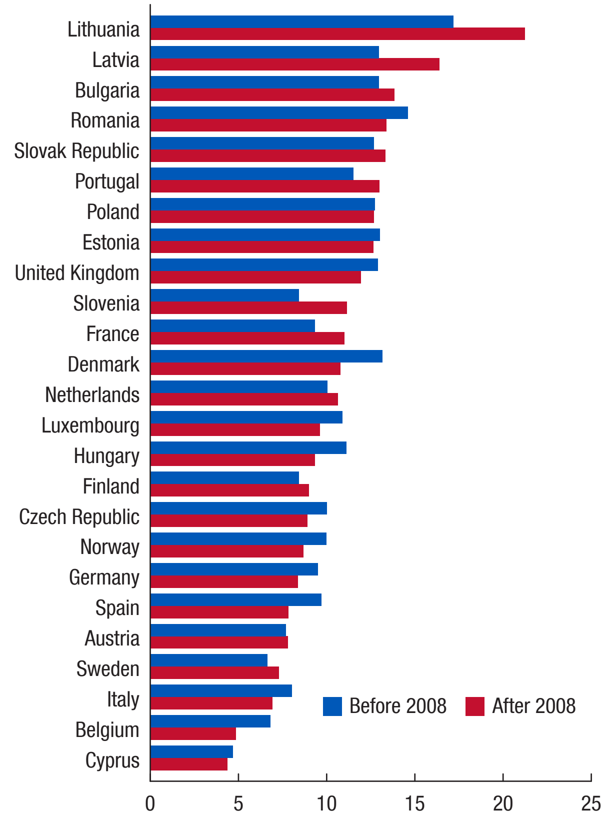
Innovation and productivity growth result not only from investment in R&D by large established companies, but also from small start-up firms engaging in experimentation and risk taking (entrepreneurship). Entrepreneurship is generally linked to the notion of creative destruction, described by economist Joseph Schumpeter, whereby new enterprises enter the market and encourage greater competition and innovation (Schumpeter 1911). A large body of evidence suggests that the entry of new firms is important for innovation and productivity growth. New firms are especially relevant for expanding the technology frontier because they tend to engage in more radical innovations, whereas incumbent firms tend to focus more on incremental innovations to improve existing products and processes (Akcigit and Kerr 2010). More than half of TFP growth at the industry level is due to new entrants, with the remainder associated with productivity improvements by incumbents (Lentz and Mortensen 2008). Competition from new entrants also spurs innovation on the part of incumbent firms, especially in high-technology industries (Aghion and others 2009).

Trends in entrepreneurship vary between countries. In 14 European countries, the rate of new businesses entering the market (a measure of entrepreneurship) has declined since the financial crisis, while in 11 others it has increased (Figure 2.11). In the United States, for which longer time series are available, business entry rates have declined gradually since the late 1970s (Figure 2.12). This decline has been especially large in retail and service sectors, highlighting a shift in these sectors toward larger firms (Decker and others 2015).

Business entry rates are typically higher in emerging market and developing economies than in advanced

Figure 2.11. Business Entry Rates in Europe before and after the Financial Crisis
(Percent of the total number of active firms)

Business entry rates have decreased since 2008 in 14 countries within a sample of 25 European countries.



Source: Eurostat.
Note: "Before 2008" refers to the average between 2004 and 2007; "After 2008" refers to the average between 2008 and 2012.

economies, but the nature of entrepreneurship is also different. A larger portion of new businesses in emerging market and developing economies is "necessity driven"—occurring out of economic need when other options for work are absent or unsatisfactory. In contrast, "opportunity-driven" entrepreneurship, which is more closely related to innovation, is relatively more prevalent in advanced economies (Figure 2.13). An important development goal in many emerging market and developing economies is therefore not so much to increase business entry itself, but rather to increase the share of entrepreneurship that is driven by opportunity.

Efficient entrepreneurial experimentation requires institutional arrangements that facilitate business entry, growth, and exit. Various obstacles can impede this process. A common obstacle is access to finance. Government programs in several countries support

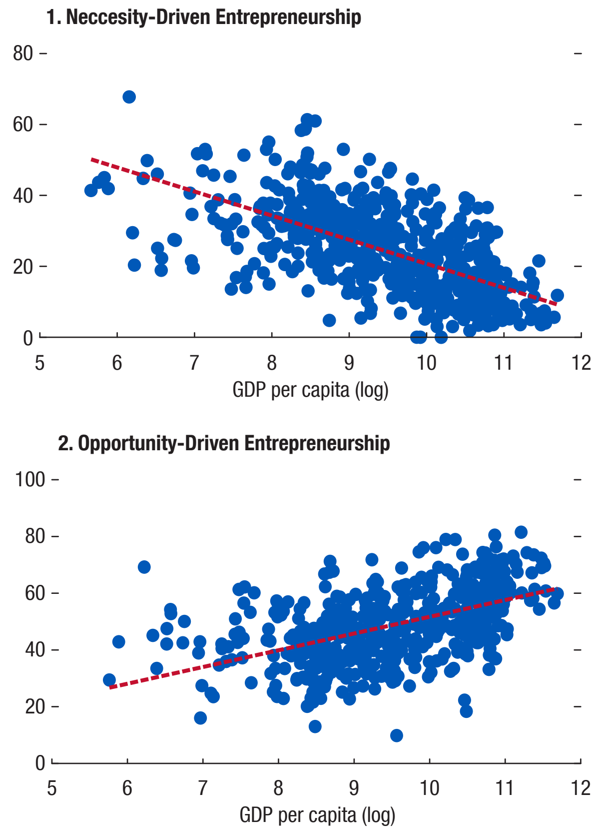
Figure 2.12. Business Entry Rates in the United States, 1977–2013
(Percent of the total number of active firms)

There is a downward trend in the entry rate of firms in the United States.

Source: U.S. Census Bureau Business Dynamics Statistics.

Figure 2.13. Types of Entrepreneurship and GDP per Capita
(Percent of total early-stage entrepreneurial activity)

Necessity-driven entrepreneurship is more prevalent in countries with low GDP per capita, but it declines as per capita GDP rises. Opportunity-driven entrepreneurship tends to rise as GDP per capita increases.



Sources: Global Entrepreneurship Monitor; and IMF staff calculations.
Note: Total early-stage entrepreneurial activity includes those who are either nascent entrepreneurs (actively involved in setting up a business) or owner-managers of a new business (less than 3.5 years old). Opportunity-driven entrepreneurship is characterized by voluntary entrepreneurial activity to exploit an opportunity. Necessity-driven entrepreneurship arises when other options for work are absent or unsatisfactory.

the provision of seed capital, early-stage financing, and venture capital through subsidized loans or grants—although with mixed success (Lerner 2009) (Box 2.5 on Chile). Another obstacle is the burden on businesses of nonfiscal policies, such as permits and licenses, bankruptcy laws, and labor market regulations. Finally, taxation can distort entrepreneurship. The rest of this section analyzes ways in which to minimize such tax distortions.[14]

Tax Policies to Encourage New Business Ventures

The decision to start a business often involves choosing between working under a secure employment contract with a certain wage and taking on risk in pursuit of an uncertain but potentially large financial reward. Tax systems can influence the costs, benefits, and risks involved in this choice. The personal income tax (PIT) is important for entrepreneurs whose firms start as a noncorporate business venture. When PIT systems provide for the full offset of losses against other income, they effectively offer insurance against risk by reducing the variability of rewards, whether those rewards are positive or negative. This system can encourage entrepreneurial risk taking. However, most PIT systems restrict the extent to which losses can be offset. High marginal PIT rates that reduce the potential rewards then serve as a disincentive to entrepreneurial activity. Meanwhile, when businesses survive and grow, they are often transformed into corporations that offer the entrepreneur limited liability protection. Income then becomes subject to the CIT—and, when distributed to the owner, to taxation of dividends or

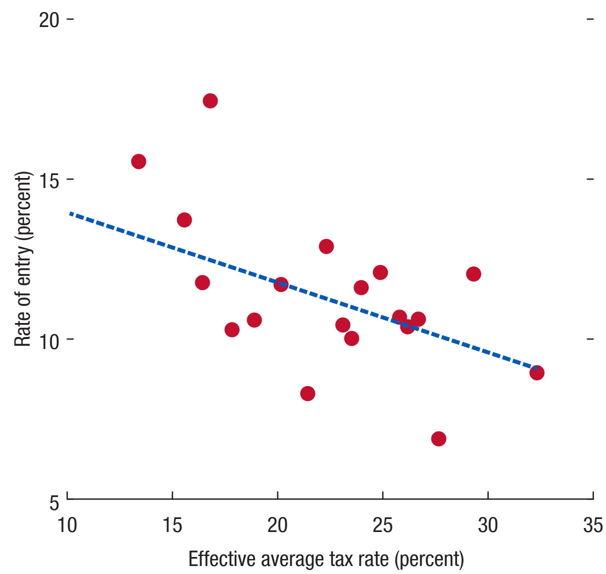
[14] The exit of unsuccessful businesses is also important for the process of entrepreneurial experimentation to be efficient. Taxation may affect exit decisions. Empirically, however, the analysis in Annex 2.4 finds that income taxation has no effect on exit rates.

capital gains. These types of taxes can also influence entrepreneurial entry and growth by changing risk and expected rewards. The effects of income taxes on business creation in advanced economies have been explored by several empirical studies, including new analysis in Annex 2.4. The findings can be summarized as follows:

- *Personal income taxes.* The effects of PIT rates on business creation are mixed. For the United States, some evidence suggests a negative relationship between tax progressivity and business entry (Gentry and Hubbard 2000), whereas another study finds that high PIT rates encourage entrepreneurial risk taking (Cullen and Gordon 2007). Annex 2.4—using a sample of 25 advanced and emerging market economies in Europe—finds insignificant effects of progressive PIT schemes on business entry; these results are robust.
- *Social security taxes.* The decision to start a new business may depend on the difference between the social security program eligibility of employees and entrepreneurs. On the one hand, high social security taxes can generate the same distortionary effects on entrepreneurship as personal income taxes. On the other hand, insurance from universal social security eligibility (against health risk, for example) may encourage entrepreneurial risk taking.
- *Corporate income taxes*. Most empirical studies find that high CIT rates have negative effects on entrepreneurial activity (Baliamoune-Lutz 2015). The results in Annex 2.4 also suggest such a relationship (Figure 2.14). The size of the effect is modest, however. Lowering the average effective tax rate on business income by 1 percentage point (for example, to 20 percent from the current average of 21 percent) would increase the business entry rate by between 0.1 and 0.3 percentage point (for instance, from the current average of 10 percent of the total number of businesses to between 10.1 and 10.3 percent).
- *Capital income taxes*. Because entrepreneurs may generate a significant portion of their income in the form of capital gains, low capital gains taxation may encourage entrepreneurial ventures. However, reducing the tax rate on all capital gains is a blunt instrument for achieving this result. Moreover, low taxes on capital gains could induce tax arbitrage by encouraging entrepreneurs to realize capital gains instead of distributing dividends. Neutral treatment of different sources of income is therefore generally desirable.

Figure 2.14. Entrepreneurial Entry and Business Taxation

As average corporate income tax rates increase, business entry rates tend to decrease.



Sources: Eurostat business demography statistics; Oxford Center for Business Taxation; and IMF staff calculations.

Overall, although income taxes can have some discouraging effect on entrepreneurial entry, there are important countervailing forces. To ensure that these forces are effective, sufficiently generous provisions in the tax system to offset losses are necessary. Some countries have special tax relief measures in place to actively encourage entrepreneurship. For example, tax allowances for venture capitalists are offered as a way to stimulate the supply of funds. These instruments, however, have been ineffective in circumstances in which most of the venture capital originates from tax-exempt institutional investors. Fiscal support directly targeted to start-ups can be more effective, especially if support provides a tax refund when income is negative.

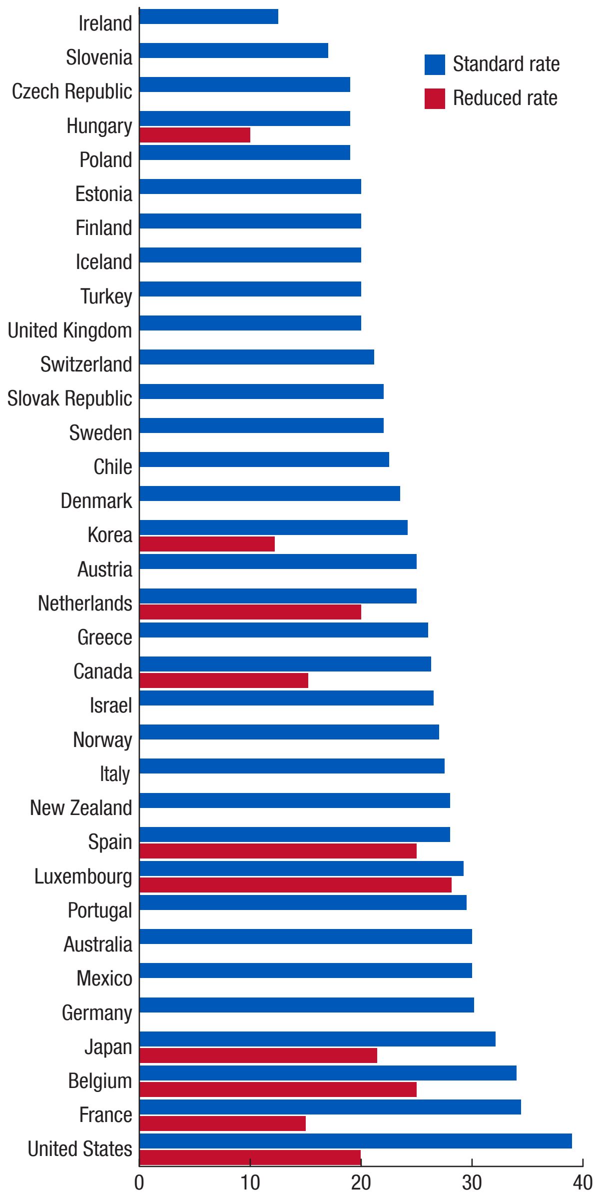
Recognizing That New, Not Small, Is Beautiful

The tax system can also affect the growth of firms. In particular, preferential tax treatment based on the size of the business, and differential taxation of various legal forms of business may affect firms' incentives to grow.

- *Size-based preferential tax treatment*. Various countries offer preferential tax treatment for small

Figure 2.15. Standard and Small Business Corporate Income Tax Rates, 2015
(Percent)

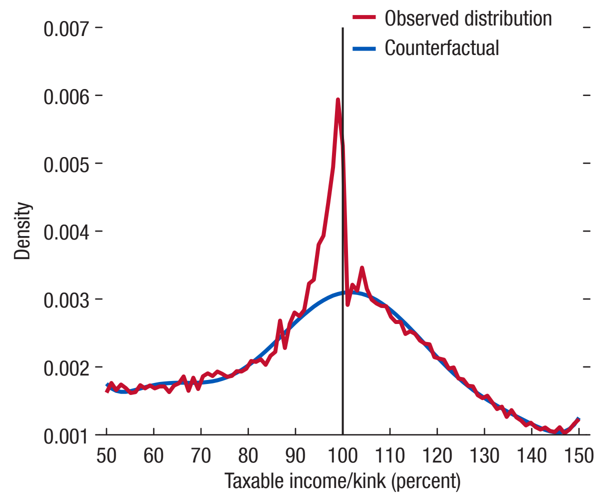
Ten OECD countries have reduced corporate income tax rates for small firms.



Source: OECD tax database.
Note: The figure shows central and subcentral statutory corporate income tax rate, including surcharges. OECD = Organisation for Economic Co-operation and Development.

Figure 2.16. Bunching at a Kink: Evidence for Costa Rica, 2006–13
(Density of taxpayers along the income distribution)

The number of self-employed people in Costa Rica who report taxable income just below the exemption threshold (the kink) is much higher than it would be without a threshold.

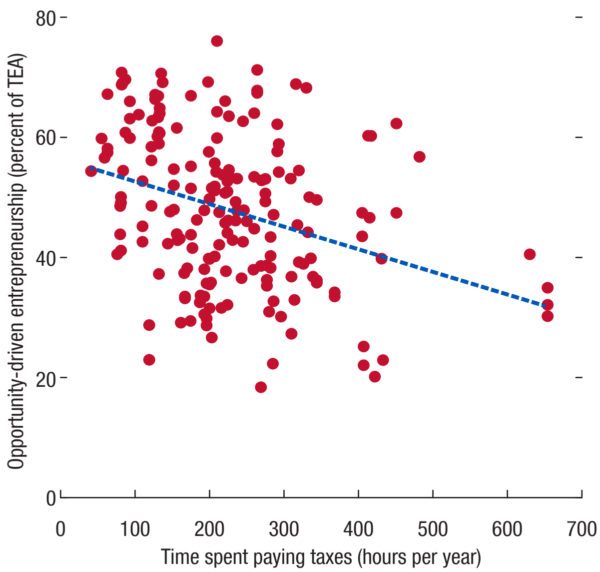


Source: Brockmeyer and Hernandez 2016.
Note: The kink refers to the income level at the exemption threshold for self-employed taxpayers for the years 2006–13. The label 100 on the horizontal axis denotes that taxable income is precisely equal to the threshold. The tax rate above the threshold is 10 percent.

companies. For instance, 10 member countries of the Organisation for Economic Co-operation and Development (OECD) have lower CIT rates on profits below a certain level (Figure 2.15). However, given that most small firms are neither new nor innovative, such tax incentives are not well targeted for relieving tax barriers to entrepreneurial innovation (except for those related to R&D expenditures, which are targeted to innovation; see Box 2.5 on France). Evidence indicates that a firm's rate of growth, job creation, and export activity are related more directly to the age of the business than to its size (Haltiwanger, Jarmin, and Miranda 2013). Moreover, size-based tax preferences can create disincentives for firms to grow larger, creating a so-called small business trap. One illustration of this, found in several microeconomic studies, is "bunching": a very high density of firms with income just below the level at which the size-based tax preference is removed (Figure 2.16). This pattern may partly reflect an underreporting of income, but it may also reflect changes in activity by firms, such as reducing investment or fragment-

Figure 2.17. Business Entry and Compliance Burden, 2012–14

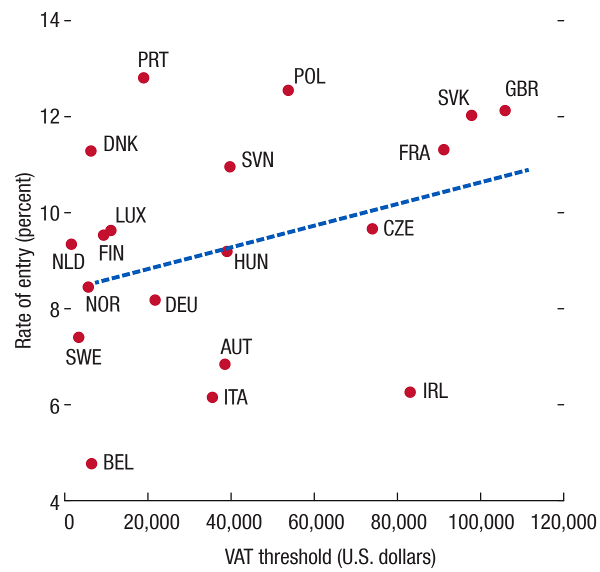
Countries where it takes longer to prepare, file, and pay taxes have less opportunity-driven entrepreneurship.



Sources: Global Entrepreneurship Monitor; and World Bank.
Note: The time spent paying taxes measures the time it takes to prepare, file, and pay tax for a representative medium-sized company. TEA = Total early-stage entrepreneurial activity.

Figure 2.18. Business Entry and Value-Added Tax (VAT) Registration Threshold, 2010–13

The magnitude of the VAT registration threshold (which relieves small firms of the obligation to register for VAT) is positively correlated with business entry.



Sources: Eurostat; and Organisation for Economic Co-operation and Development VAT Statistics.
Note: Entry rates are country averages for 2010–13, which are expressed as a percentage of the total number of active businesses. Data labels in the figure use International Organization for Standardization (ISO) country codes.

ing the business (in inefficient ways) to remain below the threshold. By deterring firms from growing larger, size-based tax preferences might thus harm productivity growth rather than support it. Encouraging the creation or growth of firms would be achieved more efficiently by targeting support to new firms. These incentives would require rules that limit potential abuse (for example, new legal entities that are created just to renew the tax preference on a continuing activity) and a strong tax administration to enforce those rules.

- *Different taxation of different legal forms of business.* Many tax systems do not provide neutral tax treatment of business income earned under various legal structures (corporate versus noncorporate). As a result, entrepreneurs are induced to run their businesses in ways that minimize their tax liability, which may distort organizational efficiency and hamper growth, especially if corporations are taxed at higher rates than noncorporate businesses (given that entrepreneurs tend to shift to the corporate legal form once they grow beyond a certain size). A slightly lower tax burden on corporations compared with noncorporate businesses can provide some encouragement to entrepreneurial risk taking or can promote formal registration of businesses.

Keeping Taxes Simple

The complexity of tax systems can hamper entrepreneurship. Tax compliance costs in Africa, Asia, Latin America, and the Middle East are sometimes estimated to be nearly 15 percent of turnover for the smallest firms (Coolidge 2012). This high tax compliance burden can impose a significant barrier to entrepreneurship (Figure 2.17). Some countries have therefore simplified their tax regimes for businesses below a certain turnover threshold. These regimes usually exempt such businesses from registration for the value-added tax (VAT)—although they normally allow voluntary registration. The higher the VAT registration threshold, the higher the rate of business entry (Figure 2.18). In several countries, the VAT registration threshold could be usefully increased. In some countries, simplified regimes also allow small firms to use less complex accounting to calculate taxes (based on turnover, for instance), pay one unified tax instead of a range of taxes, and pay tax less frequently. Simplification is especially relevant in emerging market and developing economies to encourage informal businesses to formalize their status. In Brazil, for example, the implementation of simplification schemes for micro and small businesses significantly raised their formal entry, turnover, and employment levels (Fajnzylber, Maloney, and Montes-Rojas 2011). Other countries that have simplified tax regimes include Chile, Georgia, India, Mexico, and South Africa. The purpose of simplified regimes for small businesses is not to provide a lower tax burden; rather, the average tax burden in the simplified regime should be set high enough to encourage firms to make the transition into the ordinary income tax regime once they grow above the threshold.

Conclusion

Identifying policies that could lift productivity growth by promoting innovation is critical at this juncture. Fiscal policy can play an important role. Based on the analysis in this chapter, the main policy conclusions are as follows:

- **Good fiscal stabilization policies promote R&D.** They can help firms maintain spending on R&D during recessions. New evidence in the chapter finds that fiscal stabilization is especially important for industries that are highly reliant on external funding.
- **Governments should do more to boost R&D.** In advanced economies, private R&D investment should be raised, on average, by 40 percent to attain levels that are efficient from a national perspective. Achieving these R&D levels could raise GDP by 5 percent in the long term. The associated fiscal costs are estimated to be about 0.4 percent of GDP per year. On a global level, the benefits from increased private R&D would be larger as a result of international knowledge spillovers.
- **Careful design of fiscal R&D incentives is imperative.** Governments can invest more in public R&D, such as basic scientific research, which will advance firms' own research activities. Moreover, new evidence in the chapter suggests that research subsidies and tax incentives targeted at R&D expenditures can effectively promote productivity growth. However, some existing policies have high fiscal costs but do little to foster innovation. For example, the analysis shows that patent boxes (which reduce taxes on income from intellectual property) are often not cost-effective in stimulating R&D. In some cases, they are simply part of an aggressive tax competition strategy.
- **Technology transfer in emerging market and developing economies requires better institutions, education, and infrastructure.** New analysis in the chapter shows that commonly used tax incentives aimed at attracting FDI are largely ineffective and costly. Good institutions may be a more effective way of attracting foreign investment. Furthermore, these countries need to strengthen their capacity to absorb technologies from abroad by improving their human capital base and infrastructure.
- **Tax preferences should target new firms, not small ones.** Empirical analysis in the chapter finds that income taxes tend to have only modest effects on business entry rates. Preferential tax treatment of small firms should be avoided; it may actually hurt growth by creating a small-business trap as a result of the higher taxes firms would face once they cross a certain size threshold. Well-designed tax relief targeted to new firms can promote entrepreneurship and innovation.

Annex 2.1. Fiscal Policy, Research and Development, and Total Factor Productivity Growth

This annex assesses the impact of fiscal R&D support on total factor productivity (TFP) growth. The analysis is conducted using both micro data and industry-level data. Industry-level data are also used to assess the effect of fiscal policy countercyclicality on private R&D expenditures. One limitation of the approach is that results cannot be interpreted as countrywide effects.

Micro-Level Analysis

The micro approach uses a measure of firm TFP, based on the Solow-residual calculated by Liu (forthcoming). The following equation is estimated:

$$\Delta \mathrm{Log}(TFP)_{ijct} = \alpha + \beta \times X_{ijct} + \gamma \times RD_{ct-1} \times X_{ijct} + \delta \times Z_{jt} + \theta_{ct} + \varepsilon_{ijct}, \qquad \text{(A2.1.1)}$$

in which $\Delta \mathrm{Log}(TFP)_{ijct}$ is a proxy for TFP growth in firm i, sector j, country c, and year t; and X_{ijct} represents a firm's intrinsic factors, such as its size.

Annex Table 2.1.1. Impact of Fiscal Research and Development (R&D) Support on Firms' Total Factor Productivity

	RD = Total Fiscal R&D Support		RD = R&D Tax Incentives Support		RD = R&D Subsidies Support	
Dependent Variable: Δ Log (Total factor productivity)	(1)	(2)	(3)	(4)	(5)	(6)
Log (tangible fixed assets)	0.108*		0.347**		0.132	
	(0.0615)		(0.139)		(0.119)	
Small Firms (dummy)		−2.619***		−2.598***		−1.712***
		(0.662)		(0.113)		(0.286)
Manufacturing (dummy)	3.240**	2.030***	1.732**	1.402*	2.669***	1.728***
	(1.284)	(0.674)	(0.823)	(0.722)	(0.343)	(0.371)
Information Technology (dummy)	1.049	−0.0316	1.283	0.438	1.087***	0.0577
	(1.442)	(0.753)	(0.823)	(0.662)	(0.365)	(0.228)
Log (tangible assets) × Lagged RD	0.118*		0.102		0.555**	
	(0.0668)		(1.734)		(0.246)	
Small Firms × Lagged RD		2.521***		13.12***		7.093***
		(0.930)		(4.264)		(1.657)
Manufacturing × Lagged RD	−2.059	−0.442	4.734	8.813	−8.282***	−0.0839
	(1.454)	(0.710)	(21.50)	(19.31)	(3.062)	(1.599)
Information Technology × Lagged RD	−0.358	0.652	0.363	5.025	−2.703	3.608***
	(1.626)	(1.009)	(19.99)	(16.91)	(4.005)	(0.611)
Observations	3,673	3,673	1,567	1,567	3,673	3,673
Number of Firms	1,933	1,933	1,492	1,492	1,933	1,933

Source: IMF staff calculations and estimates.
Note: Robust standard errors are in parentheses. Country year fixed effects are included in all regressions.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Z_{jt} are sector-specific control variables. θ_{ct} denote country-year fixed effects. Estimation is based on the difference-in-difference method. Dummies are adopted for small firms (fewer than 50 employees) and the manufacturing and information technology sectors to explore differentiated impacts of R&D policies. RD_{ct-1} represents public R&D support as a percentage of GDP (in lagged terms to avoid potential endogeneity), reflecting either total fiscal R&D support, direct support through subsidies, or indirect support through tax incentives.

Firm-level data are taken from ORBIS. The focus is on industrial firms (nonagriculture and nonfinancial entities) and only those reporting positive R&D. Data on public R&D support come from the OECD's Main Science and Technology Indicators database. The sample comprises 24,130 observations for 9,027 firms in seven countries (Belgium, Czech Republic, Germany, Italy, Spain, Sweden, United Kingdom).

Annex Table 2.1.1 shows that the impact of fiscal R&D support on firm-level TFP growth is generally positive and significant. Effects are larger and more significant for small firms, while the distinct effects in manufacturing and the information technology sector are significant in only some specifications. Subsidies have a larger effect in firms with more tangible fixed assets. Quantitatively, the results in columns (4) and (6) of Annex Table 2.1.1 suggest that an increase in R&D tax incentives of 0.1 percent of GDP raises the value added of small firms by 1.3 percent more than of medium-sized and large firms; the effect of a similar increase in subsidies is about 0.7 percent larger.

Industry-Level Analysis

A similar analysis is carried out using industry-level data. The analysis follows Rajan and Zingales 1998 and Aghion, Hemous, and Kharroubi 2014 by estimating the following specification for a panel of 24 advanced economies and 16 industries:

$$TFP_{jc} = \alpha_c + \gamma_j + \beta \times FinDep_j \times RD_c + \delta \times RDint_j \times RD_c + \theta \times FinDep_j \times FS_c + \varepsilon_{cj}. \quad \text{(A.2.1.2)}$$

TFP_{jc} is average TFP growth in industry j and country c from 1970 to 2007, taken from the OECD. $FinDep_j$ is a measure of external financial dependence for each industry j. Following Rajan and Zingales 1998, it is measured as the median across all firms in a given industry of the ratio of total capital expenditures minus current cash flow to total capital expenditures.[15] $RDint_j$ is a measure of R&D intensity for each industry j, based on the U.S. industry average of R&D expenditures. RD_c measures fiscal R&D support in country c, taken from the same source as above for the micro-level analysis. FS_c measures fiscal stabilization,

[15] Data were kindly provided by Hui Tong. For details, see Tong and Wei 2011.

Annex Table 2.1.2. Impact of Fiscal Stabilization and Fiscal Research and Development (R&D) Support on Industry Total Factor Productivity Growth

Dependent Variable: Total Factor Productivity Growth	Estimates	Differential Impact (percent)
External Finance × Fiscal Stabilization	0.51*** (3.56)	6.04
External Finance × Direct R&D Subsidies	1.31** (2.53)	3.37
External Finance × R&D Tax Incentives	0.53 (1.33)	
R&D Intensity × Direct R&D Subsidies	–0.07 (–0.87)	
R&D Intensity × R&D Tax Incentives	0.11* (1.77)	5.62
Observations	305	
R^2	0.54	

Source: IMF staff calculations and estimates.
Note: Estimates are based on equation (A2.1.2), including industry and country fixed effects. The t-statistics based on clustered standard errors are reported in parentheses. Differential impact in the last column is computed for an industry in the 75th percentile relative to the 25th percentile of the financial dependence distribution (or R&D intensity) when the country increases fiscal stabilization (or R&D support) from the 25th to the 75th percentile.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Annex Table 2.1.3. Impact of Fiscal Stabilization on Private Research and Development

	Fiscal Stabilization Based on GDP Growth		Fiscal Stabilization Based on Output Gap	
Dependent Variable: Private Research and Development	(1)	(2)	(3)	(4)
External Finance × Fiscal Stabilization	0.96***	0.98***	0.76***	0.78***
	(3.36)	(3.45)	(3.01)	(3.17)
Differential in Research and Development (percent)	9.65	9.84	15.79	16.2
Observations	5,131	5,131	5,478	5,478
R^2	0.91	0.91	0.91	0.91

Source: IMF staff calculations and estimates.
Note: Estimates are based on equation (A2.1.3). The t-statistics based on clustered standard errors at country-industry level are reported in parentheses. Country-time fixed effects are included in all regressions, industry fixed effects in (1) and (3), and industry-country fixed effects in (2) and (4). Differential in research and development computed for an industry with external financial dependence at the 75th percentile relative to the 25th percentile of the financial dependence distribution when the country increases fiscal stabilization from the 25th to the 75th percentile.
*** $p < 0.01$.

which follows the approach in the April 2015 *Fiscal Monitor*, and is taken from new estimates by Furceri and Jalles, forthcoming. Finally, α_c and γ_j are country and industry dummies.

Regression results show that direct R&D subsidies increase TFP growth more in industries with higher external financial dependence (Annex Table 2.1.2). R&D tax incentives increase industry TFP growth more in industries with higher R&D intensity. TFP growth is significantly and positively correlated with the interaction of external financial dependence and fiscal policy countercyclicality, as in Aghion, Hemous, and Kharroubi 2014.

A time-varying measure of fiscal stabilization (FS_{it}) from Furceri and Jalles, forthcoming, is used to estimate the following specification for a panel of 24 advanced economies and 16 industries for the period 1970–2007:

$$RD_{jct} + \alpha_{ct} + \gamma_j + \beta \times FinDep_j \times FS_{ct} + \varepsilon_{jct}. \quad (A.2.1.3)$$

RD_{jct} is private R&D expenditures in industry j, country c and year t; α_{ct} and γ_j are country-time and industry dummies. For fiscal stabilization (FS_{ct}), two indicators are used based on either GDP growth or the output gap. Results show that private R&D expenditures are significantly and positively correlated with the interaction of external financial dependence and fiscal policy countercyclicality (see Annex Table 2.1.3). This result is robust to different estimates of fiscal stabilization.

Annex 2.2. Corrective Fiscal Incentives for Research and Development

This annex provides a back-of-the-envelope calculation of the so-called underinvestment in private R&D discussed in the main text of the chapter. It combines a simple analytical framework with consensus estimates from the empirical literature.

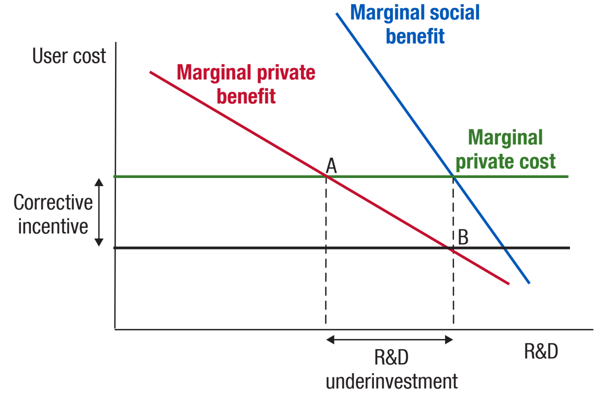
Consider a neoclassical framework in which R&D investment of an individual firm is determined by the usual optimality condition that the marginal private cost (*mpc*) (or user cost, *u*) equals the marginal private benefit (*mpb*). Assuming a constant *u*, decreasing returns to scale with respect to R&D capital determines the optimal private R&D (point A in Annex Figure 2.2.1). Assume further that the marginal social benefit (*msb*) is two times the *mpb*—as suggested by the empirical literature—and that the externality exhibits the same decreasing returns to scale as the *mpb*. The socially optimal outcome will then be: $mpc = msb = 2 \times mpb$, or $\frac{1}{2}u = mpb$. Firms should thus continue to conduct R&D until the *mpb* equals half the user cost (point B in Annex Figure 2.2.1). The government can encourage firms to achieve this level of R&D by adopting a corrective fiscal R&D incentive that reduces the user cost by 50 percent.

Effective R&D subsidy rates for 36 countries for 2015 are available in the *OECD Science, Technology and Industry Scoreboard* 2015 (OECD 2015b). These rates are derived from the so-called B-index, which expresses the R&D subsidy as a percentage of the user cost (Jaumotte and Pain 2005). The unweighted average subsidy in the sample is 12 percent. An efficient corrective fiscal incentive (50 percent of the user cost) would therefore, on average, require the subsidy rate to be increased by 38 percent of the user cost. An extensive literature has estimated the sensitivity of private R&D to the user cost and, on average, reports a consensus elasticity in the long term of about −1 (Hall and van Reenen 2000; Parsons and Phillips 2007; Kohler, Laredo, and Rammer 2012; EC 2014). These findings imply that, at current effective subsidy rates, the average underinvestment in R&D is 38 percent.

The B-index is an experimental indicator that requires a number of assumptions. An alternative measure of the effective subsidy is based on government funding of business R&D as a ratio of R&D spending. The unweighted average for 37 countries in 2013 implies an effective subsidy rate of 14 percent and is thus close to the 12 percent derived above. Average government spending on fiscal support to private R&D is 0.15 percent of GDP. Proportionately scaling up the effective subsidy to the efficient level of 50 percent would entail an increase in government support of 0.38 percent of GDP.

The effect on GDP of eliminating the current underinvestment can be explored by using estimates of the domestic GDP elasticity of private R&D. Donselaar and Koopmans (2016) find an average elasticity of 0.135, based on 15 macro studies (which together produce 329 estimates).[16] A simple linear approximation with an average elasticity of 0.13 suggests that eliminating the R&D underinvestment of 38 percent would increase GDP by roughly 5 percent in the long term.

Annex Figure 2.2.1. Underinvestment in Research and Development (R&D) and the Efficient Corrective Incentive



Source: IMF staff.

International R&D spillovers could add to these effects. Coe and Helpman (1995) and Coe, Helpman, and Hoffmaister (1997, 2009) find international spillovers of about 25 percent of the domestic social return to R&D in G7 countries. These additional externalities imply that the efficient corrective fiscal incentive on a global scale is 60 percent.[17] The global R&D underinvestment would then be 48 percent. The global GDP elasticity of R&D would also be 25 percent higher ($1.25 \times 0.13 \approx 0.16$). Hence, eliminating the R&D underinvestment could increase global GDP by almost 8 percent in the long term.

Of course, these calculations rely on a number of simplifying assumptions—perfect market conditions, decreasing returns to scale to private R&D, externalities that vary proportionately with the private return, and the absence of distortionary taxation. The user cost of R&D is held constant, while researcher wages might rise in light of their inelastic supply (at least in the short term), thus driving up the user cost. The

[16] Studies based on firm-level data find an average output elasticity of a firm's own R&D of 0.08 and a similar average output elasticity of other firms' R&D (Hall, Mairesse, and Mohnen 2010). The sum of the two effects suggests a total output effect that is roughly similar to the consensus estimate based on macro data. The confidence intervals around these mean values are large.

[17] The optimality condition now is $u = gmsb = 1.25 \times msb = 2.5 \times mpb$, where *gmsb* is the global marginal social benefit. Thus, the optimal private cost is 40 percent of the user cost; the corrective subsidy is 60 percent.

first-order approximations also take no account of possible nonlinearities, such as those with respect to the effectiveness of subsidies or the impact on GDP. The results should therefore be interpreted with caution and are for illustrative purposes only.

Annex 2.3. Taxation and Foreign Direct Investment

This annex assesses the impact of statutory corporate income tax (CIT) rates and institutional quality on foreign direct investment (FDI) by estimating the following equation:

$$\mathrm{Log}(FDI_{ct}) = \alpha \times \log(FDI_{ct-1}) + \beta \times CIT_{ct} + \Sigma\, \gamma\, X_{ct} + X_{ct} \times IQ_{ct} + \mu_c + \eta_t + \varepsilon_{ct}. \quad \text{(A.2.3.1)}$$

FDI_{ct} is FDI in country c and year t; X_{ct} are control variables (level of development, real GDP growth, trade openness), and μ_c and η_t are country and time fixed effects.

FDI inflows are taken from the World Economic Outlook (WEO) database, while statutory CIT rates are taken from the IMF Fiscal Affairs Department tax database for 103 countries between 1990 and 2013. Control variables are obtained from the WEO. An indicator of "institutional quality" is computed as a simple average of six indices from the World Bank World Governance Indicators database: control of corruption, government effectiveness, political stability and absence of violence or terrorism, regulatory quality, rule of law, and voice and accountability.

Equation (A2.3.1) is estimated by both ordinary least squares (OLS) and difference generalized method of moments (GMM). The preferred specification, which includes control variables in columns (7)–(9) of Annex Table 2.3.1 suggests a semielasticity of FDI to the CIT rate of –4.4 in advanced economies, –1.4 in emerging market and middle-income economies, and –2.3 in low-income developing countries. Institutional quality positively affects FDI to emerging market and developing economies. It has an opposite sign for advanced economies, which is unexpected.

Annex 2.4. Taxation and Entrepreneurship

This annex estimates the effects of taxes on business entry rates in an unbalanced panel of 25 European countries for the period 2004–13. The benchmark model estimates the following equation:

$$entry_{ct} = \alpha \times entry_{ct-1} + \beta \times Tax_{ct} + \gamma \times X_{ct} + \theta_c + \mu_t + \varepsilon_{ct}, \quad \text{(A.2.4.1)}$$

in which $entry_{ct}$ is the entry rate of enterprises in country c in year t; Tax_{ct} is a measure of tax (corporate or personal); and θ_c and μ_t are country and year fixed effects.

A second model takes a difference-in-difference specification of the following form:

$$entry_{jct} = \alpha \times entry_{jct-1} + \beta \times FinDep_j \times Tax_{ct} + \gamma \times X_{jct} + \delta_{ct} + \lambda_j + \varepsilon_{jct}, \quad \text{(A.2.4.2)}$$

in which $entry_{jct}$ is the entry rate in sector j in country c in year t, and δ_{ct} and λ_j are country-year and industry dummies. The index $FinDep_j$ is the same as in Annex 2.1 (for this analysis computed for the same sectors for which data on entry rates are available, based on U.S. firms between 2005 and 2015). This index serves primarily for identification. Intuitively, taxes might have larger effects on entry in sectors characterized by higher financial dependence, to the extent that this is a proxy for risk.

Data on entry rates are obtained from Eurostat business demography statistics. The entry rate is defined as the ratio of new enterprises to all active enterprises.[18] The analysis uses the effective average tax rate (EATR) on business income from Oxford University Centre for Business Taxation. Progressivity of the personal income tax (PIT) is captured by the coefficient of residual income progression (CRIP), defined as (1–*marginal tax wedge*)/(1–*average tax wedge*). A higher value indicates a less progressive tax system. Data on tax wedges are obtained from the OECD Tax Database.

Equation (A2.4.1) is estimated using either system generalized method of moments (GMM) or ordinary least squares (OLS). In column (1) of Annex Table 2.4.1, the estimated coefficient of –0.097 implies that an increase in the EATR of 1 percentage point decreases the entry rate by almost 0.1 percentage point. OLS estimates are slightly larger, but significance is reduced. The estimated effects of the average tax wedge (ATW) or CRIP on the entry rate are insignificant. Estimates of equation (A2.4.2) confirm the importance of the EATR. The ATW and the CRIP enter again with a statistically insignificant coefficient. Results are robust for assumptions about clustering of standard errors.

[18] The same regressions as in equations (A2.4.1) and (A2.4.2) were run for business exit rates. Estimated coefficients for the tax variables were insignificant in all specifications. They are not reported here for the sake of brevity.

Annex Table 2.3.1. Impact of Taxes and Institutional Quality on Foreign Direct Investment (FDI)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dependent Variable: Log (FDI)	Advanced Economies	Emerging Market and Middle-Income Economies	Low-Income Developing Countries	Advanced Economies	Emerging Market and Middle-Income Economies	Low-Income Developing Countries	Advanced Economies	Emerging Market and Middle-Income Economies	Low-Income Developing Countries
		OLS			GMM			GMM	
Lag of Log(FDI)	0.316***	0.522***	0.505***	0.505***	0.633***	0.603***	0.313***	0.156**	0.588***
	(0.060)	(0.031)	(0.068)	(0.032)	(0.018)	(0.028)	(0.045)	(0.067)	(0.033)
CIT Rate	–0.014**	–0.015***	–0.018**	–0.058***	–0.035***	–0.048***	–0.044***	–0.014**	–0.023***
	(0.006)	(0.003)	(0.009)	(0.008)	(0.004)	(0.007)	(0.014)	(0.006)	(0.008)
Institutional Quality							–0.809*	0.525**	0.463*
							(0.471)	(0.243)	(0.255)
								New	
Level of Development							0.0145	0.022	0.125**
							(0.011)	(0.015)	(0.050)
Real GDP Growth							0.075***	0.020***	0.029***
							(0.016)	(0.007)	(0.007)
Lag of Real GDP Growth							–0.004	0.016**	–0.002
							(0.016)	(0.006)	(0.007)
Trade Openness							0.009*	0.004	0.016***
							(0.005)	(0.004)	(0.003)
Lag of Trade Openness							–0.004	–0.004	–0.005
							(0.005)	(0.003)	(0.003)
Observations	737	1,621	817	679	1,499	720	431	1,015	551
R^2	0.537	0.811	0.789	…	…	…	…	…	…
Sargan Test				0.466	0.442	0.444	0.257	0.118	0.418
AB AR (2)				0.670	0.00830	0.432	0.691	0.475	0.170

Source: IMF staff calculations and estimates.
Note: All columns include year and country dummies. AB AR (2) = Arellano-Bond test for zero autocorrelation in first-differenced errors. The GMM estimator is a difference GMM. Standard errors are in parentheses. CIT = corporate income tax; GMM = generalized method of moments; OLS = ordinary least squares.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Annex Table 2.4.1. Impact of Taxes on Business Entry

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
			Equation (A2.4.1)					Equation (A2.4.2)	
		GMM			OLS			Difference-in-Difference OLS	
Lag Entry Rate	0.496***	0.404***	0.310**	0.223**	0.883	0.8	0.052***	0.543***	0.543***
	(0.077)	(0.109)	(0.136)	(0.104)	(0.079)	(0.076)	(0.032)	(0.034)	(0.034)
EATR	–0.097***	–0.124**	–0.141**	–0.334*	–0.362*	–0.319**			
	(0.03)	(0.044)	(0.064)	(0.178)	(0.183)	(0.149)			
CRIP		–0.004			–0.019				
		(0.023)			(0.02)				
ATW			0.005			–0.087			
			(0.066)			(0.163)			
ΔEATR × FinDep							–0.016*	–0.015*	–0.011
							(0.008)	(0.008)	(0.008)
ΔCRIP × FinDep								0.004	
								(0.01)	
ΔATW × FinDep									–0.034
									(0.025)
Growth	0.164*	0.133	0.141*	0.236*	0.091	0.085			
	(0.09)	(0.132)	(0.083)	(0.137)	(0.069)	(0.071)			
Observations	121	110	110	121	110	110	15,534	14,079	14,079
R^2				0.206	0.235	0.233	0.509	0.525	0.525
AB AR (2)	0.438	0.136	0.058						
Sargan Test	0.99	0.99	0.99						

Source: IMF staff calculations and estimates.
Note: Columns (1)–(6) include year and country dummies. Columns (7)–(9) include sector and country-year dummies. The GMM estimator is a system GMM. In columns (1)–(3), standard errors are based on the conventionally derived variance estimator for GMM estimation. In columns (4)–(6), standard errors are clustered at the country-year level. Standard errors are in parentheses. AB AR (2) = Arellano-Bond test for zero autocorrelation in first-differenced errors; ATW = average tax wedge; CRIP = coefficient of residual income progression; EATR = effective average tax rate on business income; FinDep = financial dependence by sector; GMM = generalized method of moments; OLS = ordinary least squares.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Box 2.1. The Role of Patents for Innovation

One way to promote innovation is to use intellectual property arrangements, such as patents, copyrights, and trademarks. These arrangements give the holder an exclusive right to exploit a particular intellectual property. Intellectual property differs from other types of property in that it embodies ideas and knowledge created by people, and so is intangible. Creating knowledge often entails a high fixed cost. However, the marginal costs of using this knowledge, once it has been discovered, are often much smaller. The possibility to free ride on creators' efforts could discourage people from producing new knowledge. Intellectual property rights seek to overcome this problem. For example, copyrights protect original expressions of arts and industrial form, while trademarks protect distinguishing phrases, logos, and pictures. Patents provide creators of an innovative product, process, formula, or technique a monopoly on its exploitation for a limited period (usually 20 years). Patents are usually granted only if the creation is truly innovative in the sense of being "new, useful, and nonobvious." In return, the applicant must publicly disclose technical information about the invention.

Between 2004 and 2014, the number of patent applications worldwide grew by 70 percent, from about 1.5 million to almost 2.7 million. More than one-third of the patents in 2014 were recorded in China, followed by the United States (21 percent), Japan (12 percent), and Korea (8 percent). The growth in patents has been especially large in areas such as biotechnology, information technology, medical technology, and pharmaceuticals. Patents have also extended into new areas, such as business processes, software, and financial products.

Although patents provide incentives for innovation, monopoly rights restrict competition and may have other, more subtle, effects on innovation and competition (Table 2.1.1). The challenge for policymakers is to design a patent regime that balances the various benefits and costs. Design parameters include the length of a patent, its scope, conditions on what qualifies as innovation, patent fees, administrative rules and procedures, and organization of the litigation process in case of patent infringement. The desirability of patents should also be compared with alternative policy instruments, such as innovation prizes (if a breakthrough can be defined in advance) or research subsidies and tax incentives.

Empirical analysis of the economic impact of patents is complicated because there is no good way to measure their effects precisely. Studies using quantitative proxies suggest that stronger patent protection does not necessarily lead to more investment in research and development. To be effective, implementation is key: patents should be granted only in cases of true innovation. More restrictive patent systems, for instance, with stronger examination seem superior to weaker ones. This finding is consistent with the evidence on "intellectual property box regimes," which have an effect on innovation only if they are designed well (see Box 2.3). Survey evidence also indicates that patents are more likely to be beneficial for innovation in particular sectors, such as biotechnology, pharmaceuticals, and medical instruments (Hall and Harhoff 2012). Finally, compared with large firms, strengthening patent protection for small firms tends to support innovation more (Galasso and Schankerman 2015). These findings suggest that a differentiated approach to patents across industries and by firm size may be superior to a uniform patent regime.

Given their cross-border implications, patents are often included in bilateral and regional trade agreements. A multilateral agreement that provides minimum standards for patent design and enforcement was concluded under the auspices of the World Trade Organization in 1995. It has led to significant strengthening of patent protection in many countries, including emerging market economies. This greater patent protection has increased inflows of foreign direct investment to these countries.

Table 2.1.1. Benefits and Costs of Patents

	In Terms of Innovation	In Terms of Competition
Benefits	• Provide incentive to invest in research and development • Public disclosure can support follow-on inventions	• Facilitate entry of new firms with limited tangible assets • Facilitate trade in technology (through sale and licensing)
Costs	• Limit diffusion to other firms • Impede combining new ideas that could lead to other (cumulative) inventions	• Reduce competition due to exclusive right • Strategic and defensive patenting restricts entry of new firms and creates high transaction costs

Box 2.2. Fiscal Policy and Green Innovation

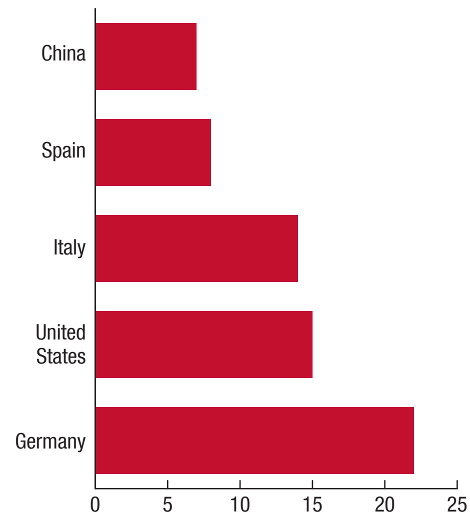
Innovations in green technologies may need policy interventions to correct two distortions. First, firms are not compensated for the overall environmental benefits they generate for society (such as fewer carbon emissions or deaths from local air pollution). Second, firms developing or pioneering the use of green technologies cannot capture spillover benefits to rival firms that can imitate these technologies, use knowledge embedded in them to further their own research, or benefit from "learning-by-doing" experiences with the new technology.

The single most important fiscal policy is to get energy prices right by charging for environmental damage (for example, through carbon taxes). Charging for environmental damage addresses the first distortion and provides across-the-board incentives for green innovation (Farid and others 2016). At present, however, undercharging for environmental costs and undertaxation relative to other consumption are almost universal practice, and effectively implied a global energy subsidy of $5.3 trillion in 2015, or 6.5 percent of GDP (Coady and others 2015). Getting energy prices right would produce much greater welfare gains than subsidizing green technologies in general (Parry, Pizer, and Fischer 2003).

Carefully sequenced application of additional interventions at different stages of the innovation process may also be needed, depending on the extent of technology spillovers. Advanced economies should invest in basic research for technologies that are far from being ready for market, but that may ultimately be critical for a low-carbon transition. Examples include carbon capture and storage, energy storage, smart grids, energy efficiency, and infrastructure for electric vehicles. Moreover, research should explore technologies that could be used in extreme climate scenarios (like expensive filters to suck carbon dioxide out of the atmosphere) or that could deflect solar radiation (by shooting sulfate aerosols into the stratosphere). Annual spending on clean technology research in the United States and the European Union (about $6 billion and €4 billion, respectively) is small relative to other sectors. Analysts have recommended that funding be ramped up—but gradually, as the supply of scientists and engineers is expanded (Newell 2015).

Incentives for applied research and development (R&D) are also needed, for example through patents, technology prizes, and fiscal incentives. Once new technologies are ready for the market, their adoption by households (for example, low-emission cars) and firms (for example, wind energy) is often heavily subsidized (Figure 2.2.1)—even though spillovers at this stage are generally weaker than for basic and applied research. Often, these subsidies take the form of guaranteed consumer prices for renewables. A better way to encourage R&D would be to provide fixed subsidies per unit of renewable energy generated; this approach would allow generation prices to vary with changing economic conditions. Deployment incentives also need to be phased out as technologies mature. Generally, a rebalancing of incentives away from technology deployment toward earlier stages in the innovation process is called for.

Figure 2.2.1. Major Subsidizers of Renewable Electricity, 2013
(Direct and indirect subsidies for renewable electricity, billions of U.S. dollars)



Source: International Energy Agency.

Box 2.3. Does Preferential Tax Treatment of Income from Intellectual Property Promote Innovation?

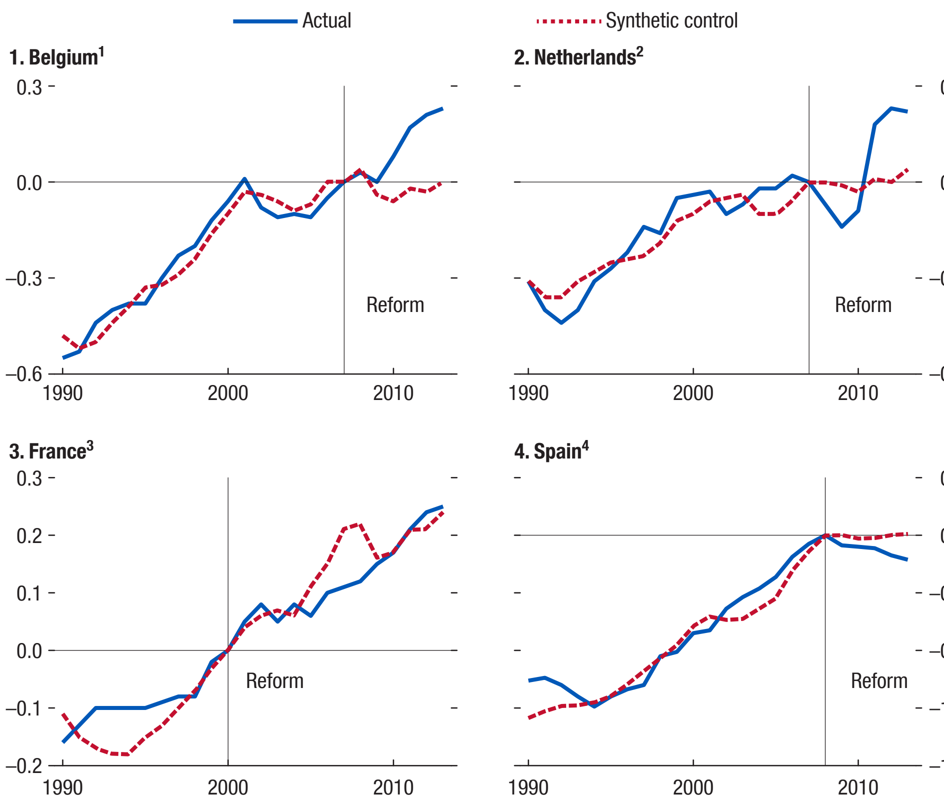
Intellectual property (IP) box regimes, which generally exempt a significant percentage of royalty and other qualifying IP income from domestic corporate income tax (CIT), have been implemented in 13 European countries. The two common objectives are to encourage innovation and to attract IP income from abroad. Forgone revenue from this tax expenditure can be significant; for example, it amounts to 6 percent of CIT revenue in the Netherlands. Is this money well spent?

Effectiveness. To identify the impact of the introduction of IP box regimes on research and development (R&D) spending in four countries (Belgium, France, Netherlands, Spain), the synthetic control method (SCM) was used.[1] For each country, a synthetic counterfactual control group was generated from 12 countries that had no IP box (Denmark, Finland, Germany, Iceland, Ireland, Italy, Japan, Norway, Portugal, Sweden, United Kingdom, United States) to mimic private R&D spending before the introduction of the IP box. The SCM measures the impact of the IP box on R&D spending after it was introduced. Sensitivity analysis was conducted to confirm the robustness of the findings (not reported here for the sake of brevity). A positive effect was found for Belgium and the Netherlands (Figure 2.3.1), where R&D spending in 2013 (six years after the introduction of the IP box) was about 20 percent higher than in the synthetic control

[1] Private R&D data come from Eurostat. Data on control variables (GDP per capita, population, and foreign direct investment) come from the Organisation for Economic Co-operation and Development (OECD). The United Kingdom, Italy, and Ireland introduced an IP box after the sample period (1980–2013). The SCM (and its limitations) are described in detail in IMF (2015).

Figure 2.3.1. Synthetic Control Estimation Results: Intellectual Property Box Regimes and Private Research and Development

(Log of real research and development spending)



Source: IMF staff estimates.
[1] Synthetic control group: United Kingdom (48 percent), Sweden (51 percent), Ireland (1 percent).
[2] Synthetic control group: United Kingdom (58 percent), Norway (36 percent), Sweden (6 percent).
[3] Synthetic control group: United Kingdom (43 percent), Japan (35 percent), Italy (10 percent), Norway (8 percent), seven other countries (4 percent).
[4] Synthetic control group: United States (43 percent), Portugal (34 percent), United Kingdom (8 percent), Ireland (15 percent).

Box 2.3 *(continued)*

group. By contrast, no positive effects were found for France and Spain.[2] This mixed evidence may be explained by differences in the design of the IP box regimes. For instance, Belgium and the Netherlands have larger reductions in the effective tax burden on IP income, and they also apply conditions with respect to self-developed IP through R&D. Clearly, design matters.[3]

Efficiency. Are IP box regimes an efficient way to encourage R&D? That is, do they achieve this at a lower cost compared with other fiscal instruments (such as R&D tax credits)? They might not for at least three reasons. First, the IP box can discriminate against innovations that are not protected by IP rights. In the absence of such protection, these innovations might actually be expected to yield larger knowledge spillovers to other firms; from that perspective, they should enjoy more (not less) fiscal support. Second, IP boxes might induce firms to apply for IP rights, even if business considerations would not, thus creating inefficiencies. Third, an IP box regime provides tax relief proportional to the amount of qualifying IP income, regardless of the level of R&D expenditure. In contrast, R&D tax credits are directly proportional to R&D expenditures. An R&D tax credit might therefore be expected to provide a larger increase in R&D per dollar of forgone tax revenue.

Spillovers. The popularity of IP box regimes might be better explained by their second policy objective: attracting foreign IP income or preventing domestic IP income from moving abroad. A review of the key design features of IP box regimes indicates that this seems to be the case (Evers, Miller, and Spengel 2015). For instance, relief is often given to income that bears little relationship to new domestic R&D, such as income from IP that predates the regime, acquired IP (rather than self-developed IP), IP created by foreign R&D service providers, and IP from trademarks (marketing intangibles). Of course, the IP box may be an effective way to expand the tax base of an individual country. However, the relocation of IP income generates adverse impacts on the tax bases of other countries and induces strategic tax competition that drives effective tax burdens on IP income down to very low levels. Whether this is good or bad is the subject of debate. For instance, this form of tax competition may undermine the ability of countries to tax income and could thus lead to shortfalls in tax revenues. However, one might argue that aggressive tax competition for the most mobile part of the tax base is less harmful than tax competition that would otherwise arise with the generally applied CIT rate for both mobile and immobile income (Keen 2002).

[2] In 2013, Spain reformed its patent box.

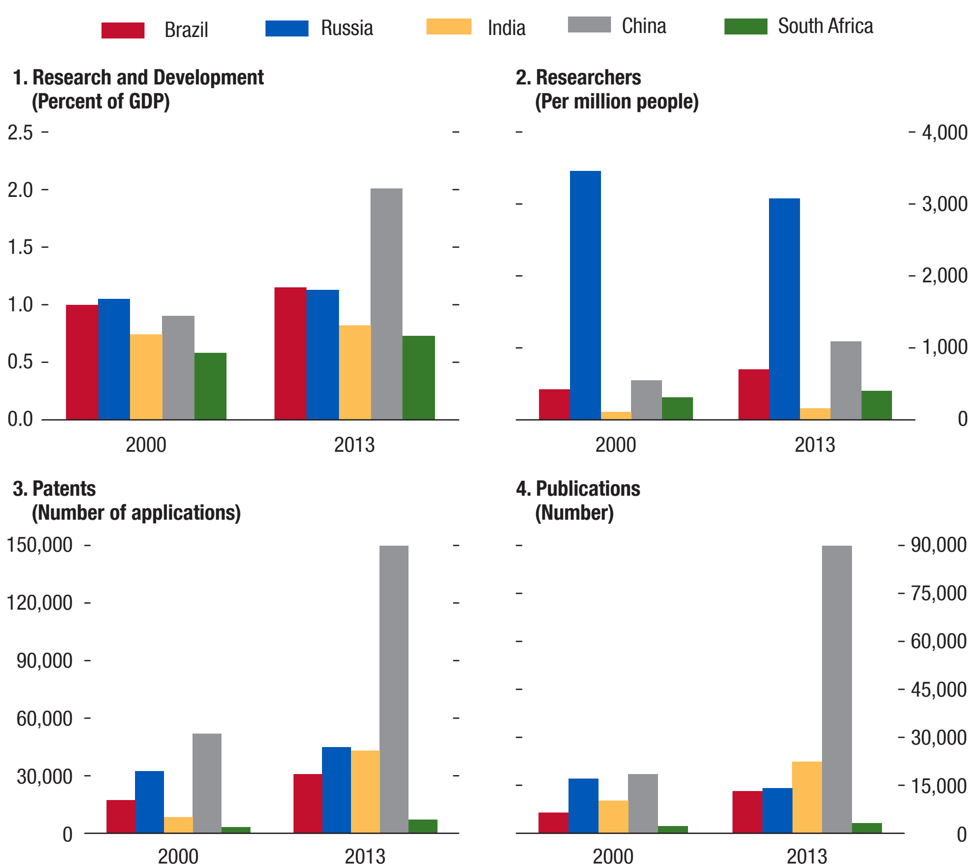
[3] OECD and Group of 20 countries have—as part of the action plan against base erosion and profit shifting—recently agreed on a minimum requirement for substantial innovative activities to become eligible for these tax preferences (OECD 2015a). This requirement might improve the impact of IP box regimes on R&D.

Box 2.4. Innovation in Brazil, Russia, India, China, and South Africa

During the past decade, indicators of innovation have improved markedly for Brazil, Russia, India, China, and South Africa (BRICS) (Figure 2.4.1). Investment in education and research has strengthened the knowledge bases of these countries. Thanks to their endowment of well-trained but low-cost scientists and engineers, Brazil, China, and India are currently considered among the top 10 destinations for multinational companies to expand their foreign research and development (R&D) activities (Santos-Paulino, Squicciarini, and Fan 2014). Since the mid-1990s, all BRICS have significantly strengthened their patent protection; as a result, inflows of foreign direct investment (FDI) have increased substantially (Park and Lippoldt 2008). This increase in FDI has been particularly beneficial for technology transfers in specific sectors in each country, such as aircraft technology in Brazil; chemicals, pharmaceuticals, and electronics in Russia; software technology in India; and telecommunications, medicine, and aerospace in China.

Although the BRICS are often treated as a group, there are striking differences among them. For example, China now spends more than 2 percent of GDP on R&D and ranked first in the world with respect to the number of patent applications in 2013. Important challenges for China remain, however, for instance, with respect to the enforcement of intellectual property rights, the diffusion of technologies outside of high-tech parks, and the need for a more level playing field between state-owned enterprises and other firms. In the other BRICS, R&D spending is about 1 percent of GDP or less, and is mainly concentrated in the public sector. The main challenge for these countries is to promote private R&D. For instance, Brazil and South Africa could improve small firms' access to their R&D tax incentive schemes. In India and Russia, financing opportunities for innovative entrepreneurs are often lacking (a new program for financing start-up firms in India was just launched in January 2016). South Africa could improve its higher education system, and Russia its legal enforcement of intellectual property rights.

Figure 2.4.1. Quantitative Indicators of Innovation in BRICS, 2000 and 2013



Source: World Bank, *World Development Indicators*.
Note: BRICS = Brazil, Russia, India, China, and South Africa.

Box 2.5. Programs for Young Innovators and Start-Ups

To promote entrepreneurship, several countries have special programs in place for innovative start-ups. To be effective, these programs require both adequate design and good implementation. This box describes two successful initiatives.

Start-Up Chile, launched in 2010, aims to attract early-phase, high-potential entrepreneurs, regardless of nationality. The program offers a 24-week training program in which selected entrepreneurs with start-ups less than two years old receive Ch$20 million (about US$28,000) in grants as seed capital. The program had attracted more than 1,000 start-ups through 2015. In that year, the government launched a new program to support high-potential start-ups that need additional capital to grow, either within Chile or throughout Latin America. It offers up to Ch$60 million (about US$85,000) of additional capital through a cofinanced grant, under which recipients must match at least 30 percent of the investment. To support female entrepreneurs, S Factory has been introduced as a pre-accelerator designed to "turn innovative ideas into scalable businesses." Selected entrepreneurs receive Ch$10 million (about US$14,000) in grants and 12 weeks of mentorship and training, after which they may apply to Start-Up Chile. Start-Up Chile has been replicated in more than 16 countries across Africa, Asia, Europe, and North and South America. (Start-Up Chile 2015).

Young Innovative Companies in France was established in 2004 to encourage the creation of small firms engaged in research and development (R&D). The tax incentives include reduced corporate and local taxes and social security contributions. To qualify, firms must be less than eight years old and legally independent, and must meet certain size criteria. R&D expenditure must be at least 15 percent of tax-deductible expenses in a given year, with qualifying R&D requiring a "new to the world" element. Most of the participating firms have fewer than 10 employees, and more than half operate with losses, reflecting the start-up nature of the businesses. In 2013, 3,000 enterprises benefited from the scheme—more than twice as many as when the program started. R&D expenditure was €700 million. The scheme had an estimated fiscal cost of €110 million in 2012. Firms participating in the program had an 8 percent higher employment growth rate, higher survival rates, and generally paid higher wages than nonparticipants (Hallépée and Garcia 2012; EC 2014).

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