Chapter 1

The role of innovation and the rationale for public policy

This chapter builds on the OECD's 2010 Innovation Strategy in exploring the contribution of innovation to economic growth. It extends that study by incorporating considerations about green and inclusive growth into the conceptual framework for innovation policy. This recognises the growing role that these objectives play in the overall policy agenda, but also in the context of innovation. The chapter also devotes attention to the various policy rationales for innovation and the overall framework for policies in this area.

Innovation – which involves the creation and diffusion of new products, processes and methods (Box 1.1) – is central to advanced and emerging economies; in many OECD countries, firms invest as much in the knowledge-based assets that drive innovation, such as software, databases, research and development (R&D), firm-specific skills, and organisational capital, as they do in physical capital, such as machinery, equipment or buildings. The use of information technologies has become universal in only a few decades, and new applications emerge almost daily. But while innovation is everywhere today, its impact does not appear in the productivity statistics, to paraphrase the quip by Robert Solow (1987).[1] And other important policy objectives, such as green growth, also require a stronger contribution of innovation to be addressed.

Box 1.1. **Defining and measuring innovation**

There is growing recognition that innovation encompasses a wide range of activities in addition to R&D, such as organisational changes, training, testing, marketing and design. The latest (third) edition of the *Oslo Manual* (OECD and Eurostat, 2005) defines innovation as the implementation of a new or significantly improved product (good or service) or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations.

By definition, all innovation must contain a degree of novelty. The *Oslo Manual* distinguishes three types of novelty: an innovation can be new to the firm, new to the market or new to the world. The first concept covers the **diffusion** of an existing innovation to a firm – the innovation may have already been implemented by other firms, but it is new to the firm. Innovations are new to the market when the firm is the first to introduce the innovation on its market. An innovation is new to the world when the firm is the first to introduce the innovation for all markets and industries.

Innovation, thus defined, is clearly a much broader notion than R&D or technological change and is therefore influenced by a wide range of factors, some of which can be influenced by policy. Innovation can occur in any sector of the economy, including government services such as health or education. However, the current measurement framework applies to business innovation, even though innovation is also important for the public sector (see Section 7.5).

The broad notion of innovation also emerges from the OECD's work on knowledge-based capital (KBC) (OECD, 2013), which points to a range of investments that firms can make beyond investment in technology (e.g. in information and communications technologies [ICT] capital) or in R&D. Increasingly, firms also invest in other forms of KBC, such as data, intellectual property, firm-specific skills or organisational capital.

This report argues that policy makers can and should do better in marshalling the power of innovation to help achieve core objectives of public policy. Treating innovation as a central tool of policy making will help ensure policy coherence, since innovation policies cross government portfolios and affect a wide range of stakeholders. Integrating

innovation as part of a broader toolbox can also help ensure that innovation contributes to greater overall well-being. For example, while innovation is a source of growth and many new jobs, it also contributes to job destruction, which means that complementary policies are needed to enable job reallocation and skills development for workers who have lost their jobs.

Innovation matters not only for growth, but also for health, the environment and a range of other policy objectives that are related to well-being. However, the links between innovation and these other policy objectives have been explored in less detail and require further elaboration. This chapter extends the discussion in the OECD's 2010 Innovation Strategy (OECD, 2010) by first considering the relationship between innovation and economic growth, and then explicitly incorporating considerations about green and inclusive growth into the conceptual framework for innovation policy. This recognises the growing role that these objectives play in the overall policy agenda, but also in the context of innovation. The chapter also devotes attention to the rationale for innovation policies and the overall policy framework.

1.1. Innovation for strong, green and inclusive growth

Innovation's contribution to economic growth

There is widespread agreement that innovation is an important driver of growth, especially in the long run. Despite this understanding, the conceptual and empirical links between innovation and growth are complex. Innovation is not a simple linear process, with a straightforward link between investments in innovation and economic or social outcomes. Moreover, metrics for certain aspects of innovation suffer from limitations. This has made it difficult to establish the role that policies for innovation – in a broad sense – can play in shaping or strengthening innovation performance, with most analyses focusing only on certain aspects of innovation, such as spending on R&D. Despite these challenges, our understanding of the drivers and impacts of innovation continues to improve, and this report highlights some of the new evidence and policy insights emerging from recent work.

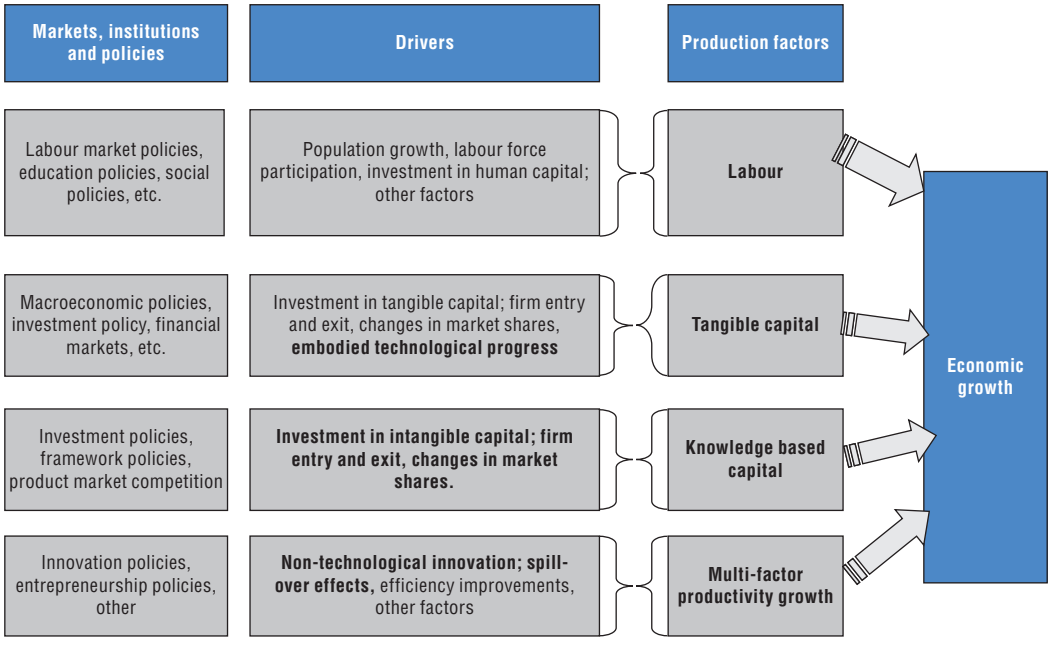
A key interest of policy makers in innovation has long been around its potential contribution to economic growth. A long-established way to look at the relationship between innovation and economic growth is through a production function where growth in output results from the input of labour and capital (both tangible and intangible) and from increases in multifactor productivity (MFP), i.e. the part of output growth that cannot be explained by increased factor inputs. In such a framework, innovation's contribution to growth can be found in three different places (Figure 1.1):

1. A contribution resulting from technological progress embodied in physical capital; for example, investment in more advanced machinery or in new computers. The OECD's Growth Study found that between 0.2 and 0.4 percentage points of gross domestic product (GDP) growth between 1985 and 2000 was linked to such embodied technological progress (OECD, 2003). The latest OECD estimates show that about 0.35 percentage points of GDP growth between 1995 and 2013 can be attributed to investment in ICT capital alone (Figure 1.2; OECD, 2015a).
2. A contribution resulting from investment in intangible capital, or KBC, such as R&D, software, design, data, firm-specific skills or organisational capital. This type of investment has risen steadily across the OECD (OECD, 2013), and recent analysis by Corrado et al. (2012) found it accounted for around 0.5 percentage points of GDP growth

in European Union (EU) countries from 1995 to 2007, and 0.9 percentage points in the United States. This factor has not yet been incorporated in the OECD estimates shown in Figure 1.2.

3. A contribution linked to increased MFP growth, reflecting increased efficiency in the use of labour and capital, a substantial part of which can be attributed to innovation, including social and organisational innovations as well as the spillover effects of investments in technology or KBC, including at the global level. MFP accounted for over 0.7 percentage points of GDP growth between 1995 and 2013 in the countries shown in Figure 1.2, or about one-third of total GDP growth (see also OECD, 2015a).[2]

Figure 1.1. **A simplified framework to analyse economic growth**



Source: Adapted from OECD (2000), *A New Economy? The Changing Role of Innovation and Information Technology in Growth*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/9789264182127-en*.

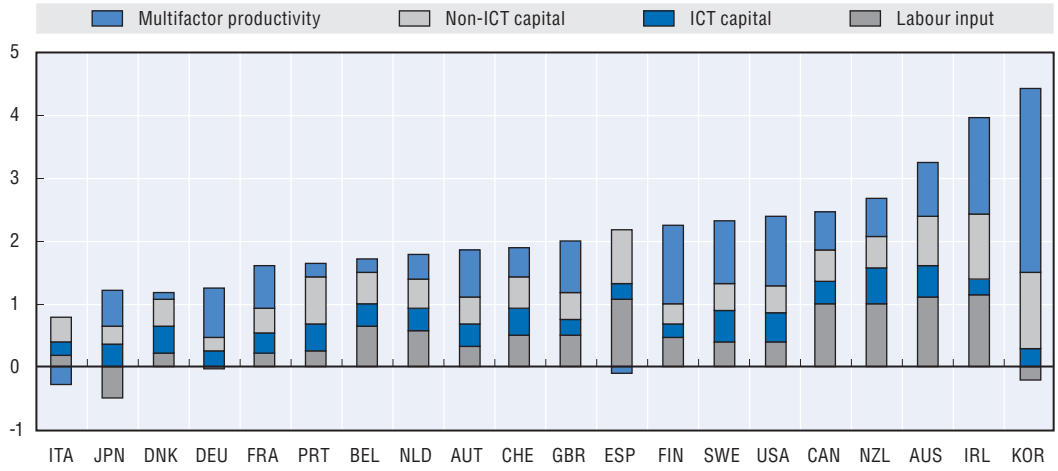
The production-function framework points to important elements in the analysis of innovation, but provides a rather static and linear perspective of innovation, ignoring its dynamic nature. As suggested by Schumpeter (1942), innovation is accompanied by creative destruction as new firms enter the market, sometimes growing quickly and thus increasing their market share, replacing other firms with low productivity that are in decline or that will eventually shut down. This dynamic feature of innovation, which involves upscaling and resource allocation (OECD, 2015b), is another important element of the link between innovation and economic growth, which also has specific implications for policy.

One approach to conceptualising and quantifying this dynamic contribution was developed by Andrews and Criscuolo (2013), who distinguished three stages in the innovation process. In the first, firms invest in innovation to develop new ideas or adapt new technologies; in the second, firms implement and commercialise these ideas; and in the third phase, they realise the benefits from innovation by changes in market shares and increased profitability. This third phase emphasises the dynamic benefits from innovation that occur through changes in market shares and the reallocation of resources from declining to growing firms. The analysis of such benefits helps to modify the static view of

innovation that emerges from the production-function framework. The policy implications of this more dynamic perspective of innovation will be discussed later in the report.

Figure 1.2. **Contributions to GDP growth**

Total economy, annual percentage point contribution, 1995-2013



Source: OECD (2015a), *OECD Compendium of Productivity Indicators 2015*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/pdtvy-2015-en*.

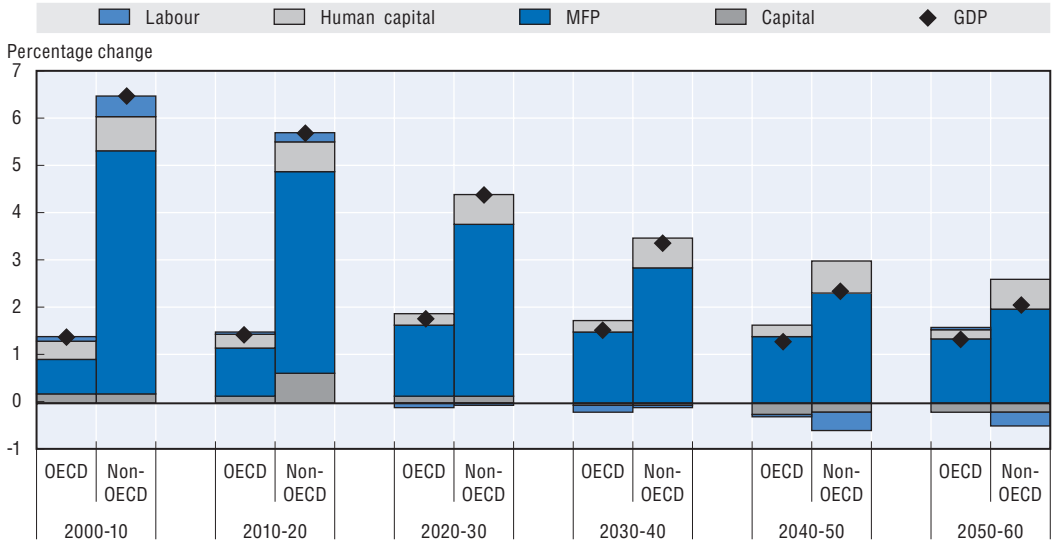
Together, the three elements included in the production-function framework, combined with the more dynamic perspective illustrated in Andrews and Criscuolo (2013), can account for a substantial share of economic growth, depending on the country, the level of economic development and the phase of the economic cycle. While not all elements can be fully attributed to innovation and there is likely to be some double counting, the different components of innovation together often account for at least 50% of economic growth.[3] Indeed, in the long run, it is difficult to imagine growth without innovation, as it would have to be based mostly on the accumulation of factor inputs, e.g. more labour (even if this might involve more qualified labour) or more of the same capital.

Studies of long-term economic development across countries show that MFP growth typically becomes a more important driver of growth in relative terms as countries exhaust some of the possibilities for productive investment in tangible capital. And much of the gap in income levels across countries is due to differences in MFP (OECD, 2015b). Moreover, in many OECD countries and some emerging economies, labour input has become less important as a factor of production over time, as the population has aged and the labour force has started to decline. For this reason alone, many OECD countries are increasingly emphasizing innovation-led productivity as the main source for future growth. OECD's long-term scenarios also emphasise the increasing importance of MFP growth for long-term economic growth (Figure 1.3) (Braconier, Nicoletti and Westmore, 2014).[4]

The conceptual links between innovation and economic growth set out above do not explicitly consider other important goals of public policy, such as the environment or well-being, that are also affected by innovation. However, recent OECD work has explored how to account for environmental impacts in the measurement of MFP growth (Brandt, Schreyer and Zipperer, 2014), as well as the role of environmental policy stringency on MFP (Albrizio et al., 2014). Another area of OECD work is seeking to move beyond GDP and address a broader range of measures of well-being (OECD, 2014a). The following sections discuss these issues in more detail.

Figure 1.3. **MFP as an increasingly important driver of future growth**

Contribution to growth in GDP per capita; 2000-60 (annual average)



Note: Non-OECD G20 countries are Argentina, Brazil, China, India, Indonesia, Russian Federation, Saudi Arabia and South Africa.

Source: Braconier, Nicoletti and Westmore (2014), "Policy challenges for the next 50 years".

Beyond growth: Accounting for the environment

A first conceptual broadening of the framework of analysis concerns the relationship between innovation and green (or sustainable) growth. The OECD's Green Growth Strategy (OECD, 2011) noted that existing production technology and consumer behaviour can be expected to produce positive outcomes only up to a certain point, or frontier, beyond which depleting natural capital has negative consequences for overall growth. By pushing the frontier outward, innovation can contribute to decoupling growth from natural capital depletion. Innovation and the related process of creative destruction will also lead to new ideas, new entrepreneurs and new business models, thus contributing to the establishment of new markets and eventually to the creation of new jobs. Innovation is therefore a key in enabling green and growth to go hand in hand.

A first important dimension of the relationship between innovation and green growth concerns the measurement of output and productivity and the implications this has for evaluating the trade-offs and synergies between innovation and green growth (Brandt, Schreyer and Zipperer, 2014). Productivity growth that results from the production-function framework in Figure 1.1 can easily be overestimated in countries where output growth relies to a large extent on the depletion of natural capital. This can lead to an overly optimistic assessment of economic potential and growth in the long run. A similar argument applies to countries that hold production costs down by relying on heavily polluting technologies. While this can generate additional output of goods and services in the short run, it also leads to higher external costs, which can impinge on well-being and the sustainability of economic development. Conversely, the economic performance and sustainability of an economy that invests in a more efficient use of the environment in production may be underestimated, as some inputs do not serve to increase the current production of goods and services. Instead, they are aimed at reducing the associated negative externalities, improving human health, or protecting the integrity of the environment and climate

stability. Therefore, when measuring productivity, it can be useful to consider as outputs not only the goods and services summarised in GDP but also the externalities, or "bad" outputs, such as air pollution and carbon dioxide (CO_2) emissions.[5]

Results presented in the paper by Brandt, Schreyer and Zipperer (2014) also suggest that considerable additional emissions reduction can be achieved at reasonable costs. The low elasticity of bad outputs presented imply that the reduction in GDP growth that would have to be accepted to achieve very considerable emissions reduction over the coming decades is limited, even in the absence of further improvements in environmental technologies. Conversely, the additional productivity growth that would be required to achieve the same emissions reduction without losses in output growth is not overly large. A combination of efficient and effective policies that price the externalities associated with bad outputs, and the promotion of R&D and new technology deployment with effective education policies, could help achieve the necessary technological progress that would allow countries to lower bad outputs without suffering income losses. Moreover, while green innovation may have some short-term implications for the (conventionally measured) rate of economic growth, these negative impacts should be outweighed by a large margin by the resulting long-term sustainability of the economy, as green innovation could contribute to avoiding the long-term impacts of diminishing environmental sinks such as potentially catastrophic climate change.

This being said, there are potential trade-offs and synergies between innovation and green growth. One key question is how a policy focus on green innovation through tighter environmental policies will affect the economy-wide rate of technological progress, as measured in the rate of MFP growth (Albrizio et al., 2014). On the one hand, proponents of the so-called Porter Hypothesis claim that environmental policies may improve incentives to innovate and lead firms to seek previously overseen efficiency improvements. On the other hand, policies that provide incentives to redirect innovation resources to reducing the cost of environmental impacts – which are not accounted for in a traditional productivity measure – may lead to an overall fall in measured productivity growth as fewer resources are channelled into "productive" innovation. Recent OECD work has tackled this question and has found that the tightening of environmental policies over the past two decades has had little effect on aggregate productivity growth (see below) (Albrizio et al., 2014).

Another argument sometimes made in favour of green innovation is that the potential spillovers arising from green innovation could well be larger than for other forms of innovation, precisely because the market is still underdeveloped and the potential for future innovation and growth may be very large. Overcoming the barriers to green innovation – such as the dominance of existing technologies and systems, a regulatory environment that may favour incumbents, or access to capital – could possibly lead to new waves of innovation comparable to those seen with other major technological revolutions. Advancing green innovation could also build on the growing interest in the private sector to use resources more efficiently. Unfortunately, this argument may be fully resolved only as green innovation expands over time and starts to have larger and more visible impacts on the economy and society.

Innovation and inclusive growth

In recent years, it has become increasingly clear that economic growth, as measured by GDP, can no longer be the overriding goal for government policy and can also not be an end in itself. Governments are increasingly focusing on inclusive growth, aiming to

Box 1.2. **Do environmental policies matter for productivity growth? Main findings**

Over the past two decades, environmental policy stringency, defined as the explicit and implicit, policy-induced price of environmental externalities, has increased significantly in the 24 OECD countries covered in new analysis. A newly developed composite indicator of environmental policy stringency, covering a range of market- and non-market-based policies, records increasingly stringent environmental policies in these 24 OECD countries, but with notable differences in stringency levels – overall, and across different policy instruments.

Countries tend to opt for similar main policy instruments but differ notably in the stringency of market- and non-market-based instruments. For example, the United Kingdom, Poland and Australia tend to show more relative stringency on market-based environmental policy instruments, e.g. environmental taxes or tradable permits. Finland, Germany and Austria tend to have relatively more stringent non-market-based policies, e.g. standards, while in the other OECD countries the relative stringency is more balanced.

There is no empirical evidence of permanent effects of environmental policy tightening on MFP, positive or negative. Analysis based on a new cross-country dataset with unprecedented time-series coverage finds that all effects tend to fade away within less than five years.

No lasting harm to productivity levels is found at the macroeconomic, industry or firm levels. On the contrary, a tightening of environmental policies is followed by a temporary increase in productivity growth, leading to an overall improvement in production efficiency for a large share of manufacturing industries.

At the macro level, the anticipation of an environmental policy tightening may also temporarily slow productivity growth – possibly due to increased investment in preparation for an expected policy change. Productivity levels subsequently rebound due to the temporary acceleration in growth rates.

The temporary effects on productivity growth are not conditional on the stringency of environmental policies already in place, but may depend on the flexibility of the environmental policy instruments. In particular, market-based instruments tend to have a more robust positive effect on productivity growth.

Advanced industries and firms generally see the largest gains in productivity levels, while less productive firms are likely to see negative effects. Highly productive firms, often the largest firms in the industry, may be best suited to profit rapidly from changing conditions – seizing new market opportunities, rapidly deploying new technologies or reaping previously overseen efficiency gains. They may also find it easier to outsource or relocate production abroad. Less advanced firms may need higher investments to comply with a new regulation, exhibiting a significant temporary fall in productivity growth.

Assuring a swift reallocation of capital and minimising barriers to entry are necessary for the efficiency gains from tightening environmental policy to be translated into economic growth. A non-negligible part of the productivity gains is likely to come from the exit of the least productive firms. To the extent that such developments are not due to increased regulatory burdens, and resources can be reallocated into fast-growing firms, they can have a positive effect on overall economic outcomes.

Designing environmental policy interventions so as to avoid generating barriers to entry and competition can help achieve both environmental and economic objectives. For example, OECD has recently measured to what extent environmental policy design unnecessarily increases fixed costs, imposes administrative burdens in permit and licensing procedures, results in the lack of coherent and consistent information, or distorts competition via vintage-differentiated regulations or tax and subsidy policies that are related to historical performance.

Cross-country evidence suggests that high barriers to entry and competition are not a necessary feature of stringent environmental policies. The new OECD indicator shows that stringent environmental policies can be pursued in a way that is more competition-friendly, with relatively low administrative burdens and little discrimination against new entrants. Countries where this has been the case include the Netherlands, Austria, Switzerland and possibly the United Kingdom. On the other hand, in Greece, Italy, Hungary and Israel environmental policies do not appear particularly stringent, but could benefit from lower distortions to entry and competition.

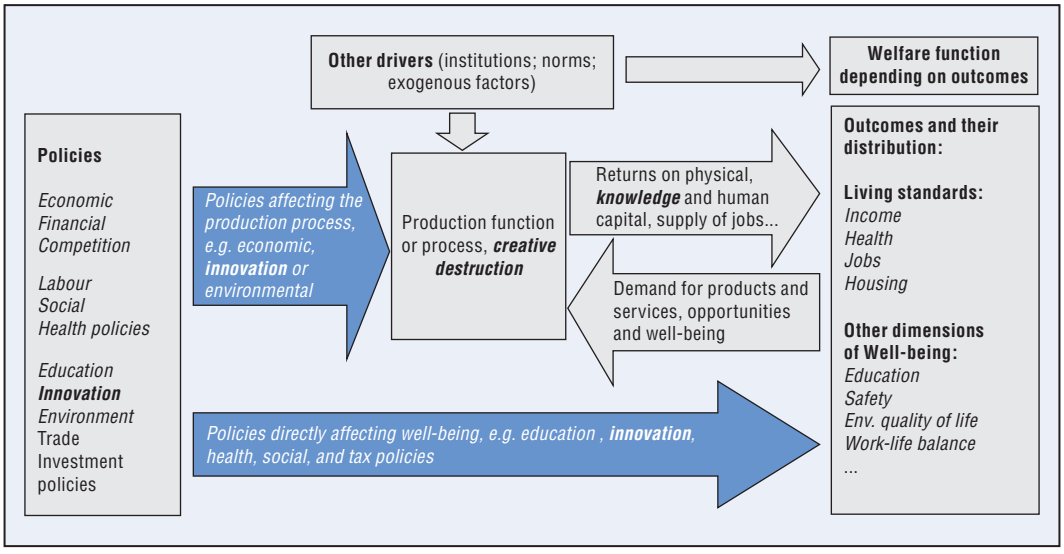
Source: Albrizio et al., 2014.

improve living standards and share the benefits of increased prosperity more evenly across social groups. This is particularly relevant in high-income countries and emerging market economies, where income inequality has reached levels unprecedented in the post-war period. Inequalities in other non-income outcomes, including educational attainment, health conditions and employment opportunities, are also increasingly recognised as influencing not only well-being, but also growth.

Innovation plays an important role in the debate on inclusive growth. The discussion below focuses on the three dimensions that are considered in the OECD's framework for inclusive growth (OECD, 2014a), namely income, jobs and health, although there are several other dimensions of inclusiveness that could also be affected by innovation, such as education. The OECD has recently developed a new framework for inclusive growth, which seeks to provide a clear link between individual dimensions of well-being and policies (OECD, 2014a).

A summary description of this framework is provided in Figure 1.4. The right-hand side of the diagram shows living standards and welfare as depending on both the level and the distribution of the key dimensions of well-being (e.g. income, health, jobs, education, security). The left-hand side of the diagram shows some of the policies potentially bearing on outcomes and their distribution. As the diagram indicates, there is a broad range of factors that mediate between policies and outcomes.

Figure 1.4. **OECD framework for policy analysis of inclusive growth**



Source: Adapted from OECD, 2014a, *All on Board: Making Inclusive Growth Happen*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/9789264218512-en*.

Innovation has been integrated into this framework in a number of ways. First, as discussed already above, innovation has a major impact on productivity growth through the production process, thus affecting the returns to human, physical and knowledge-based capital. It tends to increase aggregate **incomes**, which has a positive impact on living standards, but can also contribute to growing income inequality. This is partly because innovation inherently creates winners and losers in the process of creative destruction, with some firms and individuals benefiting through substantial returns to their invested labour and capital. Moreover, much technological change over the past decade has tended to be

skill-biased, favouring those with the highest skills, sometimes to the detriment of those with lower or medium-level skills. Digital technologies in particular allow small differences in skill, effort or quality to yield large differences in returns, in part by increasing the size of the market that can be served by a single person or firm. For instance, average income among writers of fiction may not have changed greatly in recent decades. But a small group of writers have become multimillionaires, facilitated by the fact that digitisation allows words, images and products to be readily transmitted worldwide.[6] Innovation-related increases in inequality may not always be a concern, however, provided that those at the bottom of the income distribution also see significant increases in incomes and well-being. For example, China's growth over the past few decades can be considered inclusive as millions of people were lifted out of poverty, even if this was accompanied by an increase in measured inequality.

Policy plays an important role in shaping the relationship between innovation and inclusive growth. Many of the existing policies aimed at stimulating innovation are not neutral in their impacts on the production process. For example, in many cases, innovation policies foster excellence and tend to promote the concentration of human, financial and knowledge resources in the strongest scientific institutions, firms and regions. This concentration does tend to foster growth, but has repercussions on the distribution of the outcomes of the innovation process across the economy. Innovation policies may sometimes also end up favouring incumbents, which can also have repercussions on the inclusiveness of innovation outcomes. Recent OECD work is considering whether innovation policies can become more inclusive, including in being more focused on the needs of the poorest in society (OECD, 2015c). Policy makers will need to carefully analyse the alternative options of making innovation itself more inclusive or allowing it to create inequality but then using redistributive policies to improve the well-being outcomes for all citizens. Section 7.2 of this report will explore the link between innovation and inclusive growth in more detail.

Second, as the impacts of innovation may be skill-biased, they may tend to reduce the **jobs** prospects for some categories of workers in the economy. For example, recent technological trends, in particular related to ICT, point to a large further potential for job displacement and creative destruction linked to ICT, potentially affecting certain skills groups. Whereas this may not lead to aggregate employment losses, the resulting structural change will require complementary policies, including effective skills, labour market and social policies. Skill-biased technological change is also contributing to a growing polarisation in the labour market, with some groups with skills that are complementary to technological change benefiting through higher wages and incomes, and others without the right skills being confronted with lower wages and fewer and often more precarious jobs. The impacts of this polarisation can also reduce the ability of certain groups in the population to participate in the economy, which can contribute to (often long-term) social exclusion.[7]

Innovation is a highly disruptive force, contributing to the process of creative destruction in the economy, and thus to job displacement and the reallocation of labour and capital within the economy. This process is not new, and in many economies, about 20% of the labour force changes jobs every year. Moreover, long-term trends suggest that innovation, productivity and job creation can go hand in hand. In recent years, however, innovation and the resulting creative destruction are sometimes considered to be among the trends that may have contributed to growing income inequality in many OECD countries. At the same time, the process of creative destruction may provide new opportunities for excluded

groups to be involved in the innovation process and to enhance incomes and create new job opportunities. For example, recent OECD work finds that most new job creation is due to young firms less than five years old (Criscuolo, Gal and Menon, 2014).

Third, innovation in **health** has been an important factor in improving well-being and living standards. Innovation has contributed to better care and improved diagnostics and treatments, including better medicines that have strongly contributed to increased longevity. Such innovations not only are technological, but also include social innovation, e.g. aimed at disease prevention and lifestyle changes. While these innovations have contributed to overall increases in well-being, challenges related to the access to innovations and their pricing remain, implying that some groups in society may benefit more than others. Section 7.3 of this report will explore some key dimensions of health innovation in further detail.

Innovation and the policies around it also affect other dimensions of well-being, including education and personal security. Sections 3.1 and 7.5 will include some discussion about the links between innovation and education. However, several of the interactions between innovation and inclusive growth are not yet fully understood and require further analysis.

It is also important to recognise that innovation is not always a positive force for change and can cause both harm and good. Governments therefore have a range of policies in place to manage the risks associated with innovation, e.g. in areas such as health and safety, but also related to the digital economy or financial markets. Risk management and risk governance related to innovation are therefore important in influencing the relationship between innovation and a wider set of determinants of well-being. The role of risk governance will be discussed in Chapter 8 of the report.

1.2. The rationale and role for policies for innovation

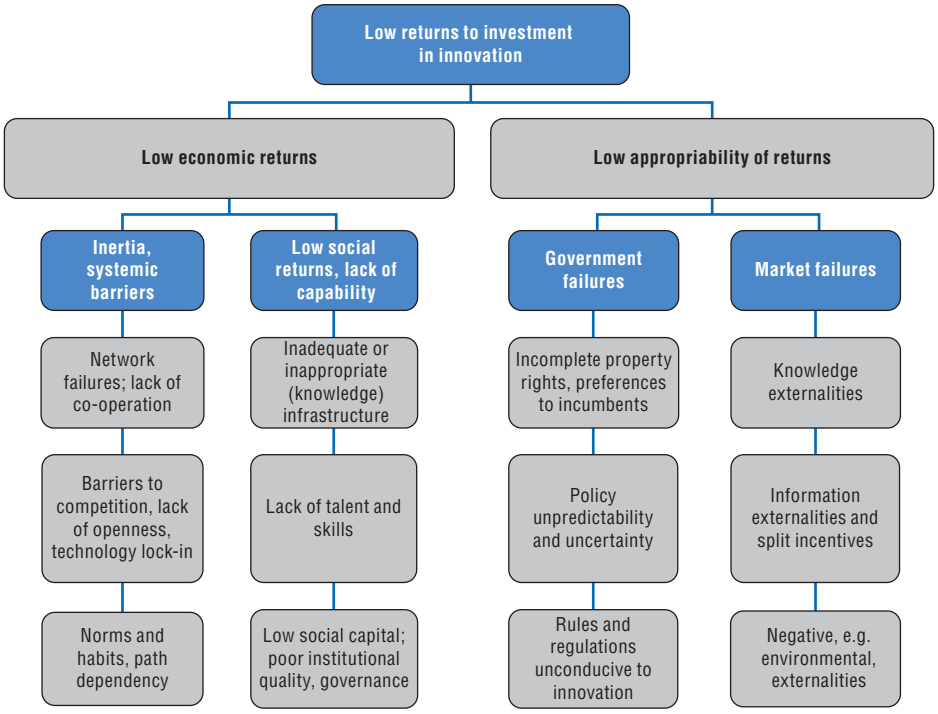
The rationale for innovation policies

There is extensive discussion among academics and policy makers on the rationale for innovation policies. The neo-classical perspective recognises only a limited set of market failures, such as externalities and information asymmetries. Other schools of thought point to a much wider range of factors and constraints that affect innovation and that can provide a rationale for policy, noting that these factors will vary from country to country and also depend on the particular area of innovation that is being considered, including the specific sector of the economy (BIS, 2014). Figure 1.5 presents a diagnostic framework for identifying the key constraints to innovation.[8] It characterises the constraints to innovation as factors that limit the returns to investment in innovation. These constraints can be divided into two categories:

- The first category refers to **low economic returns**, encapsulating factors that create inertia in economic systems (i.e. fundamental – systemic – barriers to change and innovation, e.g. linked to barriers to competition, lack of co-operation within an innovation system, prevailing norms and habits, as well as technology lock-in), and capacity constraints, or "low social returns", that are often linked to lack of skills or infrastructure, or inadequate institutions.
- The second category refers to **low appropriability of returns**. This is where market and government failures prevent firms or other innovation actors from capturing the full value of their investments in innovation, thus leading to underinvestment. Examples include

the externalities associated with investment in R&D, where a firm can never capture all the returns to its investments, due to the spillover effects associated with investment in knowledge. Another example concerns the negative externalities related to environmental damages. These damages are often not priced by the market, which adds to the difficulties faced by private investors to fully appropriate the returns from innovation.

Figure 1.5. **The potential rationale for innovation policies**



Source: Adapted from OECD (2011), *Towards Green Growth*, drawing on Hausmann, Velasco and Rodrik (2008), "Growth diagnostics".

Low economic returns due to inertia and systemic barriers can constrain the expansion of new or innovative production techniques, technologies or other forms of innovation. These constraints are often a mixture of market failures and market imperfections. For example, network effects (e.g. barriers to entry that arise from increasing returns to scale in networks) and the bias in the market towards existing technologies are examples of market imperfection. Addressing these barriers can involve a range of policies, including competition and regulatory policies, but may also require more active government intervention in the form of specific innovation policies, e.g. to overcome the lack of co-operation within an innovation system, or to overcome technology lock-in (OECD, 2015d).[9] However, government failures can arise from attempts to deal with these market failures or imperfections (e.g. governments may create regulatory barriers to competition, including in maintaining government monopolies in network industries). The policies that can help overcome these barriers are discussed in Chapters 4 (the business environment for innovation) and 6 (effective innovation policies).

"**Low social returns**" implies the absence of enabling conditions for productive investment in innovation. These constraints reduce the choices of firms and other actors to invest in innovation. For example, inadequate ICT infrastructure can limit the opportunities

for firms to benefit from the network effects associated with the technology. Other barriers include insufficient human capital that may imply that firms have insufficient know-how to deploy new technologies or to adjust to them through organisational change. Lack of social capital and the poor quality of institutions are other barriers that will affect the returns to investment in innovation. Addressing these barriers typically requires capacity building, based on a mix of public and private investments in infrastructure, education and skills, as well as institutions. Some of the policies that can help overcome these barriers are discussed in Chapter 3 (talent and skills), 5 (knowledge creation and diffusion) and 8 (governance and policy coherence).

Government failures that contribute to a low appropriability of returns can affect many areas of the innovation system. Figure 1.5 points to only some of them, e.g. the preference to incumbents that can sometimes characterise policy making related to innovation (discussed in Chapters 4 and 6); the lack of policy predictability and stability that often characterises innovation policies (discussed throughout the report); and regulatory barriers that affect innovation (discussed primarily in Chapters 4 and 6). Addressing government failures may also require reform – and innovation – within the public sector, which is discussed in Section 7.5 and also in Section 8.1 of this report.

Market failures provide the main neo-classical rationale for innovation policies, and lead to well-recognised areas of policy, such as government support for business R&D (e.g. through R&D tax credits or grants, discussed in Chapter 6); government investment in basic R&D and knowledge infrastructure (discussed in Chapter 5); or policies that address negative environmental externalities, e.g. through carbon taxes, thus supporting green innovation (discussed in Section 7.4).

The categories of constraints described in Figure 1.5 are not entirely separable. There are, for example, some overlaps between market and government failures. Incomplete property rights are in many cases a market failure but are listed as a government failure as they may result from inadequate policies, e.g. in the case of an inadequate system of intellectual property rights. Similarly, the presence of regulatory uncertainty is an important impediment to private investment in many areas of innovation, such as green growth or health, even though some of these areas are also affected by market failures.

The importance of constraints to innovation will vary according to level of development, socio-economic context, and existing economic and environmental policy settings. Low human capital, inadequate infrastructure and poor institutional quality will often tend to be associated with lower levels of economic development (though not exclusively). Rectifying these constraints will be of high priority and perhaps a precondition to resolving many other constraints.

Where human capital is relatively abundant and infrastructure relatively well supplied, the focus often first shifts to resolving government and market failures. However, for innovation to have impact, attention also needs to be paid to some of the disadvantages that new firms and technologies may have relative to incumbents and existing technologies and policies that can help advance these.[10] Sequencing of reforms may be important in this context, in particular in areas where market failures are important, e.g. environmental innovation. Improving the returns to activities with low environmental impact, e.g. through carbon taxes, can help create market conditions that are conducive to the introduction of new green technologies.

Identifying which constraints are most important is not, however, entirely sequential. In particular, when institutions in some countries are not well equipped to address the prevailing barriers to innovation in a country, government failures or split incentives may need to be addressed. One constraint that is likely to be common to all countries, regardless of development, is regulatory certainty, i.e. the extent to which governments articulate and ideally legislate a clear plan for closing the gaps between private and social returns so that firms and other actors in the innovation system can plan and act without too much risk that governments will change the rules of the game. Due to the long-term character of investments in innovation, this is an important challenge for policies related to innovation, which will be further discussed in Chapter 8.

The diagnosis of key constraints will require country-specific information and data from across the economy as well as an understanding of the position and performance of a country in the global context. The OECD's indicators on innovation mentioned throughout this report provide some of the high-level measures that can be used to inform a diagnosis of constraints to innovation, as can the OECD analysis of structural policy settings, including in the area of innovation policy.

Moreover, as was already noted above, while there are many common barriers to innovation across the economy, other barriers are specific to sectors or to particular challenges (BIS, 2014), which implies they may need to be tackled through more tailored policy actions. For example, government policies to address complex societal problems, such as the development of smart cities, will need to look at the full range of system-wide barriers that affect the challenge (OECD, 2015d), with government taking an active role in supporting and managing the transition to a more sustainable system.

A further note to Figure 1.5 concerns the global context for innovation and for policy making related to innovation. As will be discussed further in Chapter 2, innovation is a global undertaking, with most innovation taking place outside national borders. The global context will affect the scope for national policy making, e.g. in attracting talent and skills, but will also provide important opportunities for governments to benefit from innovation abroad.

Finally, and crucially, while there are many barriers and obstacles to innovation, and there are many reasons governments may wish to take action to strengthen innovation, policy makers will always need to consider carefully whether they have the tools and understanding of innovation in their economy to take effective and efficient government action. This also involves a consideration of alternative policy actions where governments can best add value, and consideration of how governments can engage with other actors and encourage them to take action. Implementation is a key constraint for innovation policy, and requires an efficient and well-developed institutional framework, strong capabilities for evaluation and monitoring, and an efficient and capable government bureaucracy. This issue will be further discussed in Chapter 8 of this report.

The role of policy

Based on the conceptual thinking set out above to link innovation to key objectives of policy and the discussion on the rationale for policy making, the next question is which policies affect the various contributing factors and how government can shape and possibly strengthen the contribution that innovation makes to performance. This is the set of policies that governments need to consider when establishing policies for innovation. Obviously, this set of policies is much broader than the policies that are

often seen as innovation policies in a narrow sense – policies to support business R&D, financing for risk capital, etc. These make up only a part – though an important one – of the full set of policies that affect innovation performance. Moreover, governments will need to consider how innovation and innovation policies affect other public objectives, and the complementary policies that need to be put in place to ensure that the overall goals of policy are being met, e.g. in regard to growth, jobs and income distribution, and to health and the environment.

So what are the policies that determine the contribution of innovation to economic growth? OECD analysis suggests that innovation thrives in an environment characterised by the following features, all of which will be explored further in later parts of this report:

- A **skilled workforce** that has the knowledge and skills to generate new ideas and technologies, to bring them to the market, and to adapt to technological changes across society. Reforms to education and training systems, and to skills policies more broadly, are therefore of utmost importance to innovation. They include policies aimed at science, technology, engineering and mathematics (STEM) graduates, but should go beyond this group and cover a wider set of skills. Moreover, the international mobility of talent plays an increasingly important role in meeting emerging skills needs. These policies are discussed in Chapter 3 of this report.
- A sound **business environment** that encourages investment in technology and in KBC, that also enables innovative firms to experiment with new ideas, technologies and business models, and that helps them to grow, increase their market share and reach scale. A range of empirical analysis on these issues has shown that innovation performance can be strengthened by structural reform – to product markets, encouraging competition and enabling new entry; to labour markets, enabling better resource allocation; and to financial markets, helping generate funding for risky investments. Regulatory reform is important, too, and should enable rather than stifle innovation. Openness to foreign sources of knowledge is also important for innovation, as most innovation happens outside national borders, and requires reforms to enhance the openness of an economy to trade, investment, knowledge flows and people. These policies are discussed in Chapter 4.
- A **strong and efficient system for knowledge creation and diffusion** that engages in the systematic pursuit of fundamental knowledge, and that diffuses this knowledge throughout society through a range of mechanisms, including human resources, technology transfer and the establishment of knowledge markets. Strong and well-governed universities and public research institutes and mechanisms that support and facilitate the interaction among knowledge institutions and economy and society are therefore important to strengthen innovation performance. So is investment in knowledge infrastructure, notably broadband and other digital networks that are critical tools to enable co-operation and provide new platforms for innovation to occur. Moreover, as knowledge creation and innovation are global endeavours, policies to better connect science and innovation activities around the world are crucial to the innovation policy agenda. These policies are discussed in Chapter 5.
- **Policies that encourage firms to engage in innovation and entrepreneurial activity.** More targeted innovation policies are often needed to tackle a range of barriers to innovation. The appropriate policy mix might include tax incentives for investment in R&D; direct public support through grants, subsidies and innovation competitions; and policies to facilitate

co-operation and networking, but also indirect incentives through public procurement and other so-called demand-side policies. Such policies can help to strengthen markets for innovation, and help focus it on specific challenges and opportunities, e.g. green growth. Many of these actions include policies at the regional or local level. Moreover, well-informed, dynamic engaged and skills consumers are important for innovation, and their role in innovation can be enabled by specific consumer policies. These policies are discussed in Chapter 6.

The precise application of the various policies for innovation set out in Chapters 3 to 6 will differ according to the national context. It may also be affected by the sector or technology concerned, and by the specific objectives of innovation. Chapter 7 will look at several aspects of the application of policies for innovation, in discussing the national agenda for innovation (Section 7.1); the role of innovation for inclusive growth (Section 7.2), including health innovation (Section 7.3); as well as innovation in the green growth agenda (Section 7.4). Particular attention will also be paid to innovation in the public sector (Section 7.5), which is important to improve effectiveness and efficiency within the public sector, but which can also help support innovation throughout the economy.

Chapter 8 of this report will focus on the governance and implementation of policies for innovation. Given the wide range of policies that affect innovation, it is important to ensure that the full set of government policies that affect innovation are well aligned, not only at the level of central government, but also between the central government and regional and local authorities, many of which are actively involved in innovation activities. The development and implementation of innovation policies also requires strong capabilities within the public sector, including in building trust in government action and ensuring the support of stakeholders for policy actions.

Establishing a national strategy for innovation is one thing; its implementation is often another matter. The framing of policies for innovation needs to recognise that they operate in a complex, dynamic and uncertain environment, where government action will not always get it right. A commitment to monitoring and evaluation of policies, and on learning from experience and adjusting policies over time, can help ensure that government action is efficient and reaches its objectives with the least possible cost. Moreover, the implementation of policies rests on an efficient and well-developed institutional framework, strong capabilities for evaluation and monitoring, and an efficient and capable government bureaucracy.

Finally, it is important to recognise that policies for innovation are part of a broader policy agenda that seeks to support a range of public policy objectives. In some cases, strengthening innovation may support these other objectives, e.g. in regard to growth, while in other cases, it may have some negative repercussions on specific objectives that may need to be addressed through complementary policies, e.g. to ensure that the gains of innovation are widely spread, or to address specific challenges that may come with strong innovation, such as harmful applications of specific technologies. Managing these risks and addressing them where needed is therefore also a key challenge for policies for innovation. This will also be considered in Chapter 8.

Before going into this more detailed discussion of policies for innovation, Chapter 2 briefly explores the landscape for innovation today.

Notes

1. R.M. Solow (1987).
2. Another factor is related to innovation in the way society uses its natural capital and produces undesirable outputs. This is further discussed below.
3. ICT capital and MFP growth combined account for over half of GDP growth in Figure 1.2. While MFP growth includes factors other than innovation, Figure 1.2 excludes most investment in KBC – software investment is included in the contribution of ICT capital – as well as the dynamic impacts of innovation on growth and productivity.
4. A recent OECD study (OECD, 2015b) provides a comprehensive assessment of the future of productivity growth and the various policy levers, including those related to innovation, that governments have at their disposal to strengthen innovation performance.
5. For example, recent OECD work (OECD, 2014b) suggests that the cost to society of air pollution is much larger than previously thought. Cost to society, in terms of willingness to pay to avoid the related mortalities and bad health, of outdoor air pollution in OECD countries in 2010 amounted to approximately USD 1.7 trillion. For China alone, the cost was estimated at USD 1.3 trillion, and for India, USD 0.5 trillion.
6. This "winner takes all" phenomenon is also mirrored in a widening of the distribution of profits across firms, particularly in sectors where firms invest heavily in ICT.
7. The impacts of innovation on employment also become apparent from the OECD's work on green growth (OECD, 2012). For example, this shows that shifting to a low-carbon economy will have different employment impacts across countries, with countries with highly polluting industries and rigid labour markets being more negatively impacted than countries with flexible labour markets that are able to become global green technology leaders. Overall labour market reallocation is expected to be modest with little impact on overall levels of job and skill demands.
8. This framework was already used in the context of the OECD's Green Growth Strategy and was slightly adapted to the context of innovation policies (see OECD, 2011, Annex 1).
9. OECD (2015d) discusses the barriers to system-wide innovation, where policy is aiming to solve complex societal problems, e.g. in areas such as smart cities, sustainable building, transport or healthy ageing.
10. The nature of this disadvantage will vary according to existing regulatory environments. In some cases, the regulatory environment will be such that incumbent firms enjoy an advantage over new entrants. In other cases the lack of a supporting network may prevent deployment of innovative technologies.

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