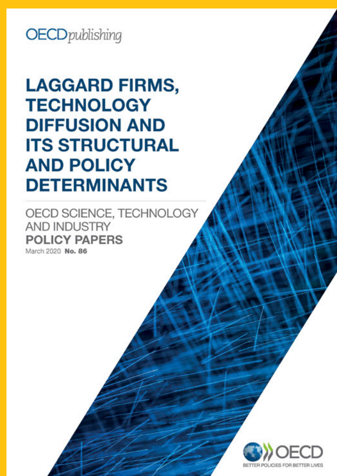
Laggard firms and technology diffusion

New technologies are transforming modern societies, affecting the way people interact, work and consume, and redefining how firms produce and compete. According to techno-optimists, the rapid pace of innovation should translate into improvements in economic performance. Yet this vision contrasts with a set of economic trends observed over the last two decades. Aggregate productivity growth has stagnated, productivity gaps and wage inequalities have widened between firms, industries are increasingly concentrated, and business dynamism has declined. This apparent discrepancy between the expectations of a brighter future and the evidence of a somewhat gloomy present can be better understood through the lens of micro data, which show that the great heterogeneity of firm performance is at the centre of the puzzle.

To better understand this heterogeneity, a recent OECD study investigates the characteristics of the least productive firms – the so-called "laggards" (Berlingieri et al., 2020) – and reveals their potential for productivity growth. The study stresses how challenges related to the process of technology and knowledge diffusion undermine laggards' ability to catch up, and even more so in a business environment where digital technologies and intangibles are increasingly important. It shows that a lack of incentives and capabilities to adopt transformative technologies slows down the diffusion towards laggards and contributes to the polarisation of the economy. The report also recommends policies that can revive the "diffusion machine" and thereby boost aggregate productivity growth in a way that benefits all.

The quick read



Berlingieri et al. (2020) explore the characteristics and the growth potential of "laggards", defined as the least 40% productive firms within a country and sector, in a given year.

Laggards are on average younger and smaller, but these average characteristics hide a variety of situations, ranging from firms at the end of their life-cycle that need either to adapt or exit the market (e.g. "zombie" firms), to those at the early stages of their life-cycle that may still be experimenting with their business model (e.g. start-ups).

Overall, laggards benefit from a "catch-up effect" driven by technology and knowledge diffusion: firms further behind the frontier enjoy higher productivity growth with respect to others. This mechanism is key to transforming innovation among leading firms into widespread productivity growth. However, catch-up is slower in digital- and skill-intensive industries, suggesting that hurdles associated with the rising importance of digital technologies and intangibles are weakening diffusion mechanisms, thereby possibly undermining aggregate productivity growth.

The transition to a digital and knowledge economy is ongoing, and some firms lack both the incentives and capabilities to keep up with and benefit from technological progress. To accelerate diffusion and revive aggregate productivity growth, policies should focus on: i) raising awareness about new technologies, their use and benefits; ii) developing firms' absorptive and investment capacity; iii) providing incentives to adopt new technologies and reducing risks and uncertainty; iv) fostering research and knowledge sharing; and v) enabling firms to experiment and bring innovations to the market.

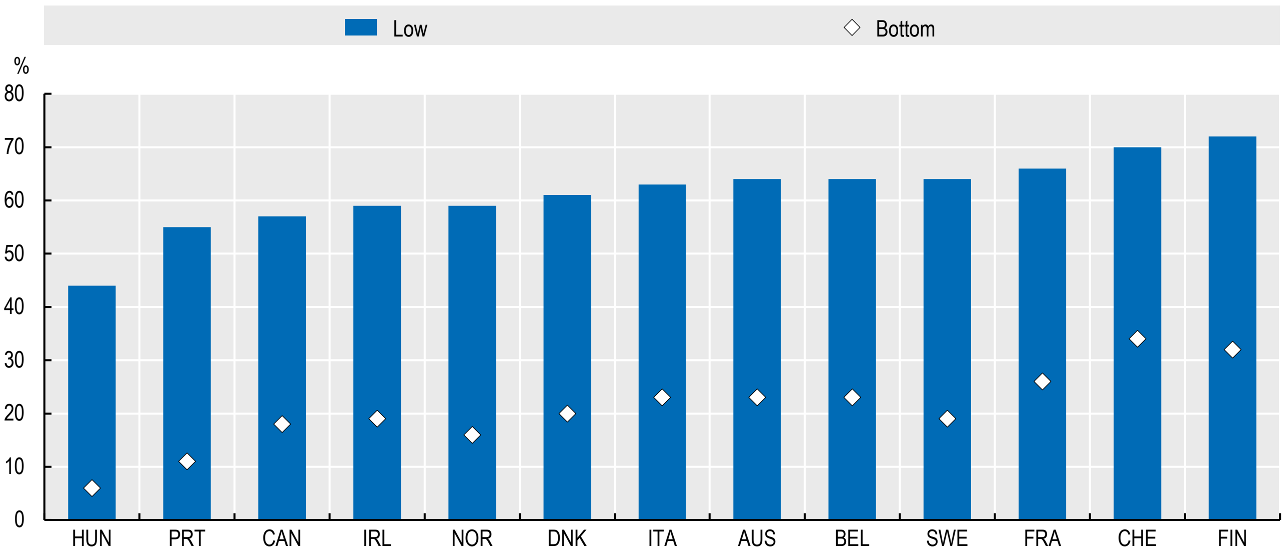
Laggards: a heterogeneous group with a potential for growth

It is well established that firms display heterogeneous levels of productivity and grow at a different pace, even within narrowly defined industries. Recent research (Andrews, Criscuolo and Gal, 2016) further reveals that the gap between frontier firms – "the best" – and the rest is widening, and documents the characteristics of firms that make it to the top. Berlingieri et al. (2020) use novel data from the OECD MultiProd project (see Box below) to focus on the other side of the coin, i.e. firms at the bottom of the productivity distribution, the so-called "laggards".

In this study, laggards are defined as the least 40% productive firms within a country and sector in a given year, and are further divided into two groups, namely the bottom (10% least productive firms) and the low productivity firms (firms with productivity levels comprised between the 10th and the 40th percentile). Focusing on the size of the productivity gap across the 13 countries considered, the study finds that firms in the bottom productivity group display average productivity levels that are 20% of the average productivity of firms in the median group (proxied by the productivity of firms with a productivity level comprised between the 40th and the 60th percentile). Firms in the low productivity group exhibit instead a productivity level which is around 60% that of the median firm, with some heterogeneity across countries (Figure 1).

Figure 1. Bottom and low productivity firms are on average 20% and 60% as productive as the median firm

Labour productivity of laggards relative to the median firms



Notes: The figure plots, for each country, the (employment weighted) average labour productivity (LP) in different groups of the productivity distribution with respect to the median firms (40th to 60th percentile of LP distribution). Laggards are split into two groups: the bottom (1st to 10th percentile of LP distribution), and low productivity group (10th to 40th percentile of LP distribution), and then compared to the median firms. Only manufacturing and non-financial market services are depicted.

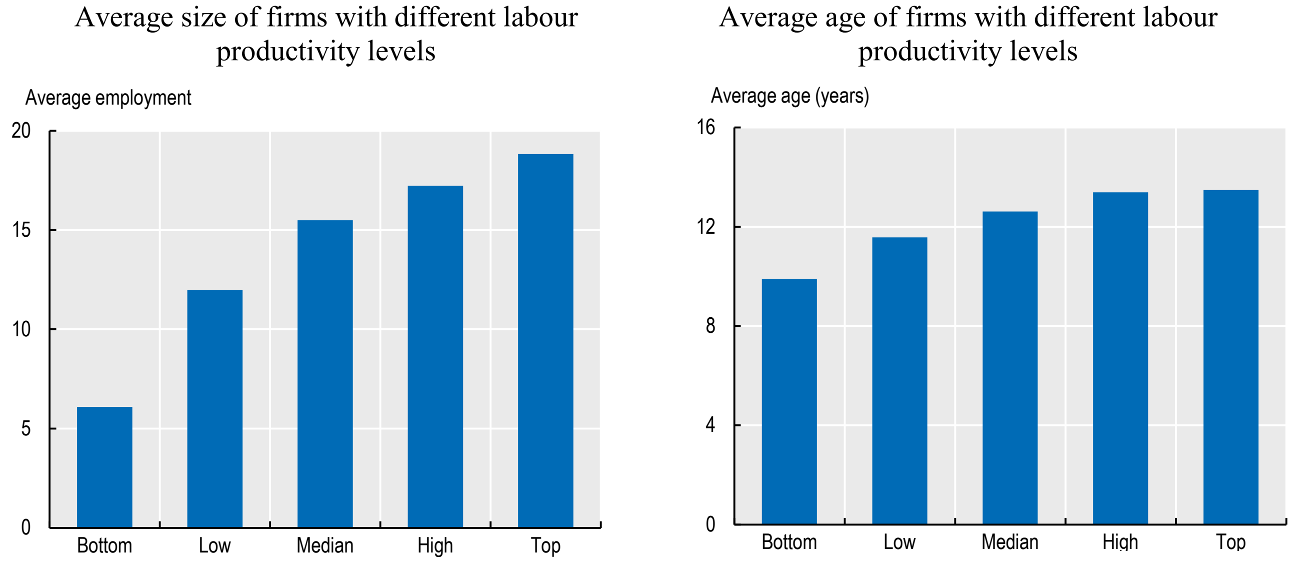
Source: Berlingieri et al. (2020), "Laggard firms, technology diffusion and its structural and policy determinants", https://doi.org/10.1787/281bd7a9-en.

Unveiling the characteristics of laggards provides a better understanding of the large productivity gaps between laggards and other forms. Comparing the average size and age across firms with different productivity levels (Figure 2) shows that laggards are smaller and younger than the median firm. Median firms are on average 2.5 times bigger than the bottom ones, and 1.3 times bigger than low productivity ones. Moreover, laggards are on average two years younger.

These findings suggest that the relatively weak performance of laggards reflects a variety of situations. Some laggards are low productivity firms that would typically exit in a competitive market. Others, generally in the early stage of their life cycle, are in a process of (potentially successful) experimentation. Some laggards are also firms that have less ambitious growth strategies (as may be the case for some local or family businesses), while others are simply facing temporary adverse conditions. To some extent, the characteristics of laggards are related to business dynamics, since firms generally enter with a relatively low level of productivity, experiment, and either exit or scale-up, while older firms may downscale and exit if they fail to innovate or adapt to a changing environment.

High productivity gaps between laggards and median firms may therefore reflect the entry of new firms with a high potential for growth, or low exit and lack of reallocation, as well as slow productivity improvements resulting from a lack of diffusion. The main policy challenges thus relate to the economy's ability to maintain the productivity enhancing process of reallocation through entry, growth and exit, as well as the ability of (surviving) laggards to improve their productivity over time and catch up with more productive firms.

Figure 2. Laggards are on average smaller and younger



Notes: The left panel plots the average (employment) size in different groups of the productivity distribution, and the right panel plots the average age in the different groups. Five groups of the LP distribution are considered: the bottom, the low productivity firms, the median firms, the high productivity firms and the top (corresponding respectively to 1st to 10th, 10th to 40th, 40th to 60th, 60th to 90th, and 90th to 100th percentiles of the productivity distribution). The left panel is based on 13 countries (AUS, BEL, CAN, CHE, DNK, FIN, FRA, HUN, IRL, ITA, NOR, PRT, SWE) and the right panel is based on 7 countries (BEL, DNK, FRA, IRL, ITA, NOR, SWE). Only manufacturing and non-financial market services are depicted.

Source: Berlingieri et al. (2020), "Laggard firms, technology diffusion and its structural and policy determinants", https://doi.org/10.1787/281bd7a9-en.

Neo-Schumpeterian growth models predict that firms lagging behind grow faster by learning from the best. As a matter of fact, laggards have substantial scope for improving their productivity by drawing from a large, existing stock of knowledge, and by adopting technologies and implementing practices that have proven fruitful at the frontier. This technology and knowledge diffusion process is a key driver of productivity growth. The study follows the evolution of laggards' productivity, and confirms that, on average, they enjoy higher productivity growth than other firms. It finds a positive correlation between a firm's productivity growth and its distance from the national (productivity) frontier. In other words, laggard firms – and especially younger ones – benefit from a catch-up effect, confirming that technology and knowledge diffusion is a robust source of productivity growth for laggards.

MultiProd: a dataset to study laggard firms

MultiProd is an OECD project designed to study a wide range of topics related to productivity and wage dynamics, as well as market power and market structure, and to investigate the extent to which different policy frameworks can shape observed macro-trends. The data infrastructure built within the project extends the analyses beyond aggregate performance, and focuses on the underlying dynamics across different groups of firms (e.g. in different sectors, age and size groups, or with different levels of productivity). It is therefore particularly well suited to the analysis of laggard firms.

The project relies on the use of confidential (longitudinal) firm-level data to produce relevant statistics in a harmonised way across a large number of countries, following the same *distributed microdata approach* used in the OECD DynEmp and MicroBeRD projects. In addition, MultiProd combines data sources, such as administrative data, production surveys and business registers, to compute statistics that are as representative as possible of the whole population of firms.

In order to guarantee comparability across firms in different productivity groups and across macro-sectors, the sample in the analysis of laggards is further restricted to 13 countries (Australia, Belgium, Canada, Denmark, Finland, France, Hungary, Ireland, Italy, Norway, Portugal, Sweden and Switzerland) for which the underlying firm-level data cover both manufacturing and non-financial market services, and do not impose any threshold for including firms in the sampling frame. This guarantees that data are representative of the whole productivity distribution, including the least productive firms. The analysis covers the period 1995-2014, depending on country-specific data availability.

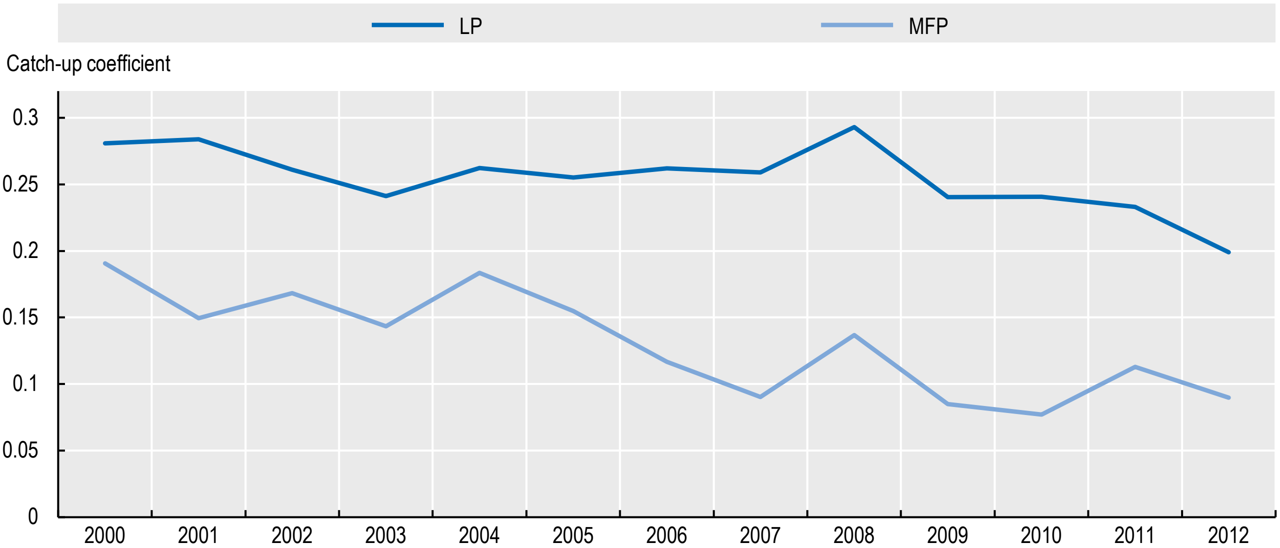
The data allow distinguishing different groups of firms depending on their relative position in the productivity distribution, using the statistics concept of percentiles. Firms are thus split into five productivity performance groups, i.e. five groups of the productivity (either labour or multifactor productivity) distribution: the bottom, the low productivity firms, the median firms, the high productivity firms and the top (corresponding respectively to 1st to 10th, 10th to 40th, 40th to 60th, 60th to 90th, and 90th to 100th percentiles of the productivity distribution). The group of "laggards" comprises firms belonging to the first two groups, i.e. either the bottom or the low productivity firms.

For additional information on MultiProd and related analyses, see: https://www.oecd.org/sti/ind/multiprod.

The transition to a digital- and knowledge-based economy challenges technology diffusion

In line with existing literature (Andrews, Criscuolo and Gal, 2016; Akcigit and Ates, forthcoming), the paper finds that although laggards catch up with the frontier, their speed of catch-up has decreased over time (Figure 3). This implies that dynamism and innovation at the top still translate into productivity growth at the bottom, albeit at a slower pace than in the past.

Figure 3. Technology and knowledge diffuse to laggards at a declining speed



Notes: LP = labour productivity; MFP = multi-factor productivity. The figure represents the estimates for the catch-up effect over time. It plots coefficients from a regression of productivity growth on the productivity gap interacted with year dummies, including country-year and industry fixed effects. The countries included are: AUS, BEL, CAN, CHE, DNK, FIN, FRA, HUN, IRL, ITA, NOR, PRT, SWE. Only manufacturing and non-financial market services are depicted.

Source: Berlingieri et al. (2020), "Laggard firms, technology diffusion and its structural and policy determinants", https://doi.org/10.1787/281bd7a9-en.

Berlingieri et al. (2020) provide evidence that this slowdown in diffusion is related to firms' unequal adjustments to the rising importance of digital technologies and intangible assets, such as innovative properties (e.g. scientific research and development [R&D]), software and databases, or competencies (e.g. digital skills). More specifically, the study reveals that the positive link between productivity growth and the distance to the frontier – a measure of the speed of technology diffusion – is lower in digital- and knowledge-intensive industries. Sectors that display lower average catch-up rates require relatively more investments in information and communication technology (ICT) equipment, software and database, rely more on ICT-related inputs, and depend more heavily on a skilled workforce capable of performing ICT-related tasks. In these industries, productivity gaps of laggards are higher than in other industries and their catch-up is slower, suggesting that they face hurdles that prevent them from benefiting from rapid technological progress.

Fundamentally, the study shows that technology and knowledge do not flow automatically and effortlessly from the frontier to laggards. Moreover, the transition to a digital- and knowledge-based economy may have reinforced barriers to a broad and rapid diffusion. The rising importance of intangibles and digital technologies has transformed the set of capabilities and assets required to adopt and harness the new technologies that help today's firms thrive. It has also reshaped incentives, as market structures have shifted and only a few winners may receive the lion's share of benefits associated with successful adoption.

These additional hurdles to diffusion seem grounded in the nature of intangible assets and digital technologies. Investments in intangible assets are generally characterised by high upfront costs, high risks and uncertainties, and higher financial constraints. Intangible assets and digital technologies also benefit from synergies and complementarities. On the one hand, the possibility to exploit these synergies and complementarities increases the productivity gains that can be expected; on the other hand, it requires co-investment in complementary assets (Brynjolfsson, Rock and Syverson, 2017). At the same time, intangibles are scalable and may favour network effects, thus potentially leading to "winner-takes-most" dynamics that may act as additional barriers to adoption for laggards. In a nutshell, in a technology- and knowledge-based economy, it has become increasingly difficult to build the right mix of digital technologies, software and databases, innovative properties, and economic competencies to compete in the market. Thus, the huge economic potential of digital and intangible assets goes hand in hand with additional barriers to harnessing the ongoing transformation.

These obstacles are also shaped by the framework conditions and policy environment directly affecting firms' capabilities and incentives to adopt new technologies.

A multi-faceted policy framework to support diffusion and boost productivity growth

Policies aimed at stimulating diffusion and productivity growth should generally aim at increasing firms' capabilities to adopt relevant technologies, ensuring that incentives align with the potential benefits from adoption and innovation, and strengthening market selection and resource reallocation. The study finds that policies aimed at improving workers' skills, alleviating financial constraints to investments and directly supporting R&D can help laggard firms to catch up, especially in sectors where diffusion is slower, as they enhance firm's capabilities and incentives to adopt new technologies.

More generally, these objectives can be achieved through a multi-pronged policy approach aimed at targeting both potential adopters of new technologies – i.e. focused on the demand for technology and knowledge – and their providers – i.e. focused on the supply of technology, knowledge and innovation (see Table 1 for a summary).

Demand-side policies affecting adoption, selection and reallocation

First, policies can foster diffusion by expanding the set of information available to potential adopters. Raising awareness about existing technologies, their potential benefits and how to use them efficiently can go a long way towards boosting adoption, especially among young and small firms that may lack information to identify which technologies are best suited for their needs. Policies may raise firms' awareness directly through dedicated instruments, such as the development of on-line platforms and virtual maps that encourage information sharing, or through business advisory support to identify tailored solutions, especially for small- and medium-sized enterprises (SMEs) and new businesses. Policies favouring knowledge spillovers can also raise awareness about relevant technologies and their benefits. Encouraging collaboration, creating networks, sustaining labour mobility and reallocation, and supporting trade and global value chain (GVC participation may help the least productive firms connect with the frontier and benefit from knowledge spillovers and technology transfers.

Second, demand-side policies could ensure that firms, and laggards in particular, have the capability to adopt relevant technologies. This requires developing their investment capacity and their absorptive capacity, i.e. the potential to successfully use technologies for the production of goods and services. Tacit knowledge that facilitates adoption can be acquired through firms' own R&D and supported through various instruments such as direct funding of

R&D (grants, subsidies or procurements), which can be particularly beneficial to laggards. A more targeted accumulation of human capital can also be encouraged through training and education policies increasing the supply of experts and talent in key areas (e.g. artificial intelligence), but also by diffusing widely the basic competencies necessary for the adoption of general purpose technologies (e.g. basic digital skills). Easy and affordable access to appropriate ICT infrastructures (e.g. high-speed broadband) and complementary inputs (e.g. data, software) is yet another pre-condition for firms to adopt and use digital technologies. When firms have the capacity to absorb transformative technologies, policies should also ensure that financial constraints are not holding back such promising investments. Co-funding of large-scale investment projects, "innovation vouchers" (small non-repayable grants to SMEs to help them implement small-scale projects), or loan guarantees for selected firms provide different instruments to support projects of various size, and alleviate financial constraints possibly weighing on laggards.

Table 1. Summary and classification of policies to foster technology and knowledge diffusion

	Objectives	Policy areas
Demand-side policies focused on potential adopters	Raise awareness about new technologies, their use and benefits	Awareness raising schemes Collaboration and networks Labour mobility Trade and GVC participation
	Develop firms' absorptive and investment capacity	Education system Training policies (especially for low-skilled) Financial support R&D support ICT infrastructures Data access
	Favour a positive return to adoption, reduce risks and uncertainties, strengthen selection and facilitate reallocation	Competition policies Entrepreneurship policies Insolvency regimes Technical standard-setting Addressing market failures (networks effects, technological lock-in)
Supply-side policies focused on potential innovators	Foster production and sharing of knowledge	Public research Science-industry linkages Collaboration Open innovation Comprehensive strategies for the development of general-purpose technologies
	Enable firms to experiment and bring innovations to the market	R&D support Entrepreneurship policies Financial support Intellectual-property systems ICT infrastructures Data access Test beds and regulatory sandboxes Open innovation

Source: Berlingieri et al. (2020), "Laggard firms, technology diffusion and its structural and policy determinants", https://doi.org/10.1787/281bd7a9-en.

Finally, demand-side policies can encourage the uptake of new technologies through framework conditions that help ensure a positive return to adoption, reduce the associated risks and uncertainty, strengthen selection, and facilitate resource reallocation. The profitability and risks of adoption are related to both firms' characteristics (e.g. size, market shares) and market features, such as contestability. The increasing returns to scale associated with the simultaneous high fixed costs and low marginal costs characterising intangible assets imply that firms must be able to obtain resources, compete in the market, scale up rapidly and gain market shares to recoup their investment. Removing barriers to trade and investment, addressing the regulatory protection of incumbents, adapting the employment protection legislation, and lifting barriers to entrepreneurship could contribute to a more dynamic and competitive environment where successful adoption is more likely to be rewarded with higher profits. Conversely, the legal and institutional framework should not discourage firms engaging in investments that may go wrong, and should favour selection through the exit of unsuccessful firms so that resources can be reallocated to firms with growth potential. Indeed, evidence shows that insolvency regimes that do not sanction business failure too severely, as well as efficient judicial systems, are likely to encourage risk taking and promote efficient resource allocation. Other instruments, such as technical standard-setting, may also directly reduce the risk related to adoption.

Supply-side policies affecting innovation

A continuous process of follow-up innovations that help make technological breakthrough more widely applicable and affordable is necessary to bring radical innovations to the market, and to diffuse them beyond the frontier. Policies that establish and support a dynamic network of innovators are therefore also required to support broad-based diffusion.

Encouraging different types of research and promoting collaboration to increase knowledge flows help increase the technological impact of innovations and reduce the time it takes for these innovations to be re-used in follow-up inventions. Incremental innovations diffuse more rapidly but have a lower technological impact, whereas science-based innovations take more time to diffuse but have a significantly broader technological impact. Strong public research systems, together with dynamic and diversified collaborations (e.g. science-industry linkages and business-to-business collaborations) can support the necessary innovation process, and can be developed with collaborative research and innovation centres, collaboration facilitators (intermediary organisations, networks and clusters), open innovations (crowdsourcing, open challenges and living labs), and financial support for collaborative R&D.

Enabling experimentation is also key to adapt existing technologies and make them usable and affordable. R&D support, competition policies (especially removing entry barriers), policies aiming at providing enough financial resource to start-ups (e.g. through loan guarantees, venture capital), as well as insolvency regimes are relevant instruments to support experimentation and entrepreneurship. Other instruments, such as the IP system that was designed for inventions embodied in physical products and processes, may need to be adapted to respond to the challenges raised by the digital transformation. More recent instruments, such as test beds and regulatory sandboxes, also help promote real-world applications of innovation in digital technologies.

Overall, there is a complementarity between support to innovative firms and support to laggards. While the specific instruments may differ, supporting diffusion and invention are two sides of the same coin, and require a balanced policy mix.

Further reading

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Please cite this note as:

OECD (2020), "Laggard firms and technology diffusion", *Directorate for Science, Technology and Innovation Policy Note*, OECD, Paris, www.oecd.org/sti/ind/laggard-firms-and-technology-diffusion.pdf.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 811181.

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