7 Industrial strategies for the green transition

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1 Introduction[45]

Governments have been using industrial policy, to varying degrees and in different forms, since the industrial revolution, but until recently these policies had a bad reputation. Among various criticisms, they were seen as instruments that allowed governments to pick winners or support losers, and that were plagued by so-called government failures, eg asymmetry of information, meaning governments do not have sufficient information to select the right projects, technologies or sectors, and are prone to policy capture by rent-seeking players.

Since the 2008 great financial crisis, and even more so since the COVID-19 pandemic and subsequent geopolitical crises, industrial policies have however made a full comeback. The urgency of global societal challenges, and in particular the need to reach climate neutrality by 2050, have heightened the need for government intervention.

There is now wider recognition of the role of industrial policies, as, in a world of imperfect markets, imperfect government intervention might still be welfare-enhancing.

- For example, the inefficient sectoral allocation revealed by the great financial crisis justified intervention to favour reallocation.
- In a period of multifaceted structural change, there is a major need

45 The opinions expressed in this chapter are those of the authors and do not necessarily reflect the official views of the OECD.

for public impetus and guidance, combined with large-scale private investment. This is particularly the case for the investment needed to transition to climate-neutral economies, which the IEA has estimated at $4.2 billion per year by 2030 (IEA, 2021).

- Similarly, the development of new general purpose technologies (eg artificial intelligence) and green technologies with potentially large spillovers requires new rules, new governance frameworks and high-level domestic and international coordination and cooperation. Some of these new (digital) technologies are also characterised by network externalities, which might provide governments with a justification to support the development of these technologies early on, in order to secure global leadership positions. The COVID-19 pandemic and the geopolitical crisis have highlighted how short-run and potential long-term disruptions in global value chains might call for industrial policy interventions – as a complement to trade and competition measures – to ensure the goals of economic resilience and strategic autonomy.
- Finally, industrial policy is being called on in support of other challenges linked to the slowdown of productivity growth (OECD, 2015), coupled with the increase in productivity dispersion and wage inequality (Andrews *et al*, 2016; Berlingieri *et al*, 2017; OECD, 2021b). In particular, Rodrik and Sabel (2019) have highlighted the potential role of industrial policies in reducing geographical and wage inequalities by providing 'good jobs' and supporting the provision of skills to make productivity more inclusive. The importance of focusing on good jobs, opportunities and skill provision – initially triggered by the impacts of globalisation – is becoming ever more relevant, given the potential costs associated with the digital and green transitions.

The world is thus witnessing the development of a new wave of industrial strategies that combine horizontal and targeted instruments, and demand- and supply-side measures. The objectives of these strategies go beyond productivity growth and innovation to include sustainability, resilience and strategic autonomy. Beyond traditional sectoral or place-based orientations, these new industrial strategies focus increasingly on specific technologies or missions. Examples include the US Chips and Science Act and the Inflation Reduction Act, the EU's proposed Net Zero Industry Act and China's 13th Five-Year Plan for Economic and Social Development (2016-2020).

Building on the conceptual framework developed in Criscuolo *et al* (2022a), several of its applications to country- or sector-specific contexts (Anderson *et al*, 2021; Cammeraat *et al*, 2022; Dechezleprêtre *et al*, 2023), and work on the role of innovation and industrial policies to accelerate the development and diffusion of low-carbon technologies (Cervantes *et al*, 2023), this chapter summarises the main lessons learned for the design of effective industrial strategies, with a focus on policies to reach climate neutrality. In fact, the discussion today is no longer about whether industrial policies should exist, but how they should be best designed and implemented.

This chapter emphasises that effective policy design is crucial and should leverage complementarities across different policy instruments within industrial strategies, which Criscuolo *et al* (2022a) defined as a consistent and articulated group of policy instruments aimed at achieving policy objectives. To encompass a broad set of instruments and ensure that many complementarities are taken into consideration, they delineate industrial policy as including "*all interventions intended to improve structurally the performance of the domestic business sector*." This definition covers both manufacturing and non-manufacturing, and includes horizontal and targeted policies.

These new industrial strategies, if well designed, can help achieve diverse objectives and contribute to addressing societal challenges. Indeed, industrial strategies, through a combination of several policy instruments, including carbon pricing, can support the urgently needed innovations and the adoption of new technologies and business models to achieve climate neutrality, while helping firms and workers adapt to the green and digital transitions, including by focusing on the skills needed to thrive in the new environment. For this, governments might need to be bold and invest in sizeable programmes.

This will not come without significant challenges, not least because of the multiple goals new industrial strategies are asked to achieve, from climate neutrality to strategic autonomy. As the Tinbergen rule (Tinbergen, 1956) highlights, this will require at least as many independent policy instruments as there are policy targets, but also coordination of policies managed by different agencies within countries and, especially when dealing with societal challenges such as climate change, coordination and cooperation across countries.

The rest of the chapter is organised as follows: the next section focuses on the need for green industrial strategies. Section 3 describes the role of innovation and technology diffusion incentives. Section 4 highlights the importance of framework conditions for green industrial strategies, while section 5 focuses on the role of competition. The last section concludes.

2 Green industrial strategies are needed

2.1 Industrial decarbonisation faces a number of market and government failures

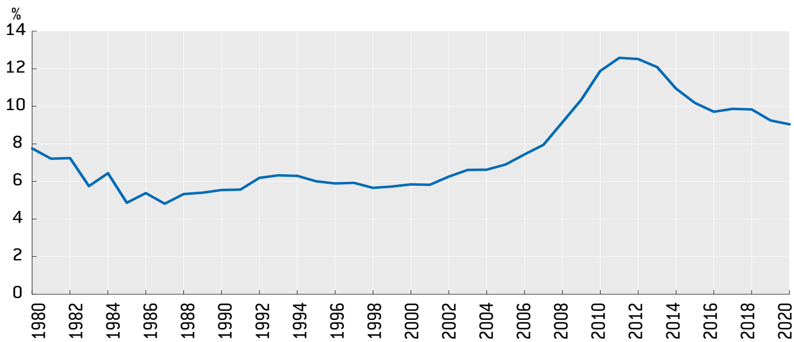
Countries representing more than 90 percent of the world economy have adopted or announced targets on climate neutrality by mid-century. Reaching this objective requires rapid deployment of zero-carbon energy sources and production processes across all economic sectors, while reducing emissions unrelated to energy consumption, for example from the agriculture sector.

Some of the carbon-free technologies necessary to reach net-zero emissions already exist, but their cost needs to be reduced so they become fully competitive with carbon-based alternatives and can be deployed rapidly and at scale (IPCC, 2022). Other technologies, such as green hydrogen, are still in their infancy and need to be further developed. According to the IEA, half of the global reductions in energy-related CO_2 emissions up to 2050 will have to come from technologies that are currently at the demonstration or prototype phase (IEA, 2021).

In heavy industry and long-distance transport, the share of emissions reductions from technologies that are still under development today is even higher. For example, the decarbonisation of manufacturing requires not only the adoption of technologies that are close to market, such as a massive increase in renewable electricity generation to enable the electrification of low temperature heat processes, but also the deployment of many technologies that are still far from maturity, notably bio-based products and green hydrogen (Anderson *et al*, 2021).

Despite the urgent need for low-carbon innovation, the current pace of innovation is not in line with the challenge of carbon neutrality. Over the past decade, climate-related frontier innovation, measured as the share of patent filings in climate-related technologies relative to all technology areas, has slowed (Figure 1). Following a period of strong growth between 2004 and 2011, innovation efforts in climate-related technologies declined around 2012, despite the signing of the 2015 Paris Agreement. Moreover, the decrease in low-carbon patenting affects nearly all relevant technologies except for energy storage (batteries), and can be observed across almost all major innovating countries, except Denmark.

Figure 1: Global low-carbon patenting efforts have declined



Source: OECD, STI Micro-data Lab: Intellectual Property Database, http://oe.cd/ip-stats, November 2022. Note: Data refers to families of patent applications filed under the Patent Cooperation Treaty (PCT), by earliest filing date.

Numerous barriers and market failures discourage low-carbon innovation.

A first obvious major market failure is related to the existence of large environmental externalities from greenhouse gas emissions. Because carbon remains largely unpriced at the global level (OECD, 2022b), the lack of economic incentives implies low financial returns for low-carbon innovations, limiting the market for these technologies and reducing incentives to develop them in the first place. There is ample empirical evidence that carbon pricing, by encouraging the diffusion of low-carbon technologies, affects innovation activity further up the technology supply chain, favouring R&D in clean technologies and discouraging it in conventional (polluting) technologies (Dechezleprêtre and Kruse, 2022; Calel and Dechezleprêtre, 2016).

Second, green innovations are characterised by the existence of significant knowledge spillovers, which have been shown to be 60 percent greater for low-carbon than for high-carbon technologies (Dechezleprêtre *et al*, 2014). For green innovation, learning-by-doing at the sector- or technology-level is also important. This occurs when the costs to manufacturers or users fall as cumulative output increases (Rubin *et al*, 2015), and accrues not only to the first movers but also, perhaps to a lesser extent, to other firms in the same sector or using the same technology. For example, production costs in renewable energy typically fall by around 15 percent each time the cumulative installed capacity doubles, with higher learning rates in earlier stages of deployment. The presence of learning-by-doing provides a strong justification for deployment subsidies. In the renewable electricity domain, these subsidies (in the form of feed-in tariffs and auctions) have been instrumental in inducing the massive cost reductions observed in the last couple of decades (Nemet, 2019).

Third, imperfections in the capital market, such as reluctance to take on risk and lack of information on the potential value of new innovations, also limit the amount of private capital available for low-carbon R&D. Small firms developing clean innovations face particularly high financial constraints, as shown by Howell (2017). Additional factors include systemic barriers to change and innovation, barriers to competition, lack of co-operation within an innovation system, prevailing norms and habits, and technology lock-in and path dependence (Aghion, 2019).

However, government failures, including a preference for incumbents, lack of policy predictability and stability, and regulatory barriers, may also act as barriers to low-carbon innovation. In particular, climate policy uncertainty is associated with significant decreases in investment, particularly in pollution-intensive sectors that are most exposed to climate policies (Berestycki *et al*, 2022).

2.2 These barriers call for the use of coherent industrial strategies

This complex set of market failures and policy objectives calls for a carefully designed strategy relying on a consistent and articulated group of policy instruments, corresponding to the definition of mission-oriented industrial strategies (Larrue, 2021; Criscuolo *et al*, 2022a).

Mission-oriented innovation policy can be defined as a "*co-ordinated package of research and innovation policy and regulatory measures tailored specifically to address well-defined objectives related to a societal challenge, in a defined timeframe. These measures possibly span different stages of the innovation cycle from research to demonstration and market deployment, mix supply-push and demand-pull instruments, and cut across various policy fields, sectors and disciplines*" (Larrue, 2021). Even though this definition is designed for innovation policies, it is straightforward to extend it to industrial strategies more generally. For instance, mission-oriented industrial strategies are motivated primarily by the societal benefits they can provide and the need to coordinate multiple stakeholders around complex challenges, such as the green transition.

Mission-oriented strategies are becoming increasingly popular in order to address societal challenges, including the green transition and more generally the United Nations' Sustainable Development Goals

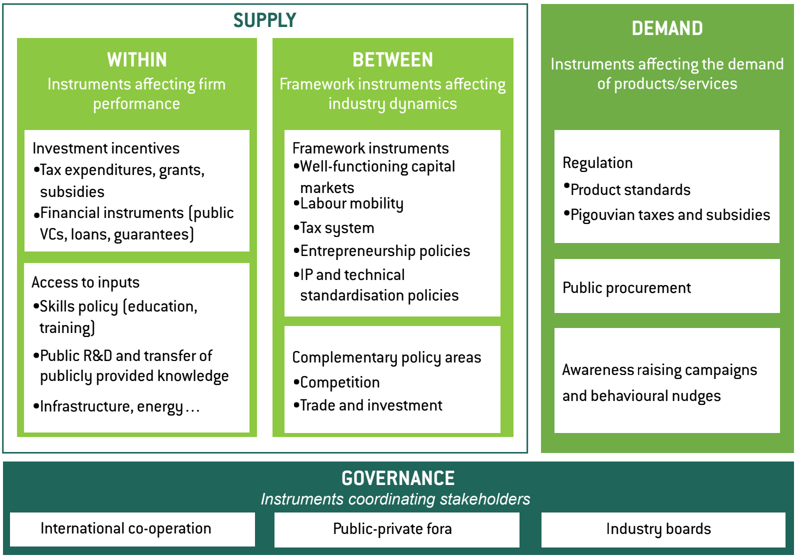
(OECD, 2021a). By improving sustainability, mission-oriented strategies can also be understood as contributing to the long-run resilience of industry.

Mission-oriented strategies differ from other types of strategies in that they are "*transformation-oriented*" (Weber and Rohracher, 2012), ie they address the direction of innovation rather than its level, and require coordination across policy domains and across stakeholders (including consumers, governments and research institutions).

Green industrial strategies must therefore feature a variety of industrial policy instruments. Alongside investment incentives, policy instruments on the demand side and governance categories are also required. Criscuolo *et al* (2022a) defined a taxonomy of industrial-policy instruments (Figure 2), which identifies the channels through which policy instruments operate and highlights potential complementarities between them. In addition to keeping with the traditional distinction between horizontal and targeted policies, the taxonomy distinguishes between demand-side instruments and two types of supply-side instrument: those that primarily improve firm performance (such as tax credits, grants, loans or loan guarantees and public support for training within firms) and those that affect industry dynamics (framework instruments including the tax system, capital and labour market policies, competition and trade policies). Green industrial strategies require all these categories of instruments.

This framework can shed light on the design of industrial strategies for the green transition, for example by helping to understand the complementarities between innovation and technology adoption support on one hand and demand-side instruments on the other. The latter can contribute to transformative industrial change by affecting the demand for products through their price, availability or public demand, and have become increasingly common, particularly in transformative mission-oriented strategies. The underlying rationale is the creation of demand to support scaling-up, and in turn lowering costs through learning-by-doing. In the context of targeted industrial strategies, demand-side policies are particularly interesting as they may be less distortive than targeted supply-side policies.

Figure 2: Taxonomy of industrial policy instruments



Source: Criscuolo *et al* (2022a). Note: Examples based on the main channel through which policy instruments work.

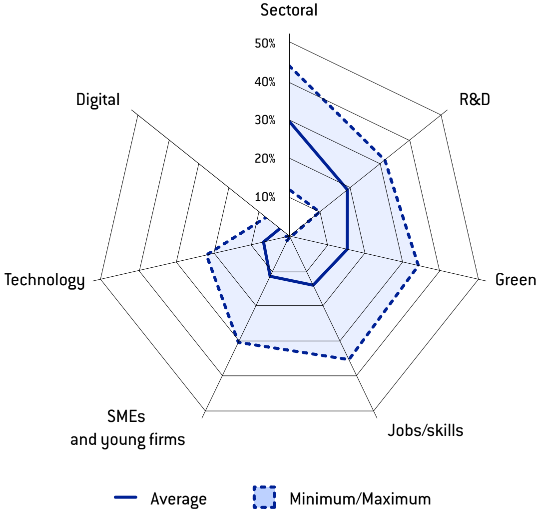
This framework highlights the need for coherent policy packages adopted as part of industrial strategies. For example, although innovation policies have a major role to play in carbon-neutrality strategies, they are insufficient on their own. While innovation policy can help facilitate the creation of new environmentally friendly technologies, it provides little incentive to adopt these technologies, unless R&D activities manage to make clean technologies competitive with high-carbon alternatives on economic grounds. Until then, incentives for adoption need to be provided by demand-side policies, which can make low-carbon options more attractive economically. However, demand-side policy cannot supplant the need for innovation policy, given the presence of barriers and market failures at the R&D and demonstration stages.

These instruments are thus not substitutes but can instead be mutually reinforcing. Carbon pricing, in particular, is also not sufficient on its own. Carbon prices ensure there will be a demand for new low-carbon technologies. However, they are unlikely to help for technologies that are far from market and require long development timelines. As any technology-neutral instrument, carbon pricing tends to favour technologies that are closest to market and with the shortest payback time. It needs to be complemented by technology-specific support, which, by lowering the cost of future green technologies, can build the case for stronger carbon pricing in the future. The Dutch climate policy package is a good example of an approach that combines a strong commitment to raising carbon prices – through a carbon levy on industrial emissions – with ambitious technology support provided by the Sustainable Energy Transition Incentive Scheme (see section 3.1; Anderson *et al*, 2021).

The digital transformation could be a key enabler for reaching climate goals, thanks to technologies including smart meters, sensors, artificial intelligence (AI), the internet of things (IoT) and blockchain, along with digitally-induced changes in business models and consumption. In the energy sector, demand-side management can help balance the renewables-based electricity system. Digital solutions are equally important on the supply side, for example by accelerating low-carbon innovation with simulations and deep learning. Already, around 20 percent of patents protecting climate change mitigation technologies have a digital component (Amoroso *et al*, 2021). However, digital technologies consume large amounts of energy, implying higher direct energy demand and related carbon emissions, which warrant further efficiency improvements. This suggests that the digital and green transformations need to be tackled jointly through coherent industrial strategies.

Preliminary estimates from the Quantifying Industrial Strategies (QuIS) project, based on evidence from nine countries (Figure 3; Criscuolo *et al*, 2022b; Criscuolo *et al*, 2023) show that green industrial policies, while not negligible, comprise on average 15 percent of industrial policy expenditures (or an average of 0.24 percent of GDP). In addition, green industrial policies are on the rise, as their weight increased by about 10 percent from 2019 to 2021, and is expected to grow even more in the near future. Post-pandemic recovery plans, which are still being ramped up, include in many countries a much higher share of green expenditures (O'Callaghan *et al*, 2021; OECD, 2022; Aulie *et al*, 2023). Similarly, digital industrial policies represent an even lower share of industrial policy expenditures (3 percent on average). Countries' priorities are in fact still dominated by a sectoral approach (Figure 3): policy instruments for specific industries still represent close to 30 percent of expenditures on average, mainly targeting manufacturing, energy and transportation. Country profiles are nevertheless diverse, with, for instance, green expenditures as high as 34 percent in some countries and almost non-existent in others, and digital going from as low as 0 percent to 8 percent.

Figure 3: Industrial policy priorities in nine selected OECD countries*, industrial policy expenditures by eligibility criteria in 2021, % of total industrial policy subsidies and tax expenditures



Source: Criscuolo *et al* (2023). Note: * QuIS covers Canada, Denmark, France, Ireland, Israel, Italy, the Netherlands, Sweden and the United Kingdom. Structural policies (ie excluding COVID-19 emergency support). Categories are not mutually exclusive, as policies can be tagged in several categories. Additionally, some policies do not fulfil any of these eligibility criteria. Hence, the numbers in this figure do not add up to 100 percent.

3 Innovation and technology diffusion incentives are the foundation for green industrial strategies

Bringing about the necessary cost reductions to make carbon-free technologies competitive with their high-carbon alternatives should be the primary objective of climate-neutral strategies. This would also help accelerate the diffusion of available technologies, which is critical to reach medium-term carbon emissions reductions. For these reasons, innovation and industrial policies – with a focus on both the development and deployment of low-carbon technologies – should underpin strategies to reach carbon neutrality. Given the wide range of barriers discouraging low-carbon innovation, the theoretical justifications for policy intervention are sound and well established.

Innovation and industrial policies can also complement carbon prices, which are often difficult politically to implement. In fact, technology support policies are more popular among voters and citizens than other climate change policies (including carbon pricing, bans or regulations), making them an attractive option from a public acceptability point of view (Dechezleprêtre *et al*, 2022). In addition, by reducing clean technology adoption costs and boosting the growth of new carbon-efficient firms and sectors, such policies can facilitate the adoption of more ambitious emissions reduction targets, including among emerging economies, where the bulk of future emissions growth is projected to take place.

3.1 Evidence suggests that specific R&D support instruments are required

Public expenditures on research, development and demonstration of low-carbon technologies are a key element of the toolkit available to governments to achieve climate neutrality. However, low-carbon public R&D spending has remained broadly flat as a percentage of GDP over the last 30 years (Cervantes *et al*, 2023).

In addition to public R&D spending on low-carbon technologies, governments can support financially the innovation activities of firms through direct and targeted instruments (eg research grants) or via horizontal and untargeted instruments (R&D tax credits). Horizontal R&D support has indisputable advantages, including its low administrative cost and technological neutrality, but by construction, it cannot be directed and likely benefits mostly technologies that have the greatest short-run returns. As such, tax credits may not be the best policy tool to promote new technologies that are far from the market and require long development timelines. Climate neutrality will require innovation in breakthrough technologies, which cannot be incentivised through horizontal support. Support for an emerging technology justifies a stronger focus on targeted instruments for

R&D, complementing horizontal instruments. Therefore, support for low-carbon R&D undertaken by business should primarily be direct, rather than horizontal. Technology neutrality – even between various low-carbon technologies – tends to favour technologies with the shortest payback time and is therefore not neutral in practice.

For example, the main technology support instrument in the Netherlands is the Sustainable Energy Transition Incentive Scheme (SDE++), which subsidises the additional costs associated with adopting a low-carbon technology. The instrument is allocated to applicants in increasing order of subsidy requirement per tonne of CO2 reduction. While this allocation design is economically efficient and ensures least-cost decarbonisation in the short run, it favours technologies that are close to the market at the expense of more radical alternatives that are still at an earlier stage of development, such as green hydrogen (Anderson *et al*, 2021).

An analysis of countries' hydrogen strategies provides a worrying example (Cammeraat *et al*, 2022). The ambitious hydrogen production targets at the 2030 horizon included in national hydrogen strategies mostly rely more on financial support for the deployment of new large electrolysers than on direct support for innovation. Between 2008 and 2019, several countries increased public R&D spending on hydrogen, but others cut public spending on R&D by more than half. The focus of public support at the deployment stage is evident in firms' filings of intellectual property rights: while patenting activity on hydrogen production technologies is growing at a very slow pace, the number of hydrogen trademarks has taken off, suggesting that companies are focusing on commercialisation rather than on innovation, and anticipate a growing hydrogen market pulled by government subsidies. This calls for greater targeted support for R&D in green hydrogen.

3.2 Financial instruments also have a role to play

Recent evidence on venture capital (VC) funding for green start-ups shows that, conditional on receiving VC, these firms are less likely to secure seed funding compared to non-green start-ups, suggesting that in the early phases of product or service development they might be perceived as riskier than their non-green counterparts (Bioret *et al*, 2023). Holding patents also increases the likelihood of being awarded a grant or of receiving VC more for green firms than for non-green firms, suggesting that grant providers and investors potentially wait for green technologies to be de-risked through patent applications before supporting the companies that hold them. The relationship between cumulative grants or cumulative VC received and subsequent innovation is substantially lower for green firms relative to non-green, which might suggest higher development costs for green products and services. Taken together, this evidence demonstrates the importance of reducing barriers to external funding to help high-risk companies raise funds. Low-interest or subsidised loans for young firms and greater mobilisation of government venture capital toward the green transition can help.

4 Framework conditions and demand-side support are also key components of green industrial strategies

Framework policies and demand-side policies complement innovation and technology diffusion policies and are important in enabling frontier firms (in terms of productivity, but also in terms of greenness) to invest and grow. These instruments not only play on strategic decisions within these firms but also directly affect the allocation of resources and their reallocation between firms, which is one of the main drivers of structural change.

This section illustrates the role of framework conditions using three examples: first, with the role of science and skills in enabling the green transition of the industry, then the role of regulations and standards in allowing the diffusion of green technologies, and finally how the carbon price is key to promote green investment and technology adoption. The next section focuses on the contribution of competition and business dynamics to structural change.

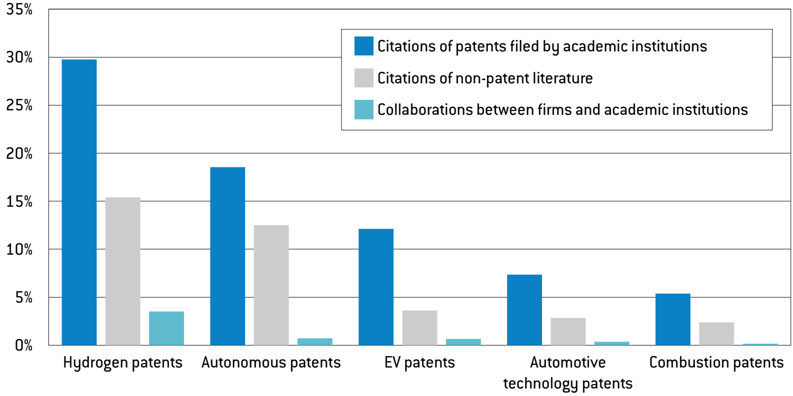
4.1 Education, skills and science policies

Education, skills and science policies are necessary to ensure that industry can rely on the right set of skills and that new research into low-carbon technologies is not performed at the expense of the development of other productivity-enhancing innovations.

Re-skilling and up-skilling displaced workers with green skills through active labour market policies and adult training is essential to address social concerns and contribute to reducing skill shortages in the future low-carbon industries. Cross-sector training programmes can ease labour market transitions from surplus to shortage sectors. Timely and transparent information on sectoral labour markets can help workers anticipate future labour needs and policymakers to monitor and accompany the changes. With a view to the longer run, education programmes need to incorporate new material and competences, so the next cohort of workers can cope with the impact of the low-carbon transition in the workplace.

Universities and research institutes play a key role in developing emerging green technologies. For instance, patents in automotive emerging technologies (particularly hydrogen, and to a lesser extent autonomous vehicles and electric vehicles) are more likely to cite university patents and the academic literature than patents in traditional combustion engine technologies (Figure 4). This result is confirmed when looking at the share of patents filed in collaboration between firms and academic institutions.

Figure 4: Emerging technologies are strongly linked with universities and scientific research, automotive technology patent citations, 2000-2019



Source: Dechezleprêtre *et al* (2023), based on STI Micro-data Lab: Intellectual Property Database, http://oe.cd/ipstats, June 2022. Note: A collaboration is defined as a patent family with at least two applicants, one being a firm and another a non-firm entity (eg universities, governments, hospitals). Patents filed by academic institutions only include patents for which the type of applicant (individual, company, government entity) is identified. A patent is labelled as citing an academic patent if at least one application in the patent family cited a patent filed by an academic institution. A patent family is labelled as citing the academic (non-patent) literature if at least one patent in the patent family cited a serial/journal/periodical citation, a chemical abstract citation, or a biological abstract citation. When labelling a patent family as citing the non-patent literature, the sample is restricted to those patent families that have at least one patent application at the EPO, USPTO or WIPO (PCT applications). This restriction is necessary as non-patent literature citations are only available for patents filed in one of these three offices.

4.2 Regulatory standards

Setting regulatory standards is another important complementary policy, which can help reduce uncertainty and facilitate coordination. Standardisation can strongly promote the diffusion of technologies with network externalities, such as carbon capture and storage (CCS; Anderson *et al*, 2021) or green hydrogen (Cammeraat *et al*, 2022).

For instance, defining liabilities would allow investors in CCS to more accurately price and potentially insure this risk. The industry, the financial sector and the different levels of government have to work together to explore potential risk-sharing solutions should such liabilities create a barrier to market development.

For hydrogen, standards are needed on the purity of hydrogen for passenger vehicles, on the gas composition for cross-border sales, on safety measures (such as materials used for hydrogen tanks) and on how to measure lifecycle environmental impacts from hydrogen production (IEA, 2019), and for blending hydrogen into the gas grid. As it is impossible to assess from hydrogen itself how it has been produced, accounting standards for the origin of hydrogen are needed to create a market for blue (out of natural gas with CCS) or green (out of renewable electricity through electrolysis) hydrogen.

Hydrogen can be produced on-site, but also in a centralised manner before being stored and transported via tanks or pipes, in a pure form or blended with natural gas. This wide variation in the modes of producing, storing and transporting hydrogen suggests that regulatory standards can facilitate the creation of a dynamic hydrogen market.

Harmonisation of standards and regulations related to the use of recycled products is necessary to promote the circular economy and, ultimately, address Scope 3 emissions (ie linked to the supply chain). This is of particular importance in the steel industry, where relabelling by-products of steel production at the European level (eg slag and fly ash) from 'waste' to 'product' with all due care to avoid pollution hazard, would reduce the administrative burden associated with purchasing scrap for companies while increasing import opportunities.

Standardisation faces a trade-off: advancing fast on a national basis or slower at the international level. For example, China has at time of writing adopted 93 standards for hydrogen infrastructure and applications. Even EU countries do not yet rely on EU standards. For example, Italy has adopted a national regulation on hydrogen fuelling stations. Most countries recognise that standards are important and should ideally be set at the international level, and international cooperation related to hydrogen is thus mostly about harmonising codes and standards.

4.3 Carbon pricing

Carbon pricing is a cornerstone of the policy toolbox for industrial decarbonisation. It is essential to have clear trajectories of gradually increasing carbon prices over the next decades to establish a level playing field and make the business case for a low-carbon transition. In this respect, the design of the Dutch carbon levy (Anderson *et al*, 2021) is particularly interesting, with an increasing price path and a levy base that phases in gradually over time. The levy adds a floating contribution on top of the EU ETS allowance price to yield a fixed price on Dutch emissions covered by the system. This price floor provides more certainty about future prices and protects investors against volatility of EU ETS allowance prices. Such a design can provide forward guidance to investors without immediately imposing new taxes on businesses in the context of high uncertainty about short- and medium-term demand and liquidity. Since expectations of future prices, rather than current prices, determine innovation, long-term regulatory consistency is crucial for new technology development. Commitments to raise carbon prices in the future and clear carbon-price trajectories can already induce innovation even if current carbon prices are low. Carbon contracts-for-difference (CCfD), experimented on in Germany, can decrease uncertainty thanks to forward contracts on the price of abated greenhouse gases (Neuhoff *et al*, 2022).

Nevertheless, all carbon pricing instruments in the Netherlands (carbon levy, European carbon market, energy tax and energy surcharge) include competitiveness provisions which grant extensive preferential treatment to energy-intensive users, for instance in the chemicals, refineries and basic metals sectors. These can take various forms, including tax exemptions, regressive tax rates and free emissions allowances. This naturally erodes the carbon pricing signal, reduces the cost-effectiveness of the policy instrument and generates equity concerns as small firms typically face much higher energy and carbon prices than large incumbents (Anderson *et al*, 2021).

In this respect, strong financial support for low-carbon technology adoption should be seen as an alternative, not a complement, to the provision of generous exemptions to energy-intensive industry, and should allow governments to gradually remove such preferential treatment, which stands in the way of long-term decarbonisation. The convergence of climate policy ambitions at EU level and beyond – notably among large emitters from the developed and developing world alike – as well as the progress made towards the introduction of a carbon border adjustment mechanism, are other justifications for removing these exemptions.

5 Competition and business dynamism are key for structural change

Competition policy is closely linked to industrial strategies, favouring an efficient allocation of production factors between firms, and thereby contributing to aggregate productivity and structural change.

At the same time, industrial policy also has an impact on competition.

- First, industrial policy, by promoting technology adoption, innovation and entrepreneurship, can foster competition by supporting business dynamism.
- Second, targeted industrial policies, by giving an explicit advantage to some firms over others, might compromise competitive neutrality principles, while horizontal industrial policies are less likely to have a detrimental effect on competition (see OECD, 2009).

In general, targeted industrial policies should be competitively neutral. In case competitive neutrality is not feasible to achieve the desired objective, interventions should be narrow, temporary and monitored closely (OECD, 2020). Inclusiveness and technology-neutrality are essential to ensure that in practice industrial policies do not discriminate unduly between firms. This issue is even more meaningful for instruments that are by essence discriminatory, such as incentives provided on a competitive basis (grants, loan or equity financing).

However, even if they might be at risk of hurting competition, targeted industrial policies that are designed to fix market failures or to address externalities do not necessarily affect competition negatively. By increasing the returns for a given project, they may even enable more firms to enter into that market (Aghion *et al*, 2015a).

Both theory and evidence suggest the existence of significant complementarities between industrial and competition policies. Competition promotes the most efficient firms and provides incentives for innovation, while industrial policy increases the ability to innovate and protects the rights of innovators, thus guaranteeing the returns to innovation and investment. For example, Acemoglu *et al* (2018) highlighted the fact that R&D support might not be effective in the absence of efficient exit policies. Interestingly, Aghion *et al* (2015b) showed that there is a complementarity between competition and intellectual property rights (patents) in fostering innovation. Indeed, with stronger patent rights, the incentives to escape competition are higher.

Besides innovation, competition is also a major driver of technology adoption and of organisational and managerial improvements, since competitive pressures boost returns to adoption (Andrews *et al*, 2016).

Finally, most of the arguments developed in this section also apply to international trade, which can contribute to increasing competition on domestic markets and expanding the size of the market for domestic firms. For instance, comparative advantage is an important lever to decrease the cost of green hydrogen, which should be produced where renewable energy is more abundant and cheaper (Cammeraat *et al*, 2022). Importantly, reconciling green investment support and trade rules is necessary (Kleimann, 2023).

5.1 The example of the automotive sector

Ongoing trends in the automotive sector, such as the major investment required for the shift to connected, automated, shared and electric

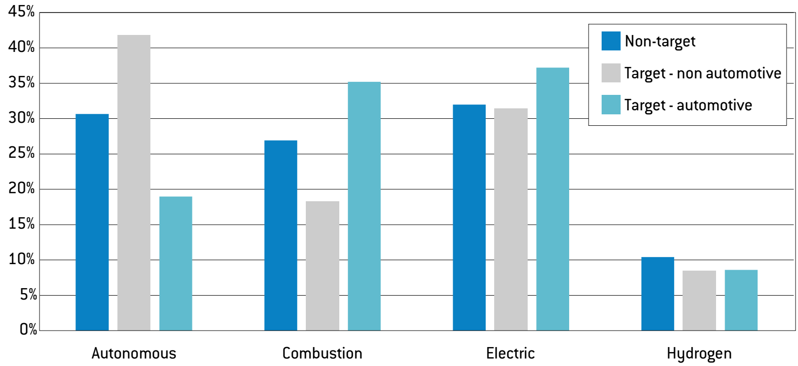
(CASE) vehicles, the network externalities linked to the increasing role of data or the potential increase in market segmentation could reduce competition in the medium run. High upfront investment needs, network externalities and high economies of scale required in this sector might indeed lead to a higher level of concentration in this industry. This could be reinforced by the evolution towards increasingly segmented markets.

Dechezleprêtre *et al* (2023) showed that the automotive sector experienced very significant growth in mergers and acquisitions (M&As) before the COVID-19 crisis. Given the likelihood of a new wave of M&As after the crisis, the level of competition and contestability in the ecosystem may decrease in the near future, thereby threatening innovation and the benefits for consumers.

Nevertheless, M&As and concentration are also an effective way to acquire new knowledge, to integrate new technologies, know-how and talents in the products, and to benefit from economies of scale or scope. M&A is often cited as a strategy to acquire external knowledge (Cassiman *et al*, 2005; Phillips and Zhdanov, 2012). If this is indeed the case, the patent portfolio of target firms should reflect the technologies of interest for acquiring firms. As transactions within the automotive sector can have other motives, such as industrial synergies or entry in a new market, target firms outside the automotive sector are more likely to be bought for their technologies.

Compared to firms that are not the target of a merger or an acquisition, target firms outside the automotive sector have a much higher proportion of patents in autonomous vehicle technologies (Figure 5). However, they have significantly lower shares of patents related to combustion engines. Target firms in the automotive sector tend to have higher shares of patents in combustion and electric engine technologies.

Figure 5: Automotive sector, patent portfolio of selected firms, by technology, 2016-2019



Source: Dechezleprêtre *et al* (2023), based on Zephyr data. Note: This figure covers the deals in the following categories: 'genuine acquisition,' 'further acquisition,' 'minority stakes' and 'joint venture.' Non-target firms correspond to firms having filed patents in at least one of the four selected technologies.

In this context, it is important to find new ways to support collaboration between firms, while preserving competition and a level playing field (eg industrial alliances in the EU). This calls for:

- Ensuring that competition authorities have adequate tools to monitor and enforce merger control. As acquisitions of young firms often remain below applicable thresholds, analyses (Crémer *et al*, 2019; Shapiro, 2019; Digital Competition Expert Panel, 2019; Kamepalli *et al*, 2020; Argentesi *et al*, 2020; Motta and Peitz, 2021) have suggested reassessing them in order to review potentially problematic mergers. Although this literature mainly focuses on acquisitions by large digital platforms, its conclusions may also apply to the automotive ecosystem, which is becoming more digital and prone to network effects.
- Ensuring that young and fast-growing firms can choose between several exit strategies. Being bought by a larger firm should remain a possibility, but young ventures should also be able to opt

for initial public offerings (IPO) or private equity funding. The development of financial markets is therefore key to allow for the growth of promising firms and to limit market concentration in the medium run. This seems to be particularly relevant for the European automotive ecosystem, which is often a target of cross-border transactions (Dechezleprêtre *et al*, 2023). Publicly provided financial instruments can also support young and fast-growing firms, especially in downturns when capital markets are more risk averse.

- Finally, competition can also be fostered by limiting market segmentation. This can notably be achieved by international cooperation on regulatory and technical standards, for instance on autonomous vehicles (eg homologation; see Fernandez Llorca and Gomez, 2021) and emissions. Technical standardisation must nevertheless balance the risk of premature standardisation against the need to provide clarity to investors and facilitate investments (see Cammeraat *et al*, 2022, on hydrogen). In addition, clear data governance rules are needed to facilitate the deployment of connected and autonomous vehicles.

6 Conclusion

Industrial policy has made a comeback and is seen as a way to achieve an increasing number of goals. Industrial strategies are indeed necessary to deal with urgent societal challenges, such as climate change. As many of the technologies required to reach carbon neutrality are still in the labs and innovation in green technologies seems to have reached a plateau, there is a strong and urgent need to stimulate these innovations and, more generally, to transform economies towards net-zero emissions, leaving no one behind. Green industrial strategies, which still represent a small share of industrial policy, even if they are growing, are therefore required to speed up the green transition.

Green industrial strategies rely on important pillars, such as incentives for innovation and technology diffusion or carbon pricing, but deserve a more encompassing approach that takes into consideration other aspects of industrial policy. In particular, this chapter stresses the importance of education, skills and science policies, regulatory standards and competition and business dynamism, which are shown to be highly complementary to green technology support and carbon pricing. In order to succeed, these policies need to be coherent and provide clear trajectories and long-term consistency.

Industrial and competition policies have often been considered as antagonistic, but major complementarities exist between industrial and competition policies. For green industrial strategies to succeed, they need to go hand in hand with competition policies to continue to foster business dynamism, business entry and the efficient allocation of resources.

The chapter also indicates fruitful avenues for future research. First, the chapter summarises the results of novel efforts aimed at quantifying industrial strategies. This is the first step of a long journey, the final goal of which is to evaluate industrial strategies. Second, the chapter focuses on industrial strategies for the green transition, but, as highlighted in the chapter, achieving climate neutrality and succeeding in the green transition requires relying on a sustainable digital transition and the buy-in of voters. For this reason, an important area of work could be on how industrial strategies can best support an inclusive twin transition.

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