Green industrial policy: a global perspective

Prepared by Simone Tagliapietra, Senior fellow at Bruegel, December 2022
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Introduction

An increased number of governments and institutions around the world have been arguing that turning the decarbonisation imperative into an opportunity for green growth requires stronger and smarter policies to foster job creation and industrial development. Also the United Nations' Sustainable Development Goals (SDGs) represent a green growth agenda, as they combine targets of economic growth and decent jobs with deep decarbonisation and environmental protection.

For governments, one of the greatest challenges in the decarbonisation process is to organise the decoupling of economic growth from GHG emissions in an effective and efficient manner, notably by putting in place a workable green industrial policy, able to foster the creation of good jobs and sustainable economic growth. This truly is a challenge of great importance, because a failure to do so – for instance, entailing that brown jobs do not get replaced by green jobs – might ultimately jeopardize the transition and put the overall decarbonization process at risk.

In the following, we will unpack this complex set of issues by taking the following approach. First, we will define what green industrial policy is. Second, we will provide an overview about how green industrial policy works in practice. Third, we will dive into each of the different aspects of green industrial policy. Finally, we will conclude discussing the risks entailed by green industrial policy, and potential governance solutions to tackle them.

Defining green industrial policy

Defining industrial policy is *per se* a challenge. Any government policy will have some impact on the economic structure of a country. Hence, the ontological limits of the definition, can be the limits of the definition of 'policy' itself.

Looking at the established literature in the field (Ambroziak, 2017), it is possible to recognize that a common factor in all definitions of industrial policy is that of targeting a set of economic activities to achieve long-term benefits to society. New tendencies in the literature on industrial policy (Lane 2019, Rodrik 2014, Aiginger and Rodrik 2020, Cherif and Hasanov 2019), which we will label as 'new industrial policy', stress that the objectives of industrial policy should look beyond short-term competitiveness and economic growth to go for a broader multi-dimensional objective, which can be captured in the notion of long-term 'social welfare'. This is the case, for instance, of Rodrik (2014), who aims at rethinking and investigating a set of interventions by the public sector – or its delegated agencies – directly in the productive sphere, and in direct collaboration with the most productive segments of the private sector. In Rodrik's view, this set of interventions should aim at building a "good jobs economy".

The necessity of a green characterization of industrial policy comes into play once decarbonisation is set as a societal goal, like in the case of Europe with the European Green Deal. While climate policy targets decarbonisation and industrial policy targets social welfare, green industrial policy has to reconcile the goal of decarbonising the economy (like climate policy) with the social welfare goal (like industrial policy). It is thus possible to define green

industrial policy as an industrial policy where climate change mitigation becomes a binding constraint in the social welfare policy objective.

By combining decarbonisation and social welfare objectives, green industrial policy is thus different from climate policy whose objective is decarbonisation solely. It is also different from industrial policy, whose objective is solely social welfare more broadly – or economic growth more narrowly. This combination of objectives identifies green industrial policy differently. It also immediately identifies the challenge of green industrial policy, namely to reconcile both objectives simultaneously, which becomes particularly challenging when they would conflict[1], when trade-offs will have to be made and costs will have to be attached when one of the objectives is not being met.

Green industrial policy will operate next to climate policy and industrial policy more generally and therefore raises the issue of coordination among the various policies, particularly when these different policies reside in different institutions or departments. Climate policy and industrial policy each have their own instruments. Would a coordination of already existing instruments from climate change and industrial policy be sufficient for a green industrial policy? Does green industrial policy need dedicated own policy instruments? And if so, how to coordinate with existing instruments?

In term of how to do green industrial policy, as any form of policy more generally, it represents a public intervention aimed at correcting problems. Industrial policy addresses problems ranging from research externalities imposing access to knowledge constraints to financial capital market imperfections imposing access to finance constraints, or again from labour market imperfections imposing access to skills constraints, to network externalities imposing access to partnerships imperfection. These constraints may lead to failures of existing markets to grow but also a failure for new markets to emerge and develop.

In addition to market failures at the core of classic industrial policy, green industrial policy also has to address market failures associated with climate change. For climate change, the main market failure is the greenhouse-gas externality. GHG emissions are a side-effect of economically valuable activities. Most of the impacts of emissions do not fall on those conducting the activities, so those responsible for the emissions do not pay the cost. The adverse effects of greenhouse gases are therefore external to the market, which means there is usually only an ethical – rather than an economic – incentive for businesses and consumers to reduce their emissions. As a result, the market fails by over-producing greenhouse gases. Economists have argued for a long time that the first-best policy to correct this market failure is to apply a cost to greenhouse gas emissions in order to encourage emitters to reduce the amount of their emissions into the atmosphere. Absent a sensible carbon price, policy-makers must recur to second-best policy interventions to correct the greenhouse gas externality, such as regulation or public investment. In addition, being general and technology-neutral, carbon pricing represents a superior policy tool also because it avoids the risk presented by more targeted policies to select wrongly.

[1] An example of when decarbonisation and social welfare objectives diverge might be the case where energy efficiency standards for buildings increases construction costs (materials, skilled labour), slowing down the rate of new buildings, thereby worsening an eventual housing crisis situation.

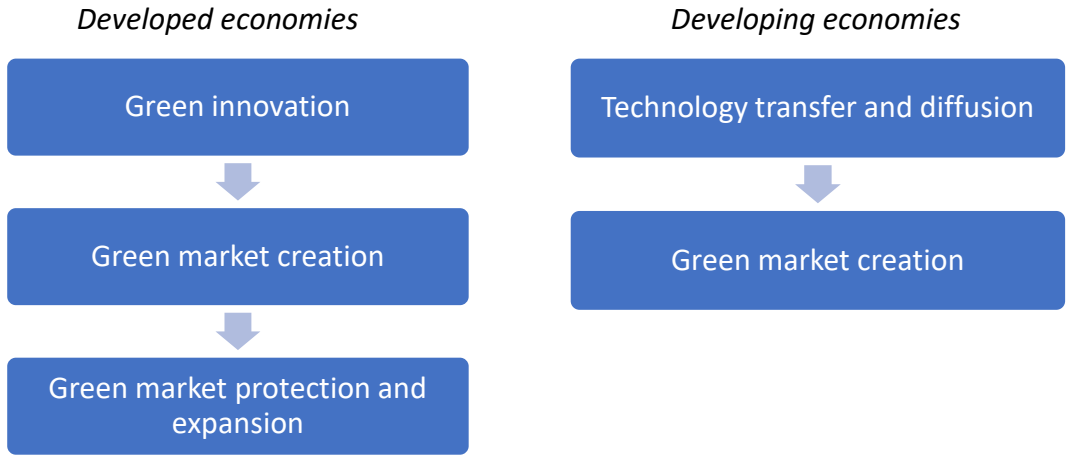
As externalities have complex reinforcing interactions, the combination of classic market failures externalities and the greenhouse gas externality represents a significant challenge for green industrial policy. This implies that green industrial policy requires the deployment of specific instruments that go beyond the general industrial policy toolkit. These instruments do not need to be new instruments, but at least specifically tailored to fit in a green industrial policy. A green industrial policy mix should in any case be developed in coordination with the policy instruments used by climate policy and industrial policy respectively, such as for instance carbon pricing.

How does green industrial policy work in practice?

As previously illustrated, green industrial policy is a multifaced discipline, entailing a wide range of policy interventions. The way green industrial policy works in practice depends on the different economic development stage of countries.

In developed economies, green industrial policy is likely to be developed alongside a scheme entailing three successive steps: green innovation, green market creation and green market protection and expansion. In developing countries, green industrial policy is likely to be developed on a different scheme, seen green innovation being replaced with technology transfer, and then followed by market creation (Figure 2).

Figure 2: Different pathways of green industrial policy



Source: authors' elaboration.

Green innovation. Developing green innovative products and solutions is the first step to build the industries of the future. To speed up the process, green industrial policies need to overcome a number of market failures. For example, knowledge spillovers mean that, because firms can learn from other firms' R&D efforts, efforts devoted to research are suboptimal from a societal point of view. Moreover, while costs of innovation can be quite high in the beginning, the returns usually come later. When financial markets do not work perfectly, for example due to imperfect information regarding potential profitability, alternative sources of financing are needed to bridge the time gap. Governments can try to correct these market failures by providing public money for innovation and by creating a stronger incentive for innovation by firms through competition policy.

Technology transfer and diffusion. Not all countries might be able to develop innovative green technologies or easily have access to them. Particularly in the developing world, some countries might need to receive technology from developed countries. The shift of inventions, materials, and technical knowledge from the pioneer of a technology to a secondary user or group of users is what is defined as technology transfer. In this case, climate technologies which are spread from nations that pioneered the technologies to developing nations without access to them. These transfers of technology can be advantageous to both developed and developing nations as the impacts of climate change do not discriminate between rich and poor, but adversely impact every country and people. But they need to be properly structured to work. With this regard, it is important to outline that technology transfer and diffusion can happen both via public policy processes (e.g., the IPCC's Technology Mechanism or the UN's Technology Bank for the Least Developed Countries, among others) and market interactions (e.g., trade, foreign direct investments, etc).

Green market creation. But innovation or technology transfer themselves are not sufficient. Once available in one way or the other, innovative green products and solutions need to find a receptive market to be deployed – and thus developed further. To have a receptive market, framework conditions are very important. For instance, a strong climate policy – ideally with a strong carbon pricing system – can drive investment decisions in both families and businesses and thus spur green market creation. In this space, a number of risks have to be carefully managed. Firstly, as market structures adjust to decarbonization, market power could arise in a few sectors. For instance, incumbent private companies might gain and exercise a predominant position in the market, with the risk of limiting competition and thus distorting the green market development. Secondly, while strong efficiencies of scale and scope playing into the hands of single, big networks can be useful in reducing the cost of the green transition, this again needs to be reconciled with competition concerns. Thirdly, sometimes entire value chains have to make investments to adjust to new green technologies, which presents markets with coordination problems. Governments have a role in actively helping with market design or transformation through competition policy, innovative regulation, public private partnerships and even direct state control in some circumstances.

Green market protection and expansion. When it comes the international dimension of green industrial policy: green market expansion. On the one hand, this entails the prevention of carbon leakage risks with the adoption of carbon border adjustment measures. On the other hand, this also entails the promotion of the export of green innovative products and solutions, focusing especially on the developing world. Firms can face barriers to exporting caused by information failures, meaning that they have to incur high sunk costs to firstly work out whether exporting is profitable and secondly, how to go about it. This can be beyond the means of especially smaller firms, so a global network of support is needed. Expanding business abroad, particularly to developing countries, can also be made difficult by institutional risk in destination countries, which can be mitigated through blended financial support. Another rational for export promotion is given by the fact that firms do not take into account the benefits their export decisions may have on society at large, causing them to make suboptimal decisions. Supporting exports in this way does not only represent a way to foster the entry of green innovative industries into rapidly growing markets, but it also is an

important way of fostering global decarbonisation – in line with the climate finance, technology transfer and capacity building commitments undertaken by developed countries in the context of the Paris Agreement.

In the following sections we will dive into each of these elements, discussing the market failures justifying public intervention and providing an overview of the policy tools that might be utilized in the area.

Green innovation

Most emission reduction scenarios that predict continued economic growth rely to varying degrees on the use of technologies that are not yet available. This is frequently used by degrowth proponents as an argument to question the feasibility of green growth. The IEA net-zero pathway (2021b), for instance, relies to a great extent on future innovation: 15 percent of the emissions reductions by 2030 and 46 percent of the reductions between 2030 and 2050 are to be achieved with technologies that are currently in a demonstration or prototype phase, such as carbon capture and storage, green hydrogen and advanced batteries.

The breakthroughs achieved in the current decade will therefore be crucial. Unfortunately, none of the technologies needed beyond 2030 are currently on track to being deployed in time (IEA, 2021c), as the road from concept to commercialisation is typically long and winding. To accelerate the development of these innovative technologies, governments must overcome several market failures that keep private investments in research and development below optimal levels. This can be done by providing public funding instead, or by using competition policy to spur innovation.

It is here important to underline that fostering green innovation entails the need of accepting failures. Experimentation is central to green innovation in specific, and to green industrial policy in general. Keeping in mind that governments do not start with the presumption that solutions are known, a green industrial policy built on experimentation ensures that the focus is not on 'picking winners' anymore, but much more on 'letting losers go' on time (Hallegatte, 2013). Openness to failure should in fact be a characteristic of the design of industrial policy, which should incorporate uncertainty in its process. As Rodrik (2014) puts it, 'failure is part and parcel of a successful industrial policy effort'. This is particularly true for green innovation. In this sense, a successful green innovation action must be intended as a portfolio, and it is key to recognize and accept that some projects in the portfolio will fail. That is, a portfolio with no failures entails no risks.

Policy tool #1: public funding for early-stage risky innovation

Developing green industrial policy, requires leveraging public resources and policy toolkits to scale-up national and regional public resources that go into climate innovation, but especially private investment in climate innovation. Furthermore, policymakers need to pay attention to the destination of innovation funds, either public or private, that are not explicitly 'green', and ensure that these are not going towards supporting investments that work against the climate goals.

It should be emphasised that fostering green innovation is not only about availability of public finance resources. It is also about allocating public finance to the best areas and projects, meaning those with the largest socio-economic and climate returns that could not have been reached without public support. In this respect, particular emphasis should be placed on high-risk, early-stage technologies with potential for general-purpose breakthroughs. Green innovation requires a significant dose of risk-taking by public institutions, and an acceptance that there will be failures. New support models that provide numerous and still sizeable grants and R&D subsidies in a relatively non-bureaucratic way are crucial to unleash frontier ideas. Green industrial policymaking should avoid deploying money only to safe bets with only average returns. In this sense, a new green industrial policy should be a portfolio, with some initiatives within the portfolio failing along the way. A portfolio with no failures entails no risks.

At global level, a case that is frequently presented as a flagship initiative with regard to public funding for early-stage risky innovation is DARPA, an agency of the US Department of Defence responsible for the development of emerging technologies. Over the last decades, DARPA has significantly contributed towards many technologies embedded in our computers and smartphones, from microchips to GPS, from voice recognition technologies to the internet itself. The success of DARPA relates to the overall US economic ecosystem, which strongly favours innovation, and to its capability in translating disruptive innovations into marketable products – also through public procurement. That is, DARPA is an illustration of how public funding for innovation alone does not guarantee industrial development. DARPA's limited budget, around $3 billion per year, shows that creating the conditions for making innovative products marketable – also through public purchase of goods and services – is as important as public funding itself.

At the European level, there have been various initiatives aimed at replicating the DARPA success story. Back in 2005, the French government established a DARPA-like agency aimed at investing in disruptive technologies such as nanotechnology and biotech. Notwithstanding the initial endowment of €2 billion, the initiative proved not to be successful and quickly vanished. In 2018, the German government set up the Agentur zur Förderung von Sprunginnovationen, an agency aimed at promoting breakthrough innovations, again modelled on DARPA. More recently, the EU established the European Innovation Council (EIC) to support disruptive innovators, also working on green technologies.

However, the main EU tool in this area is Horizon Europe, which can be seen as a key component of the EU's green industrial policy toolbox not only for its focus on green technologies and projects, but also due to its attempt to put into practise a new industrial policy vision of an institutionalised process of collaboration between institutions, the private sector and civil society. Horizon Europe is indeed built on missions, and each one has a Mission Board of 15 high-level experts and an Assembly that brings together a larger number of experts from academia, industry, civil society, finance and end-users to foster iterative collaboration.

It is very important to appreciate that while innovation is key in any industrial policy action, it is even more important in the green space. That is, as the world needs to develop the technologies that are necessary to replace fossil fuels, innovation becomes a key driver of

decarbonisation. To appreciate the importance of innovation policy for the green transition, it might be useful to remind the historical role of innovation policy in the development of solar panels. Governments were indeed critical in bringing solar PV from the laboratory to the market, stimulating early adoption and spurring continuing innovation, but no single country was instrumental. The first demonstrations of PV cells were made in the 1950s in the United States by Bell Labs. US dominance of the technology persisted through the 1970s under the supervision of NASA, which had sizeable public R&D funds, and which began using PV in satellites and shuttles. The oil shocks of the 1970s spurred Japan and the United States to increase their public funding for PV research in a quest for more secure energy sources. In the US, companies were spun off from government-regulated laboratories and found niche business opportunities for PV. In Japan, companies like Sharp were helped by the government to build production facilities and they too found market niches. Throughout the 1980s and 1990s, PV for electricity production was uncompetitive except for off-grid customers with a willingness to pay a high price for small amounts of power. Suppliers in the United States, then Japan and then Germany were, however, able to scale-up as a result of government procurement and incentive policies in these countries. As the potential became more apparent to researchers in more countries, R&D funding increased, the number of patents accelerated and costs fell. Of particular significance in helping to create a market were government feed-in tariff programmes, first in Germany in the 1990s, then in Italy, Spain, the United States, China and India by the 2010s. These programmes, backed by rising deployment targets, targeted grid- connected systems and provided the guaranteed scale-up needed for global supply chains. At this point, patenting peaked and the market consolidated around a dominant design – unleashing economies of scale, and massive cost reductions that today the whole world can enjoy.

Policy tool #2: competition policy to push firms to innovate

Beyond the role of the public sector in funding early-stage risky innovation, companies have a crucial role to play in translating this research into new products[2]. Ensuring that companies have the right incentives to invest in research and development is a key parameter of the transition, and the degree of competitive pressure is an important determinant.

Innovation helps companies earn extraordinary profits by having better production processes, products and services than their competitors. It also supports their ability to maintain these profits through time by staying ahead of the competition. Competitive pressure allows for an efficient allocation of innovation effort because it encourages companies to target resources to the most commercially promising innovative ideas, and crucially, to cut resources when these activities cease to look promising. Finally, it also spurs innovation by punishing non-innovators with shrinking market shares and profits.

However, the relationship between the degree of competition and innovation activity is not straightforward. The relationship between market power and innovation is a longstanding research topic with diverse theoretical and empirical results (e.g., Schumpeter 1942, Arrow

[2] Measuring private R&D devoted to green technology is difficult. According to IEA three quarters of clean energy R&D is done by business while one quarter by governments: www.iea.org/reports/clean-energy-innovation/global-status-of-clean-energy-innovation-in-2020

1962, Gilbert and Newbery 1982, Cohen 2010, Aghion et al. (2021), Gilbert (2020)). Overall, the literature indicates that market structure impacts innovation in a complex way.

While more competition increases the incentives to innovate, it reduces the means to do so. Neck-and-neck competition reduces the free cash-flow of companies and their ability to fund innovation activities internally (Aghion et al. 2005). The ability of firms to attract external finances to fund innovation then becomes all the more important.

More generally, the market structure also affects which companies innovate. High fixed costs of entry tend to generate oligopolistic market structure as seen in many decarbonisation-related sectors (e.g., energy industry; energy intensive manufacturing). This seems to affect the locus of innovation effort within complex supply chains. There tends to be more innovation in the non-oligopolistic segments, where more modular technologies ensure contestability. This can be seen for example in electricity production, where wind and solar PV compete against large complex power plants. In sectors that do not easily support multiple providers – such as electricity transmission and distribution, railroads or logistics services – we observe very little R&D by incumbents (Popp et al. 2020). In those parts of the supply chain where market-incentives for innovation are weak, regulation or public ownership might have to step in to foster innovation.

This divergence in the innovation incentives between different actors also affects the type of innovation[3]: while larger incumbents are suited to developing incremental innovations, small new firms are better at developing radical innovation (D'Estea et al. (2011), Christensen (1996), Hamiltan and Singh (1992), Henderson (1993)). This is particularly relevant in the case of the transition to net-zero, as it will involve the emergence of new business models and new technology solutions. Start-ups have an important role to play in contributing disruptive ideas that enable more efficient transition pathways. Policies should ensure that new market players with different backgrounds can bring new ideas and different capabilities to old sectors that are dominated by incumbents.

Finally, having a more integrated markets across regions or countries not only increases the degree of competition that innovators are exposed to, but it also guarantees higher benefits from investments in successful technologies. This is particularly important in sectors with high upfront costs in R&D and subsequently in infrastructure, such as energy provision and electricity generation. In fact, increasing the potential customer base of energy companies makes risk-taking more appealing because the returns of fruitful investments will be higher.

As innovation is so crucial for an efficient transition, policymakers, especially competition authorities, should put a high value on protecting and encouraging competition in green sectors in the many cases where it is good for innovation.

[3] Market power over a complementary asset may allow a firm to capture value from innovative effort (Teece 1986). One might expect more innovation from incumbents in sectors where businesses can create market power through complementary assets. By the same token however, an incumbent's dominance of a necessary complementary input may dissuade entry by others, potentially resulting in less innovation and dynamism in the sector. The sector-wide effect is ultimately unclear.

Technology transfer and diffusion

One of the main objectives of the Paris Agreement is to facilitate the adoption and diffusion of green technology in developing nations and strengthen these nation's abilities to withstand and adapt to climate impacts. This is what is generally defined as technology transfer, i.e. the shift of inventions, materials, and technical knowledge from the pioneer of a technology to a secondary user or group of users. These transfers of technology can be advantageous to both developed and developing nations as the impacts of climate change do not discriminate between rich and poor, but adversely impact every country and people. But so far, this technology transfer has not represented a success story, due to several bottlenecks.

Historical role of technology transfer in the UNFCCC process

Since the establishment of the UNFCCC, technology transfer has been a crucial feature for supporting developing countries on climate change. According to Article 4 of the Convention: "All Parties…shall: (c) Promote and cooperate in the development, application and diffusion, including transfer, of technologies… that control, reduce or prevent anthropogenic emissions of greenhouse gases…". This establishes the key clause that all nations have a responsibility to coordinate the transfers of climate technology. No longer is it a moral responsibility alone, but by consenting to the Convention, nations agreed to recognize their responsibility contractually.

But how to facilitate these transfers? Article 4 continues stating that: "The developed country Parties… shall take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to other Parties, particularly developing country Parties, to enable them to implement the provisions of the Convention…". Specifically, developed nations take responsibility here to help finance and facilitate these climate technology transfers to developing nations.

In 2001, building upon previous agreements, countries crafted the technology transfer framework to enhance the implantation of article 4. The technology transfer framework is centered on 5 main themes for technology needs, these are: technology needs and needs assessments, technology information, enabling environments for technology transfer, capacity building for technology transfer and mechanisms for technology transfer.

In 2007, these themes were expanded with 4 sub themes appearing to specify further how to aid in the technology transfer process for climate technologies. These themes included: innovative financing, international cooperation, internal development of technologies, and cooperation in research and development.
Climate technology transfers are not simple, requiring extensive human capital training, infrastructure building and financing. So further elaboration on the procedures and the mechanisms of new bureaucratic bodies was necessary. To tackle the micro level needs of nations and communities as well as the large-scale issues facing the globe, more was needed.

Key public institutions and policy mechanisms for technology transfer and diffusion

To manage the process of these transfers, the UNFCCC established various institutions and mechanisms to guide and oversee the technology transfers. However, the creation of new administrative bodies are not themselves a signal of success, but rather can be hinderances or examples of virtue signaling without action. Below is a brief exploration of when these groups came about, what their established purpose is and how they are intended to aid or assist in the technology transfer process.

In 2010, the Technology Mechanism was established by the UNFCCC with the express purpose of furthering climate technology development and transfer. The Technology Mechanism is made up of two organizations that work together, the Technology Executive Committee (TEC) and the Climate Technology Centre and Network (CTCN). TEC analyzes policies and makes recommendations to countries to help in enhancing climate technology efforts. It is made up of 20 technology experts from a variety of countries, both developed and developing. CTCN instead works with implementation within countries, supporting nations and enhancing their implementation of climate technology projects and programs.

The last two pieces of the UNFCCC's support system are the Technology Framework and the technology needs assessments. The Technology Framework acts as part of the vision of the Technology Mechanism, providing guidance for its work in advancing and facilitating technology transfer and development. It was established by article 10, paragraph 4 of the Paris Agreement to pursue the long-term vision of technology development and transfer stated in article 10, paragraph 1.

Meanwhile, the Technology Needs Assessments (TNAs) work to find a solution by better understanding the problem through a more complete analysis of each country's climate technology needs. To ascertain the extent of their needs, nations undergo these assessments which determine how best to reduce GHG emissions and adapt to the impacts of climate change. Since 2001, more than 85 nations have undertaken TNAs which have supported national sustainable development, increased technological growth, and facilitated the implementation of climate technologies.

Another institution overseeing the technology transfer is the Technology Bank for the Least Developed Countries, established by the General Assembly in 2016. This body prepares assessment reviews on science, technology and innovation needs and digital access to research. It is charged with identifying technological gaps, prioritizing needs and providing recommendations to build national and regional technological capabilities. There are 46 countries labeled by the UN as Least Developed.

The rationale behind all these institutions is to help developing nations industrialize and modernize without the same climate impacts of GHGs that current developed nations caused in the industrial revolution. Developed nations have a moral responsibility to share this knowledge and technology if they also want to prevent developing nations from using GHG producing methods for modernization and growing their GDP. Developing nations also need to accept and prioritize the implementation of these technologies in their respective countries. If done successfully, GHGs can be greatly reduced, and climate collapse can be prevented. Otherwise, GHG producing methods will remain prevalent as the main way for nations to industrialize and raise the standard of living.

Public policy-induced technology transfer and diffusion: what data tells

A recent report from the World Bank (Pigato et Al, 2020) illustrates how not much has been done in recent history in this field. Between 2017 and 2020, 134 of the world's developing nations accounted for less than 10% of global imports of low-carbon technology (LCT), meanwhile the top 10 wealthiest nations accounted for more than 50% of LCT imports each year.

Good news exists however, as LCT becomes cheaper, more frequently traded and a source of future innovation. The World Bank finds that in just eight years between 2010 and 2018, the installed cost per gigawatt fell for solar power by 80%. This cost savings in the industry of LCT was furthered by a drop of 54% for energy storage and 22% for onshore wind power. On the innovation side, the total number of LCT inventions tripled in the two decades following 1990, and the value of LCT exports in USD has grown twenty times. From $43.6 billion in 1990 to $809 billion in 2017.

Reporting from the Climate Technology Centre and Network (CTCN) is more optimistic. In the group's most recent report it declares 106 developing nations served, 320 climate technology transfers implemented, 12.9 million expected tonnes of CO2 (eq) reductions per year, with more than 100 million anticipated beneficiaries. This group has been tracking technical assistance requests from developing nations since 2014. In Q2 of 2021 there were 316 requests which were being processed, a third of which were completed. This shows remarkable growth from 241 such requests in processing at the same time the year prior. Since mid 2019, in fact, the rate at which these technical assistance requests have been designed, implemented, and completed has greatly increased. This shows that while the world may be falling short on many of its climate goals, rapid progress is being made.

Key bottlenecks and possible way forward for public policy-induced technology transfer and diffusion

Several bottlenecks continue to throttle the rate at which new LCT technologies are being adopted by poorer nations. These obstacles range from insufficient funding and motivation on both supply and demand sides, legal and regulatory issues, different priorities, poor communication and distribution of information, limited human capital in green technologies, intellectual property rights.

Often focused on the supply side, the perspective of developing nations, who make up the demand side of this equation, is often lost. Their largest need consistently is overcoming the cost of installation and operation of these technologies. LCT require integrated technical knowledge and supply chains. The World Bank's report on LCTs states that low carbon technologies are particularly difficult as they have high up-front capital requirements, highly complex production inputs, and face deep-seated inertia and competition from the fossil fuel industry.

Another great area of complication is communication. This comes in many forms, from language barriers, a lack of communication of important details, or culturally ineffective forms

of communications. English is not only the main international language, but it is also the main language of science and technology.

Motivation on both demand and supply sides is another obstacle. Many of these technologies are poorly situated to adapt to local needs, which hurts local uptake. Developing nations lack the motivation to adopt technologies that do not immediately benefit their citizens as they combat pressures to industrialize and fight poverty. Further, the top 3 polluting nations – the US, China and India – account for 50% of all emissions. Further still, only the top 20 emitters are responsible for 80% of all GHG pollution. There does not seem to be much prioritization by these nations to go green when the culpability of carbon pollution heavily falls on one side of the equation. Much larger problems face the governments of these developing nations. Developed nations face many concerns too, like energy security concerns. Considering the current conflict with Ukraine, motivation to split from fossil fuel sources and to share low carbon technologies is low. The recent rise in energy insecurity has caused setbacks in moving away from brown energy sources as Europe and other parts of the world face the possibility of a cold winter without gas or electricity.

To overcome these bottlenecks better policy are needed in the field of technology transfer. It requires substantial policy efforts on both a domestic and international level to overcome the barriers above, however progress is achievable.

On the domestic side, policies that can promote LCT transfers include creating demand for LCT products and encouraging innovation through policies such as subsidies, public procurement, and financing. A lack of these resources is a major problem noted by developing nations, which find that the internal funding and support structures for the implementation of LCT and other climate technologies fall short and hinder progress. Another key component necessary for successful implementation domestically is complementary investment in human capital, infrastructure, and financial markets. Without these a country cannot make proper use of climate technology it receives. Proper investment in these complimentary resources increases a country's ability to absorb and utilize technology.

In the international sphere, policies that can facilitate this process more successfully include reducing trade and foreign direct investment restrictions on low carbon technologies. This can be achieved through international trade and investment agreements. Additionally, a formal process through which international institutions can acquire and make available LCT patents to the poorest countries is necessary for integrated implementation. This helps overcome the issues of communication through standardization. Additionally, it has been long argued that strong patent protections incentivize technology transfers and implementation, however this is uncertain. The previously mentioned World Bank report (Pigato et Al, 2020) finds that strong IPR protections have no significant effect on LCT transfer from either high-income or developing countries. Therefore, it stands to reason that other solutions, such as relaxing IPR protections on green tech or patent sharing programs, should be further investigated.

Much remains to do in the field of technology transfer. There is great potential to enact change and counteract climate change if the world can act together in facilitating these transfers across borders. Better policies and roadmaps are required if nations hope to

succeed in this. The first step has been to understand the problem, now it is time to be the solution.

Technology transfer and diffusion through commercial interactions

On top of the illustrated public policy mechanisms, technology transfer and diffusion can also happen through commercial interactions such as foreign direct investment (FDI) and trade.

Such interactions can indeed play a role in fostering the transfer and diffusion of green technology to developing countries. FDI and trade can provide the financial resources and technical expertise needed for the development and implementation of green technology in these countries. In particular, FDI can help to build the infrastructure and support systems necessary for the successful adoption of green technology.

That is, FDI and trade can provide developing countries with access to new technologies, knowledge, and expertise that can help them transition to more sustainable and environmentally friendly practices. This can be particularly important for countries that may not have the resources or infrastructure to develop their own green technologies. But for FDI and trade to expand and enable technology tranfer and diffusion, certain barriers need to be overcome.

One example is legal and regulatory barriers. Take the example of renewable energy. Most developing countries have by now adopted renewable energy targets, but achieving them ultimately relies on the presence of sound and stable renewable energy regulatory frameworks. On this front, efforts remains to be done in several countries. For instance, renewables have been 'locked out' of many countries as a result of distorting fossil fuel subsidies, as well as the simultaneous presence of risk and uncertainties, weak institutions, and inadequate grid infrastructure. Frequent changes in feed-in-tariff schemes are, for instance, a concern for investors in several developing countries, while in other countries the lack of an independent regulatory authority or of a fully developed regulatory framework is also a matter of concern for investors. Concrete solutions to be promoted in specific countries might include measures to increase clarity and transparency of rules; to provide legal and administrative support to international energy companies willing to invest in the country; to enhance transparency and clarity of rules in dispute procedures and to shorten dispute resolution timeframes; to phase-out fossil fuel subsidies; to establish one-stop-shops for renewable energy permits.

Another example is financial barriers. Currency convertibility, inflation and lack of foreign reserves are concerns for investors in several developing countries. The cost of financing and the limited availability of debt from commercial sources for renewable projects represent a general challenge in several countries, though to different degrees. These barriers are felt either through non-availability of finance or inflexible grace periods that are not adapted to the characteristics of such investments. Developing countries can take action to overcome these barriers, for instance by reforming their energy sectors in order to unleash private investment. In this space, concrete solutions to be promoted in specific countries might include measures to enhance local banks' capacities and ranges of instruments for supporting international investors; to establish a more stable central-bank monetary policy; to encourage

transactions and power-purchase agreements with a more stable currency; to establish favourable tax regimes for renewables.

Green market creation

Once a new green technology has been developed through green innovation or made available through technology transfer, it is necessary to bring it to the market. But scaling up new technologies is not straightforward. Prototypes need to be tested and demonstrated in real world situations to become the first commercial-scale generation of the technology. If successful, this might mark the early adoption of the technology in niche markets. Thanks to further innovation, technological enhancements and efficiency gains, new generations of the technology can then be developed at lower costs and through economies of scale become mature and scalable. The market alone might not deliver on this, because of market failures such as abuse of market power, network effects and coordination failures. Policy intervention is required to tackle these issues.

The politically but also technically most challenging intervention with this regard possibly is designing efficient markets. Well-designed markets with robust regulatory oversight will often be the only realistic option for benefiting from the efficiencies of markets, without falling for the inefficiencies arising from market power especially in sectors dominated by network economies. This is not made easier by the fact that market design is a continuous process – that is at constant risk of being taken over by the incumbents.

Many of the sectors relevant for the green transition have characteristics (network effects, scale and scope economies, platform-effects, high capital-specificity,…) that imply that unregulated markets either underinvest in socially desirable capital (e.g., back-up capacities) or that market concentration makes resource allocation inefficient. Coordination problems are likely to further exacerbate inefficiencies. To produce efficient results, market rules need to be put in place that provide market actors with incentives that are aligned with maximising citizens welfare. Moreover, governments can pursue different degrees of engagement with the private sector, all the way to direct state control.

Finally, a huge expansion in green investment is needed. For instance, the IEA's (2021b) net-zero pathway estimates that global energy capital investments must increase from a current yearly average of about $2 trillion to $5 trillion (2019 prices) by 2030, after which they must stay at almost the same level until 2050. As a fraction of global GDP, this would be an increase from 2.5 percent today to 4.5 percent in 2030, followed by a gradual decline back to 2.5 percent. The private sector will need to cover most of the investments. By creating efficient markets for green capital goods with different forms of public funding, governments can pave the way for the private sector to take over the investment burden.

Policy tool #1: credible climate policy to provide a clear direction to companies and investors

Climate targets are an important tool of green industrial policy, as they give a clear direction to companies and investors in terms of the decarbonisation trajectory. Setting strong climate targets for tomorrow, if backed-up by legislation to effectively turn them into practice, can have a major influence over the behaviour of the private sector already today. It should be

noted that the difference in time horizons between policy planning and political cycles makes achieving coherent and sustained green industrial policy efforts extremely challenging. In this sense, clear climate targets – particularly if enshrined into law – also protect green industrial policy from significant uncertainty.

For example, the EU's pledge to reach climate neutrality by 2050 and its target of reducing emissions by at least 55 percent by 2030 compared to 1990 send a clear signal to market players about the irreversibility of the EU's climate trajectory. But to be credible, these targets need to be supported by detailed legislation. Changes are needed, for example, in the design of the emissions trading system (ETS), the effort sharing regulation (ESR) for non-ETS emissions and the energy taxation directive. Major challenges include how to cut the number of ETS allowances given out for free (a concern for industry), how to put a price on emissions coming from the transport sector (e.g. inclusion in the ETS versus national taxation), how to use ETS revenues (allocated to the central EU budget or to national budgets, support for green investments or alleviation of the distributional effects of climate policy), and how to design a functional carbon border adjustment mechanism.

Always to remain in the European case, EU legislation on renewable energy and energy efficiency will also need a substantial upgrade. EU 2030 targets for renewable energy and energy efficiency at time of writing (respectively, a 32 percent share of final energy consumption, and a 32.5 percent improvement against a baseline) will only deliver greenhouse gas emissions reductions of 45 percent by 2030. The EU must find ways for its countries to deliver on higher targets in the absence of nationally binding commitments, and for private investment to be really mobilised (one example is simplification of permitting procedures for renewables). Other important areas of EU legislation, including transport and agriculture, will have to be revised to push the decarbonisation of these sectors.

Policy tool #2: fostering regulatory innovation

Innovation is needed not only for technological solutions, but also in terms of policies and regulations to bring about the transition. Hence, competition between different regulatory systems also has the potential to let new solutions emerge.

Different regulatory and policy approaches between countries have improved the common understanding and selection of the most effective policies for the roll out of low-carbon technologies. For example, comparing different regulations in Germany and in Sweden, Midttun and Gautesen (2007) infer the appropriateness of two policies according to the maturity phase of renewable technologies. Feed in tariffs or specialised auctions, preferred in Germany, seem to be particularly good for technologies in early deployment, following the research and development phase. In contrast, certificates, preferred in Sweden, appear to be better in later stages of development. In fact, the authors note that "…tariffs have the advantage of allowing differentiation and specific pricing of individual technologies, thereby permitting simultaneous development of a broad spectrum of technologies. In later phases, where some technologies develop performance characteristics closer to established incumbent technology, niche markets, such as the certificate markets will probably provide a more adequate stimulus to further commercialisation before full competitiveness in the mainstream market is achieved."

Such normative competition between systems has probably sped up convergence towards more efficient and politically workable tools while fostering the adoption of the fittest renewable energy sources. For instance, countries at the forefront of solar energy production, including Denmark, Germany, the Netherlands and Spain, have shown how photovoltaic solar can win technology-neutral tenders against any other renewable technology. Regulatory convergence is now emerging around the auctioning of feed-in premiums as the most common policy framework for incentivising the adoption of renewable energy sources. This is the standard price-setting mechanism in the Czech Republic, Denmark, Germany, Italy, the Netherlands, Estonia, Finland, Slovenia, Slovakia and Spain.

Policy tool #3: competition policy to facilitate an efficient green tech deployment

Relatively light-handed interventions to protect virtuous competition, such as adjusting the competition authority toolkits, can contribute to the decarbonisation objective. For example, reshaping market definitions (e.g., when investigating decline brown sectors), clear rules on how to evaluate green efficiencies (e.g., to prevent green-washing) or state-of-the-art market monitoring (e.g., in certificate markets) can go a long way to prevent abuses of market power that threaten efficient resource allocation.

Competition rules are primarily devised to address the strategic behaviour of companies with market power that result in inefficient allocation of resources. The main powers given to competition authorities in advanced economies are: to prohibit anti-competitive agreements between companies (e.g. cartels), to punish or prevent abusive practices by powerful firms, and to block mergers that threaten to significantly reduce competition.

But competition policy tools interact with other externalities. In the course of their work, competition authorities may find that some ostensibly anti-competitive practices have environmental benefits. An industry-wide agreement to phase out energy-intensive washing-machines may restrict competition, for example, but promise to reduce carbon emissions. Conversely, competition authorities may find some industrial actions acceptable on pure-competition grounds, but alarming for environmental reasons. They could, for instance, be called to rule on an acquisition by a dirty incumbent that wants to delay greening its production process by eliminating a competitor—one that exerts little competitive pressure, but commands green potential.

Consumers often care about purchasing sustainably, and they are willing to pay for it (Volpin, 2020). Consuming more sustainable products thus increases consumers' welfare. Nine in ten Europeans (94%) say that protecting the environment is important to them personally and a third believe that changing consumptions patterns is the most effective way of tackling environmental problems (Eurobarometer, 2017). This is a strong motivation for companies to distinguish themselves from competitors by offering more sustainable products.

Competition for sustainability is hence a driver for innovation and a speedier transition – and policy should encourage it. Under current competition policy practices, environmental protection is not treated as a standalone non-economic goal to be defended in the same way

that market integration is. Nor has environmental protection justified derogation from competition rules.

In Europe, where the competition authority has considered environmental concerns, it has done so as an element of consumer welfare, more specifically, as a 'quality' of products. That is, competition policy is not blind to consumers not only wanting cheap, but also sustainable products, as sustainability is clearly a dimension of the "quality" of products and services that consumers care about. "Quality" is a key dimension of competition under EU law. When firms compete on quality, any agreement or behaviour that artificially weakens quality may be subject to a prohibition. In the context of mergers for example, the European Commission states that "competitive harm caused by a reduction of quality [is] on an equal footing with an increase of prices, or a reduction of output, choice of goods and services" (European Commission, 2013).

Degradations of sustainability as a result of mergers, acquisitions and abuse of market dominance can already be considered by competition authorities, by referring to the negative impact on "green quality". But it becomes very difficult for competition authorities if such degradations need to be balanced against potential benefits for consumers (e.g., lower cost) from the same case. Marginal sustainability gains should not automatically allow companies to engage in anticompetitive behaviour to the detriment of all-economy resource allocation. Hence, the assessment will remain an exercise in the weighting of the arguments – with more visibility of the sustainability effects.

Policy tool #4: developing public-private partnerships

To develop a successful green industrial policy, policymaking has to be embedded with the private sector. Public-private partnerships are not only about activating co-funding, but are also ways to access skills, knowledge and information. This requires a high degree of interaction between the public and private sectors, and collaboration should be iterative since the solutions are not assumed as known, but only as discoverable. The literature and case studies show that the design of public-private partnerships can take different forms. Deliberation councils, investment advisory councils, round tables, public-private venture funds and smart development banks are all examples of ways in which governments can make operational the principles described above.

One example of fruitful public-private partnership is the format of European Alliances, which has been employed since 2017 for batteries and since 2020 for clean hydrogen. The principles for a new green industrial policy should serve as guidelines when selecting and governing new alliances. Alliances should focus on addressing mega-problems covering the whole value chains of all relevant clean markets, rather than solving more discrete problems. In general, green industrial policy should also employ a balanced mix of alliances involving already-connected value chains that need to be scaled-up and very early-stage emerging value chains with still-to-be-connected stakeholders, even if the latter are higher risk choices that will result in higher failure rates.

Given the complexities of both green industrial policy and the policy-making machinery in advanced economies, strong governance is a prerequisite for effective green industrial policy.

It is crucial for efficient coordination of different types of stakeholders and for the management of different policy governance areas, different instruments and different projects. First, the various partners must be incentivised with a set of balanced, clear, credible and time-consistent commitments. Second, it is necessary to set clear and realistic intermediate goals throughout the process to promote more risk taking. Third, flexible policy design is required to cope with the uncertainties of new green technologies, with clear intermediate targets and milestones that can be monitored in order to strengthen policy measures over time. Fourth, it is key to ensure accountability, with incentives and penalties where needed.

Implementing all this requires strong governance, which should be based on three principles: competence, ownership and political independence. This could be provided through a governance body that is politically independent but still fully accountable. Ensuring the coordination and cooperation of multiple government players, each responsible for aspects of policy needed for green industrial policy, and ensuring that they will work together, requires a central figurehead. This person should be selected externally, based on their skills, and given political independence and broad powers to coordinate and run dedicated green industrial policy. The various administrations in charge of the wide array of policy tools needed to activate green industrial policy should also be closely connected. These include the energy, transport, cohesion and reform, budget, trade, innovation and competition policy portfolios.

Policy tool #5: direct state control

The economics in some sectors make it very difficult to engineer virtuous competition between companies, even with sophisticated market rules. Moreover, it is difficult to design markets such that they produce the most politically desired resource allocation and distributional results. Direct state control of essential pieces of infrastructure might end up being optimal, but the costs and benefits need to be evaluated on a case-by-case basis.

The level of state-ownership in the economies has varied across countries and over time, reflecting different understandings of the relative importance of market imperfections, trust in indirect tools to address them and imperfections of direct public management. Striking examples of these differences are the energy sectors of France and Germany, where state-ownership has remained constant in the former, while it went through a phase of liberalisation in the 1990s and some re-communalisation in the 2010s in the latter.

Furthermore, as indicated by the discussion on new industrial policy, state control in specific sectors comes in degrees. It can range from (i) very light touch provision of company coordinating services that actually even shield companies against certain policies, (ii) via medium level interventions such as strongly regulating the activities of private companies through specific agencies, public-private partnerships and minority shareholdings to (iii) very heavy handed direct control through majority shareholding in essential companies (e.g., platforms or network providers) or even complete value chains (electricity and rail sector in several EU countries).

One way of intervening here is to allow governments to take some temporary coordination role, as for example tried with "EU industrial alliances", being careful these initiatives do not end-up protecting incumbents. Another example is regulation. Since a regulatory agency can never be completely independent of political influences, its intervention can shift from providing a solution to market failures, to creating a barrier to entry protecting the market position of regulated firms. As in standard network utilities, regulation can become a form of barrier against technological change that may create inefficient path dependence and reduce dynamic competition.

Policy tool #6: stimulating green investments

Investment for the deployment of existing technologies will be important to realise the green transition. This includes mobilising funds from national budgets and from the private sector, for example with feed-in tariffs, which attract initial private investment in clean energy production by temporarily offering guaranteed above-market prices for the output, or with tax credits and purchasing subsidies for green capital goods. National budgets can also directly contribute to kickstarting green markets through the use of green public procurement (e.g. governments can electrify their car fleet, allowing producers of charging infrastructure to scale up and lower prices).

Clear public spending targets, such as the EU's decision to devote 30 percent of its budget for 2021-2027 to climate action, are necessary steps. But these goals need to be well defined. In particular, it is important to ensure that the shares of public budgets that are not targeted towards green activities do not actively counter-act green spending by going into activities that increase emissions. In addition, current international accounting rules need to clearly define which activities can truly be considered green investment. The risk of green-washing is high, especially given that emissions reducing activities are very diverse, ranging from agricultural subsidies to research and innovation funding. For all these reasons, a solid methodology for monitoring and regularly reporting climate spending should be developed (Claeys and Tagliapietra, 2020).

Mazzucato and Penna (2016) propose a revived role for development banks as channels for entrepreneurial states to direct finance towards ambitious societal goals, such as the green transition. Fernandez-Arias et al (2020) study smart development banks in more detail as facilitators of new activities within a new industrial policy perspective. Well-designed development banks can help governments discover where problems and failures lie. They should engage in the search for nascent economic activities that face obstacles from market or government failures. This requires intelligence gathering and dissemination of lessons learned rather than simply providing credit. Development banks should transmit information on market and government failures to the relevant agencies. Fernandez-Arias et al (2020), in a survey of development banks, concluded that current practice is very far from what they propose. Nevertheless, they believe that development banks can be reoriented to exploit the complementarities between their lending and intelligence gathering. In the European context, the European Investment Bank (EIB) can take on this role, as the EU's 'smart climate development bank'.

Finally, Important Projects of Common European Interest (IPCEI), a vehicle for channelling public funding into priority industries, are an example of European industrial policy.

Focus on the specificities of developing countries: the issue of local content requirement

While what has been described in this section does apply to any country in the world, it is important to appreciate that certain specificities exist in the case of developing countries. In particular, it is important to outline the role of a specific policy, local content requirement, to help developing countries foster the diffusion of green technologies in their economies and make sure they organically grow with the domestic industries.

UNCTAD (2014) defines local content requirements as provisions, usually under a specific law or regulation, that commit foreign investors and companies to a minimum threshold of goods and services that must be purchased or procured locally. From a trade perspective, local content requirements essentially act as import quotas on specific goods and services, where governments seek to create market demand via legislative action. They ensure that within strategic sectors – particularly those with large economic rents, or vehicles where the industry structure involves numerous suppliers – domestic goods and services are drawn into the industry, providing an opportunity for local content to substitute domestic value-addition for imported inputs. Thus – in contrast to the traditional protected export platform proposed by many development advocates in the 1960s and 1970s – local content requirements seek to attract FDI by firms. Moreover, through local content requirements, government can achieve these goals often without sharing in the risk of commercial undertakings.

Local content requirements have long been utilised by both developed and developing nations in an attempt to foster the domestic manufacturing of certain technologies. Local content requirements are most often imposed as a precondition for access to government programs that guarantee above-market prices for renewable energy producers, known as feed-in-tariff programs. They are also imposed as part of eligibility requirements in renewable energy public tenders. The issue now features prominently in the global economic debate, as the US Inflation Reduction Act does include strong local content requirements as a way to fix supply chain bottlenecks and decrease reliance on foreign countries, and especially China. In this context, local content requirements are controversial, as they may be seen as protectionist measures that can limit access to global markets and raise the cost of goods and services for consumers. This is, for instance, the way Europe sees such provisions under the Inflation Reduction Act. It is thus important for policymakers to carefully consider the potential benefits and drawbacks of local content requirements when deciding whether and how to implement them.

Having said this, local content requirements can certainly help developing countries foster green technologies by requiring that a certain percentage of a project's components or materials be sourced from within the country. This can be a way for them to create demand for domestic production of green technologies, which can in turn drive investment and innovation in the sector. Some countries with large renewables markets have sought to create domestic supply chains and jobs by implementing local-content requirements. However, as the cases of Brazil, South Africa and India also illustrate (Bazilian et Al, 2020), companies in developing countries might focus on taking on roles that are more easily borrowed from other

industries, such as project development or less sophisticated ancillary services, rather than setting up manufacturing capacity in core green technologies. If badly designed, local content rules might even contribute to increasing project costs, thus slowing down green market creation. Setting realistic expectations about which precise steps of the supply chains can viably be targeted by local requirements rules is thus a fundamental prerequisite to make it work for the benefit of a more organic growth of green technologies in developing countries.

Green market protection and expansion

After having established a receptive domestic market for green technologies to grow, it is then important to ensure level playing field vis-à-vis third countries with weaker climate policy and to expand this green market beyond national borders. This external dimension of green industrial policy might be conceived along two main directions.

On the one hand, there is a need to make sure that climate policies do not compromise a country's industrial competitiveness *vis a vis* third countries with less ambitious climate targets. With this regard, a potential solution that has been advanced in recent years is to impose an import tariff on carbon intensive goods, which is discussed in this section.

On the other hand, even when domestically, competitive green markets are already in place, there are several hurdles to overcome for firms that wish to export to other markets. This includes a lack of knowledge about how to navigate foreign regulations and finding foreign partners. It also includes the need of firms to get public support in form of blended finance instruments (e.g., guarantees, concessional loans, grants) to cover part of the country risk (i.e., the uncertainty inherent to investing within a given country, due to macroeconomic, regulatory or political issues). Furthermore, it is also important to consider that there might be a misalignment of incentives to make socially optimal export choices.

Policy tool #1: carbon border adjustment measures

Carbon border adjustment measures are aimed at preventing the risk of carbon leakage. This policy tool entails placing a tariff on imported goods on the basis of their carbon content - i.e., the GHG emitted during their manufacture. The amount of this tariff should mirror the level of the domestic carbon price. Consequently, goods with low or zero carbon content will pay low or zero carbon border adjustment accordingly. On the other hand, a fair carbon border adjustment measure would be discounted according to the carbon price paid in the country of origin, if there is one. High-carbon goods can thus pay a low or zero carbon border adjustment, provided that their production is located in a country where the carbon price is similar or even higher.

Carbon border adjustment will be necessary in any country that intends to seriously scale-up its climate action. That is, carbon border adjustment is not about protectionism, but about ensuring a level-playing field in a situation in which some countries are doing more than others to implement their decarbonisation pledges. In fact, such measures are compatible with the World Trade Organization (WTO). The General Agreement on Tariffs and Trade (GATT) indeed allows a charge "equivalent" to an internal tax on "like domestic products" to be imposed on imported products (Art. II:2 (a) and Art. III:2). Furthermore, pursuant to Art.

XX, measures that are "necessary to protect human, animal or plant life or health" may always be imposed, if they are not applied in an arbitrary or discriminatory manner. To be WTO-compliant, carbon border adjustment measures only need to be commensurate with domestic climate efforts and must be designed in a clear and transparent manner to minimise the risk of protectionist abuse (Mehling et Al, 2018).

Policy tool #2: green export promotion

Green export promotion concerns services to facilitate exports by domestic firms. This can entail providing information and advice to bridge cultural gaps, to understand administrative processes in foreign markets and to reduce trade costs, as well as matching buyers and sellers. It can also entail providing blended finance support to stimulate exports and green investments in developing countries.

In principle, such services could be provided cheaply to multiple firms by a private consultancy or by an industry organization, thus overcoming the problem of information failure affecting individual firms. But governments are often seen as more reliable intermediaries and as having more privileged access to information and relations with governments of destination markets than private entities. Moreover, very few private organisations have the means to provide export support across the whole world like governments do through their embassies and consulates (Wilson and Leicester, 2021)

Blended finance support plays a very important role in fostering the export of green technologies and the undertake of green investments in developing countries characterized by high country risk. The rationale for blended finance is motivated by a series of market failures and market imperfections in receival countries – such as regulatory instability, lack of workable financing institutions, currency volatility, etc. The provision of guarantees, concessional loans or grants might help overcome these issues – generally referred to as country risk – and allow firms to export their green technologies in rapidly growing markets . This is also how international development policies can assist in the creation of global green tech markets while at the same time meeting international climate commitments and sustainable development goals.

Promoting green exports can also be achieved through means such as environmental standards and green provisions in trade agreements. Big economies such as the EU could for example use their status as an international standard setter to create the foundation for international green tech markets in which the own green technologies can easily be traded. They can also require compliance with strict environmental regulations as a condition to access their markets, which represents a strong incentive for trading partners to green their production processes. This in turn can stimulate foreign demand for domestically produced green tech (Leonard et al., 2021).

The example of the EU Global Gateway

On 1 December 2021, the European Union unveiled the Global Gateway, its plan to support infrastructure development around the world. This would mobilise €300 billion between

2021-2027 for connectivity projects, notably in the digital, climate and energy, transport, health, education and research sectors.

The rationale behind this initiative is clear: the world needs major infrastructure investments. The World Bank estimates that to achieve the goals of climate and environmental protection, universal access to energy, water and sanitation, greater mobility, and improved food security, the world must invest around €1.3 trillion per year in infrastructure.

China understood the strategic importance of global infrastructure development when it launched the Belt and Road Initiative in 2013. To provide an alternative to the Chinese approach to global infrastructure development, some G7 leaders committed in June 2021 to "a values-driven, high-standard, and transparent" set of infrastructure partnerships: the US's Build Back Better World, the UK's Clean Green Initiative and the EU's Global Gateway.

The European Commission pitched the Global Gateway as "a template for how Europe can build more resilient connections with the world", but critics quickly attacked the initiative, claiming it represents a repackaging of existing instruments rather than fresh EU cash.

However, this view misses the point. The EU and EU countries are already the world's leading providers of official development assistance (ODA). In grant equivalent (a methodology in which only the grant elements of loans are reported, instead of their full-face values), Europe disbursed €66.8 billion in 2020, 46% of world's total. What Europe really needs is not new resources, but to use existing ones more strategically.

To further put things into perspective, between 2014 and 2018 the EU and EU countries provided around €350 billion in ODA grant equivalent, while the Belt and Road Initiative (BRI) – against which the Global Gateway is being compared – provided around €200-€400 billion in loans, according to different estimates of the American Enterprise Institute and UNCTAD. Given that a grant represents a much bigger financial contribution than a loan, Europe's role as a donor is thus more significant than that of China or any other country.

The problem is that EU action in the field is fragmented into countless initiatives, undertaken at both EU and national levels. As clearly outlined by the High-Level Group of Wise Persons on the European financial architecture for development, this has led to overlaps, gaps, inefficiencies and lack of geopolitical stance.

The Global Gateway represents an important step in the process of consolidation of Europe's development finance, and an important one because of its focus on the strategic issue of infrastructure development and connectivity.

The real question will be how well strategic coordination between EU countries and EU institutions and financial institutions will work. The attempt to improve that coordination is positive, but whether it will succeed remains to be seen.

Infrastructure investments are the material way of turning sustainable development goals into practice. Climate action requires renewable energy plants, power grids and electric vehicle charging infrastructure, in the same way that health requires hospitals, education

requires schools or connectivity requires ports. By promoting Europe's values in the world, the Global Gateway can thus also become the export arm of a new EU industrial policy.

It can help meet the EU's international pledges, such as on climate finance, by supporting partner countries in the implementation of their sustainable development agendas. It can enable EU industry to enter new growing markets, a win for EU industrial policy. On top of this, it can help economic development in the EU's partner countries, providing an invaluable foreign policy dividend for the EU.

In geopolitical terms, the Global Gateway can help the EU better position itself in the global infrastructure and connectivity race. Rule-based cooperation focused on a clear set of priorities represents an attractive alternative to the BRI in several partner countries, starting in Africa. By scaling up cooperation on economic and social infrastructure projects, the EU thus has an opportunity to promote its values and vision of sustainability in a way that is tangible and long-lasting.

In implementing Global Gateway, the EU will have to work closely with like-minded partners to develop synergies between their respective efforts on connectivity and quality infrastructure with third countries and achieve the maximum impact in closing the global infrastructure gap.

This cooperation will have to be extended to all aspects of the Global Gateway, including coordination of policies, collaboration on and co-financing of joint or parallel projects, joint engagement with host countries, the private sector and international financial institutions, and cooperation in the context of relevant international standard setting forums.

Green industrial policy entails risks: good governance is essential

As we have now amply illustrated, green industrial policy is a highly complex area, which encompasses a wide range of policy interventions spanning from innovation policy to competition policy, from fiscal policy to trade policy. This complexity, coupled with the overall sensitive issue of public intervention into the economy, does entail risks. Governments are indeed not omniscient, efficient, and benevolent actors. Bureaucracies and policy makers have their own sources of "failures" that sometime prevent them from reaching efficient results.

As the experience of industrial policy shows, especially in the traditional vertical style that prevailed during the 1960s and 1970s, public intervention raises three related challenges. The first is the capacity of bureaucrats and administrators to access information to allocate public resources correctly (by picking winners and subsidising them). The second is the inherent bias of public administrations to favour the status quo. The third challenge stems from the incentives for rent seeking and "capture" inherent in any policy that redistributes rents.

The market failure justification of industrial policy emphasizes lack of information as a key obstacle for the functioning of the economy. This implies that to implement a first-best correction, policymakers would have to master an extraordinary range and depth of knowledge and information, which the market participants themselves do not possess, at

least individually. Policymakers would have to be knowledgeable about firms and industries that generate knowledge spill-overs, the relative amount of learning by individual firms from others and from their own experience, the precise path of such learning over time, the magnitude of the cost disadvantage at each stage of the learning process, and the extent to which early entrants generate benefits for future entrants. The breadth of knowledge and skills needed to implement an optimal policy would exceed that possessed by almost any institution.

More generally, government decisions, about resource allocation (e.g., R&D budgets) or regulations (e.g., on market rules), do not follow the logic of price-based resource allocation. Politicians compete for voters and campaign funding, bureaucracies compete for power, and decision-makers for careers. These incentives are often more aligned with the interests of incumbents, than with those of the general public that might benefit from a fairer treatment of new entrants. Accordingly, administrations are, for example, worse at stopping projects that turn out inefficient, which is a prominent problem in a transition with a lot of uncertainty. They also set standards and regulations that tacitly form barriers against technological change. For example, rules to protect specific rights in a status quo market might become so complex that only large players can safely navigate them. As government decisions shape the structures of competition in markets that will be crucial for an efficient resource allocation in the transition, preventing an undue bias towards the interest of incumbents goes far beyond the role of competition authorities and courts.

Finally, distortions could arise from lobbying efforts through which vested interests try to capture rents arising from public finances. Where accountability and transparency are lacking, pervasive lobbying efforts and corruption have resulted in inefficient and socially suboptimal allocation of rents (Schmitz and Altenburg, 2015).

The presence of implementation challenges that place first-best policies out of reach does not entirely rule out policy intervention. The effectiveness of industrial policy ultimately has to be evaluated on the basis of its realised outcomes compared to no intervention. However, even on this criterion, the justification for industrial policy is equivocal. The history of industrial policy in Europe provides many examples of failures, such as the loss to the United States of the race to develop computers in 1960s and 1970s, the loss to Japan of the race to develop semiconductors in the 1980s and 1990s, and the failure of Concorde, the British-French project to develop the first supersonic passenger aircraft. Such examples of failed programmes have strengthened the case for a laissez-faire approach to industrial policy.

At a more systematic level, larger-scale evaluation studies most often have looked at the impact of trade protection, R&D subsidies and tax credits, and general subsidies. Also in these studies one can find cases – such as subsidies for specific industries or public procurement programmes – which have distorted the market, resulted in the picking of the wrong firms and have burdened the taxpayer with disappointing returns[4]. The big problem with evaluation studies is to determine what would have been the outcome if no intervention had taken place. More recent studies, which try to deal better with causal identification and to correct for the

[4] For a review, see Noland & Pack (2003); Dechezleprêtre et al (2020), Rodrik (2004), Aiginger and Rodrik (2019); Aghion et al (2014).

non-random selection of projects, show that industrial policy can be effective in stimulating activities, but much depends, unsurprisingly, on the policies used and the institutional context.

A long-standing tension exists between the ability of markets to allocate resources efficiently and that of governments to intervene to improve rather than worsen market mechanisms. The main conclusion is that policy makers need to get away from simplistic state-or-market narratives. The focus should be on developing politically feasible frameworks for leveraging the benefits of competition that go beyond a focus on static efficiency to encourage useful investments in new systems and innovation. The role of institutions that determine resource allocation in the transition is an underappreciated but crucial area of policy action. A new wave of academic debate has sought to improve the design of industrial policy and proposed a new framework.

This new industrial policy perspective, which started with the work of Rodrik (2014), is an attempt to move beyond the ideological division between state-driven intervention and purely market-based solutions. It argues for a smart combination of both. Going back to the fundamental role of markets as institutions to mobilise resources, new industrial policy is best understood as a process. In the words of Rodrik (2014), new industrial policy should strive to be a "process of institutionalised collaboration and dialogue rather than a top-down approach" in which the government picks sectors or firms and transfers money to them. The private sector has to be one of the three fundamental stakeholders in this collaboration, in which the other two elements are the government and civil society.

That is, green industrial policy should be designed in a way that makes it easier for the state to build policies based on the knowledge that resides in the private sector, while being legitimate from the point of view of civil society. The state's role should be to identify constraints and opportunities, in order to develop solutions that bring together private and public capacities and information, with aligned public and private motives, in a very pragmatic way. A modern framework should address the issues of rent-seeking and political capture, and all the inefficiencies and risks that lie at the intersection between the public and the private sectors, by effectively combining incentives and regulatory constraints, and building in accountability and transparency.

Rodrik (2014) posits three pillars for this theoretical framework: i) embeddedness; ii) discipline; iii) accountability[5].

The concept of embeddedness (or embedded autonomy) dates back to the work of Evans (1995). It starts from the notion that different stakeholders have specific characteristics, and that governments do not know in advance where market failures will occur. Therefore, government agencies have to be embedded with the private sector and have access to their information in order to leverage it to design policies. Embeddedness thus requires a high degree of collaboration between the public and private actors, which should work closely to discover solutions. In the Rodrik interpretation, new industrial policies by definition assume

[5] This framework is also used in Altenburg and Rodrik (2017); Ambroziak (2017); Altenburg et al (2017); Andreoni and Chang (2019); Fernández-Arias et al (2020).

that trust and competences can be developed over time. Embeddedness relies on a continuous, fair and open dialogue between the different stakeholders, something that could be defined as policy learning.

To avoid the risk of moving too slow or staying inactive in the face of high uncertainties and high risks of failure, experimentation is crucial. Policies designed as learning experiments can help to reduce risks, provided that they are closely monitored and adjusted when new information arises. Monitoring will be required to deal with failures and mistakes. The instruments and tools used by industrial policy might initially not be the correct ones or might not work as planned. Testing and learning can offset these problems if built into the design of the policy.

Governments should not start with the presumption that solutions are known, and industrial policy built on experimentation would ensure that the focus is no longer on 'picking winners', but much more on 'letting losers go' (Hallegatte et al, 2013). Openness to failure should be a characteristic of the design of industrial policy, which should incorporate uncertainty in its process. As Rodrik (2014) put it, "failure is part and parcel of a successful industrial policy effort". A new industrial policy approach would therefore be a portfolio approach, with some initiatives within the initial portfolio failing along the way. A portfolio with no failures entails no risks.

While embeddedness and collaboration represent a way to solve the information problem, they also entail the risk of capture and of provision of distorted information. While embedded, government agencies should not be 'in bed' with the private sector. The implementation of embeddedness must take into account informational asymmetries between different partners and how asymmetries change over time. To deal with the risk of political capture, industrial policy should include monitoring and transparency mechanisms, as well as mechanisms to align private and public incentives. To activate private agents and prevent 'cheating', proper incentives and accountability need to be in place.

Transparency on incentives and accountability mechanisms should be facilitated by roadmaps and clear government communication (Kemp and Never, 2017). A process of open policy dialogue should ensure a high degree of accountability. Accountability will be critical to the success or failure of industrial policy exercises. Civil society will play an important role in new industrial policy (Bowles and Carlin, 2020). In the bottom-up policymaking which the embedded model involves, civil society including NGOs, trade unions, activist groups and citizen lobbying initiatives, must be as engaged as the private and public sectors in policy design.

So far, this discussion on the design of new industrial policy has focused on promoting and improving existing economic activities. Designing industrial policy for activities that do not yet exist is a very different challenge, and one that is particularly relevant in the domain of green innovation.

Mariana Mazzucato has introduced the notion of the 'entrepreneurial state', whereby the role of the state should not be conceived merely as stepping into the economy to solve market failures, but also to act as market creator when markets for the most innovative solutions do

not yet exist (Mazzucato, 2011). She furthermore proposes a broader "mission-oriented" approach to industrial policy (Mazzucato, 2018). Society should set itself a restricted number of ambitious missions, taking into account the diverse range of stakeholders. The prominent mission used to illustrate this argument is the Apollo program of the United States, which set the goal of landing humans on the Moon.

Policies should then be designed to direct economic and technical change towards reaching these missions. Broad acceptance of the missions would be rooted in citizen engagement, via multi-stakeholder consultations. This system also implies setting concrete but ambitious milestones during the process. The United Nations' Sustainable Development Goals would be examples of missions, according to Mazzucato (2018). Meeting these goals requires a new toolkit that goes beyond fixing failures in existing markets. Strategic public investment in many different sectors should open up new industrial opportunities, to be developed further by the private sector.

This new stream of work on a new industrial policy provides fresh ideas on how to put in place a workable green industrial policy to help markets reconcile economic prosperity and climate objectives. The good news is that, notably in the European Union, these concepts are now well understood. It Is now a matter of good policy-making and good governance to implement them. Should the world be able to embark into such a process, achieving the green growth - techno-optimistic - view about global absolute decoupling of economic growth and GHG emissions will be at hand.

References

Acemoglu, D., P. Aghion, L. Bursztyn and D. Hemous (2012) 'The environment and directed technical change', American Economic Review 102(1):131-166, available at http://dx.doi=10.1257/aer.102.1.131

Acemoglu, D., P. Aghion, L. Barrage, and D. Hemous(2019), 'Climate Change, Directed Innovation, and Energy Transition: The Long-Run Consequences of the Shale Gas Revolution,' *Working Paper,* 2/2019 Harvard University, available at https://scholar.harvard.edu/files/aghion/files/climate_change_directed_innovation.pdf

Acemoglu, D., U. Ackigit, D. Hanley, and W. Kerr(2016), 'Transition to Clean Technology', *Working Paper*, 1/2016, MIT, available at https://economics.mit.edu/files/11668

Aghion, P., A. Dechezlepretre, D. Hemous, R. Martin and J. Van Reenen (2016) 'Carbon taxes, path dependency and directed technical change: evidence from the auto industry', Journal of Political Economy, 124(1):1-51, available at https://doi.org/10.1086/684581

Aghion, P., R. Bénabou, R. Martin and A. Roulet (2021) 'Is Market Competition Clean or Dirty?' American Economic Review: Insights, forthcoming' *The Quarterly Journal of Economics* 120(2):701-728, available at https://econpapers.repec.org/article/oupqjecon/v_3a120_3ay_3a2005_3ai_3a2_3ap_3a701-728..html

Aghion, P., N. Bloom, R. Blundell, R. Griffith, and P. Howitt(2005), 'Competition and Innovation: an Inverted-U Relationship'

Aiginger, K. and D. Rodrik(2020), 'Rebirth of Industrial Policy and an Agenda for the Twenty-First Century' *Journal of Industry, Competition, and Trade* 20: 189-207, available at https://link.springer.com/article/10.1007/s10842-019-00322-3#citeas

Altenburg, T. and D. Rodrik (2017) 'Green industrial policy: Accelerating structural change towards wealthy green economies', Green Industrial Policy

Alenburg, T. et al(2017) 'Green Industrial Policy: Concept, Policies, Country Experiences', *Working Paper,* 12/2017, UN and DIE, available at https://stg-wedocs.unep.org/handle/20.500.11822/22277

Altenburg T., O. Johnson, and H. Schmitz (2015) 'Rent management – The Heart of Green Industrial Policy', New Political Economy 20(6): 812-831

Ambroziak, A.(2017) 'The New Industrial Policy of the European Union' *Springer*

Andreoni, A. and H.J. Chang (2019) 'The political economy of industrial policy: Structural interdependencies, policy alignment and conflict management', Structural Change and Economic Dynamics 48: 136-150

Arrow, K. (1962) 'Economic Welfare and the Allocation of Resources for Invention', Volume Title: The Rate and Direction of Inventive Activity: Economic and Social Factors (pp609 - 626), Princeton University Press

Baldwin, R. (1969) 'The Case against Infant-Industry Tariff Protection' *Journal of Political Economy* 77: 295-305

Barbieri, N., A. Marzuchi, and U. Rizzo(2020), 'Knowledge sources and impacts on subsequent inventions: Do green technologies differ from non-green ones', Research Policy, 49(2), available at https://www.sciencedirect.com/science/article/abs/pii/S0048733319302197#:~:text=We%20find%20that%20green%20technologies,partially%20by%20novelty%20and%20complexity.

Bazilian et Al (2020), *Local-content rules for renewables projects don't always work*. Available at: https://www.sciencedirect.com/science/article/pii/S2211467X2030122X

Bowles, S. and W. Carlin (2020) 'Shrinking capitalism', American Economic Review, Papers and Proceedings 110: 372-377

Cherif, R. and F. Hasanov(2019) 'The Return of the Policy That Shall Not Be Named: Principles of Industrial Policy' , *Working Paper* 3/2019, *IMF*

Christensen, C. and J. Bower(1996) 'Customer power, strategic investment, and the failure of leading firms.' *Strategic Management Journal* 17: 197-218

Claeys, G. and S. Tagliapietra(2020) 'Is the EU Council agreement aligned with the Green Deal ambitions?' *Policy Contributions* 07/2020, *Bruegel*, available at https://www.bruegel.org/2020/07/is-the-eu-council-agreement-aligned-with-the-green-deal-ambitions/

Cohen, W. (2010) 'Fifty Years of Empirical Studies of Innovative Activity and Performance', Handbook of the Economics of Innovation, pp129-213, available at https://doi.org/10.1016/S0169-7218(10)01004-X

Cosme, I., R. Santos and D. O'Neill (2017) 'Assessing the degrowth discourse: a review and analysis of academic degrowth policy proposals', Journal of Cleaner Production, 149: 321-334, available at https://doi.org/10.1016/j.jclepro.2017.02.016

Demaria, F., F. Schneider, F. Sekulova and J. Martinez-Alier (2013) 'What is degrowth? From an activist slogan to a social movement', Environmental Values, 22(2): 191-215, available at https://doi.org/10.3197/096327113X13581561725194

D'Estea, P., S. Iammarino, M. Savonac and N. von Tunzelmann (2011) 'What hampers innovation? Revealed barriers versus deterring barriers', Research Policy, available at https://iris.luiss.it/retrieve/handle/11385/197495/101980/Research%20Policy

Eurobarometer (2017) 'Eurobarometer survey – Protecting the Environment', https://ec.europa.eu/commission/presscorner/detail/en/QANDA_20_330

European Commission (2013) 'The Role and Measurement of Quality in Competition Analysis - submission by the European Union', submission to the OECD

Evans, P.(1995) 'Embedded Autonomy: States and Industrial transformation', *Princeton University Press*

Fernandez-Arias, E., R. Hausmann, and U. Panizza(2020). 'Smart Development Banks', Journal of Industry, Competition, and Trade, 20(1):395-420, available at https://doi.org/10.1007/s10842-019-00328-x

Gilbert, R. J. (2020) Innovation Matters - Competition Policy for the High-Technology Economy, MIT Press

Gilbert, R.J. and D. Newbery (1984) 'Preemptive Patenting and the Persistence of Monopoly: Reply', The American Economic Review, vol 74, no1, pp251–253, available at http://www.jstor.org/stable/1803330

Ghisetti, C. and F. Pontoni, 'Investigating Policy and R &D effects on environmental innovation: A meta-analysis', Ecological Economics, 118(C): 57-66, available at https://www.sciencedirect.com/science/article/abs/pii/S0921800915003006

Hallegate, S., M. Fay, and A. Vogt-Schlib(2013) 'Green Industrial Policy: When and How', *Working Paper,* 12/2013, World Bank

Hamilton, W. and H. Singh (1992) 'The evolution of corporate capabilities in emerging technologies', Interfaces, vol22, no 4, pp13–23

Henderson, R. (1993) 'Under investment and incompetence as responses to radical innovation: evidence from the photolithographic alignment equipment industry', Rand Journal of Economics 24, pp248–270

IEA (2021b) Net Zero by 2050. A roadmap for the global energy sector, International Energy Agency, available at https://www.iea.org/reports/net-zero-by-2050

IEA (2021c) Tracking Clean Energy Progress, International Energy Agency, available at https://www.iea.org/topics/tracking-clean-energy-progress

Kallis, G. (2011) 'In Defence of Degrowth', Ecological Economics, 70(5): 873-880, available at https://doi.org/10.1016/j.ecolecon.2010.12.007

Kallis, G., V. Kostakis, S. Lange, B. Muraca, S. Paulson and M. Schmelze (2018) 'Research on Degrowth', Annual Review of Environment and Resources 43: 291-316, available at https://doi.org/10.1146/annurev-environ-102017-025941

Kemp, R. and B. Never (2017) 'Green transition, industrial policy, and economic development', Oxford Review of Economic Policy 33(1): 66-84

Lane, N. (2019) 'Manufacturing revolutions: Industrial policy and industrialization in South Korea', *Working paper*, Institute for International Economic Studies

Lenaerts, K., S. Tagliapetria, and G. Wolff (2021) 'Can climate change be tackled without ditching economic growth?', *Policy Contribution* 09/2021, Bruegel, available at https://www.bruegel.org/comment/can-climate-change-be-tackled-without-ditching-economic-growth

Leonard, M., J. Pisani-Ferry, J. Shapiro, S. Tagliapietra and G. Wolff (2021) 'The geopolitics of the European Green Deal', Policy Contribution 04/2021, Bruegel, available at https://www.bruegel.org/2021/02/the-geopolitics-of-the-european-green-deal/

Loehr, D. (2012) 'The euthanasia of the rentier—a way toward a steady-state economy?' Ecological Economics 84: 232–239, available at https://doi.org/10.1016/j.ecolecon.2011.11.006

Mazzucato, M. (2011) 'The entrepreneurial state', Soundings 49: 131-142

Mazzucato, M. (2018) Mission-oriented research & innovation in the European Union, Publications Office of the European Union, Luxembourg, available at https://op.europa.eu/en/publication-detail/-/publication/5b2811d1-16be-11e8-9253-01aa75ed71a1/language-en

Mazzucato, M. and C.C. Penna (2016) 'Beyond market failures: The market creating and shaping roles of state investment banks', Journal of Economic Policy Reform 19(4): 305-326

Mehling, M., H. van Asselt, K. Das, and S. Droege(2018), 'Beat protectionism and emissions by a stroke'*Policy Contributions*, 07/2018, Nature, available at https://www.nature.com/articles/d41586-018-05708-7

Midttun, A. and K. Gautesen (2007) 'Feed in or certificates, competition or complementarity? Combining a static efficiency and a dynamic innovation perspective on the greening of the energy industry', Energy Policy 35 , pp1419–1422, available at https://www.sciencedirect.com/science/article/pii/S0301421506001856

Noland, M. and H. Pack (2003) Industrial Policy in an Era of Globalization: Lessons from Asia, Peterson Institute for International Economics, Washington, D.C.

International Monetary Fund (2021), *Five things to know about carbon pricing*. Available at: https://www.imf.org/en/Publications/fandd/issues/2021/09/five-things-to-know-about-carbon-pricing-parry

Pigato et Al (2020), *Technology Transfer and Innovation for Low-Carbon Development*. Available at: https://openknowledge.worldbank.org/handle/10986/33474

Rodrik, D.(2014) 'Green Industrial Policy' *Oxford Review of Economic Policy* 30(3):469-491, available at https://drodrik.scholar.harvard.edu/files/dani-rodrik/files/green_industrial_policy.pdf

Schumpeter, J.A. (1942) 'Capitalism, Socialism, and Democracy', University of Illinois at Urbana Champaign's Academy for Entrepreneurial Leadership Historical Research Reference in Entrepreneurship, available at https://ssrn.com/abstract=1496200

UNCTAD (2014), *Local Content Requirements and The Green Economy*, available at: https://unctad.org/system/files/official-document/ditcted2013d7_en.pdf

World Bank (2021), *State and Trends of Carbon Pricing 2021*, available at: https://openknowledge.worldbank.org/handle/10986/35620

Volpin, C. (2020) 'Sustainability as a Quality Dimension of Competition: Protecting Our Future (Selves)', CPI Antitrust Chronicle, pp9-18