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Who is at the forefront of the green technology frontier? Again, it's the manufacturing sector

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Abstract

The development of green technologies is a pre-condition for effectively addressing climate change. Green technological change has accelerated in the last decade, pointing to a potential new technological revolution around the green economy. This policy brief explores who is driving this incipient revolution. We find that private sector firms in the manufacturing sector account for the lion's share of green patents at the global level. This finding underscores the crucial role industrial development plays not only in accelerating economic growth and job creation, but also in fighting the most pressing challenge of our times: climate change.

Key Messages

- 1.** New technologies to accelerate the transition to net zero have been steadily growing since 2000
- 2.** The manufacturing sector is the main engine of green innovation: 6 out of every 10 global patent applications for climate change mitigation technologies are submitted by industrial firms.
- 3.** A new divide is emerging: 85% of green patents are held by industrial firms from just five countries: Japan, China, USA, Germany and the Republic of Korea.

The green transition

The world is on the verge of a climate catastrophe. Meeting the goals of the Paris Agreement, which aim to reduce global warming by 2050 to below 2 degrees Celsius above pre-industrial levels, is one of the key challenges of the 21st century. Addressing this challenge requires not only a radical change in our consumption patterns but also of our production systems,¹ a shift that can only take place if we develop new green technologies, i.e. technologies aimed at protecting the environment and reducing the impact of human activities.

The shift towards environmentally friendly production is driven by cost-effectiveness and sustainability concerns. The pricing of instruments and subsidies, among others, are used to encourage the adoption of green technologies. Political dynamics, such as trade disputes and competition over standards, also play a significant role in shaping relevant policies.² Concrete action to promote green production through the development of

green technologies has varied between both developed and developing countries, as well as between different sectors of activity. But who is at the forefront of this new frontier?

Evidence is presented in this policy brief that manufacturing firms are the trailblazers of the green transformation. Industry, which has always been perceived as one of the major sources of the problem due to its high contribution to global greenhouse gas (GHG) emissions, is increasingly becoming part of the solution. However, our findings also alert to the high concentration of only a handful of highly industrialized countries in the production of green technologies. Addressing the climate change challenge calls for all countries, especially those at the beginning of their industrialization process, to more actively engage in the production of green technologies that are tailored to their local environment, needs and capacities.

The rise of green technologies

Technological revolutions come in waves. They need time to take off, but once they do, they permeate every aspect of our lives and radically change society's consumption and production patterns. Computer

technology, which fuelled the information and communication technology (ICT) revolution, is a case in point.

The first computers were introduced in the United States in the 1950s, but were extremely large and far

too expensive for the average consumer. The invention of the microprocessor in the early 1970s enabled the production of computers that were small enough to fit on a desk and that were affordable. Nonetheless, the expertise required to operate them limited their use to engineers and hobbyists. All this changed by the end of the 1970s when Apple introduced a microcomputer that was both small *and* user friendly.³ The introduction of computers rapidly impacted all areas of life ranging from industry to homes, thus dramatically changing our production and consumption patterns.

Green technologies—especially those associated with renewable energy—have the potential to drive a new revolution that could also affect most aspects of our lives.⁴ Evidence suggests that the production of such technologies started taking off at the beginning of this century.

One way of identifying technology trends is to analyse the number of patent applications in a specific field of technology. Patents protect inventors' right to exploit the economic benefits of their inventions. It is therefore highly likely that an individual, university or company that achieves an important technological breakthrough will patent it at home and in other relevant patent offices around the world. Several patents related to the same invention are typically bundled together in what is called "patent families". We can get a first glimpse of how this field is evolving by looking at how many new patent family applications are submitted in one particular field.

In this brief, we use patent data on green technologies to describe some salient features of the global technological landscape in this emerging field (see Box 1).

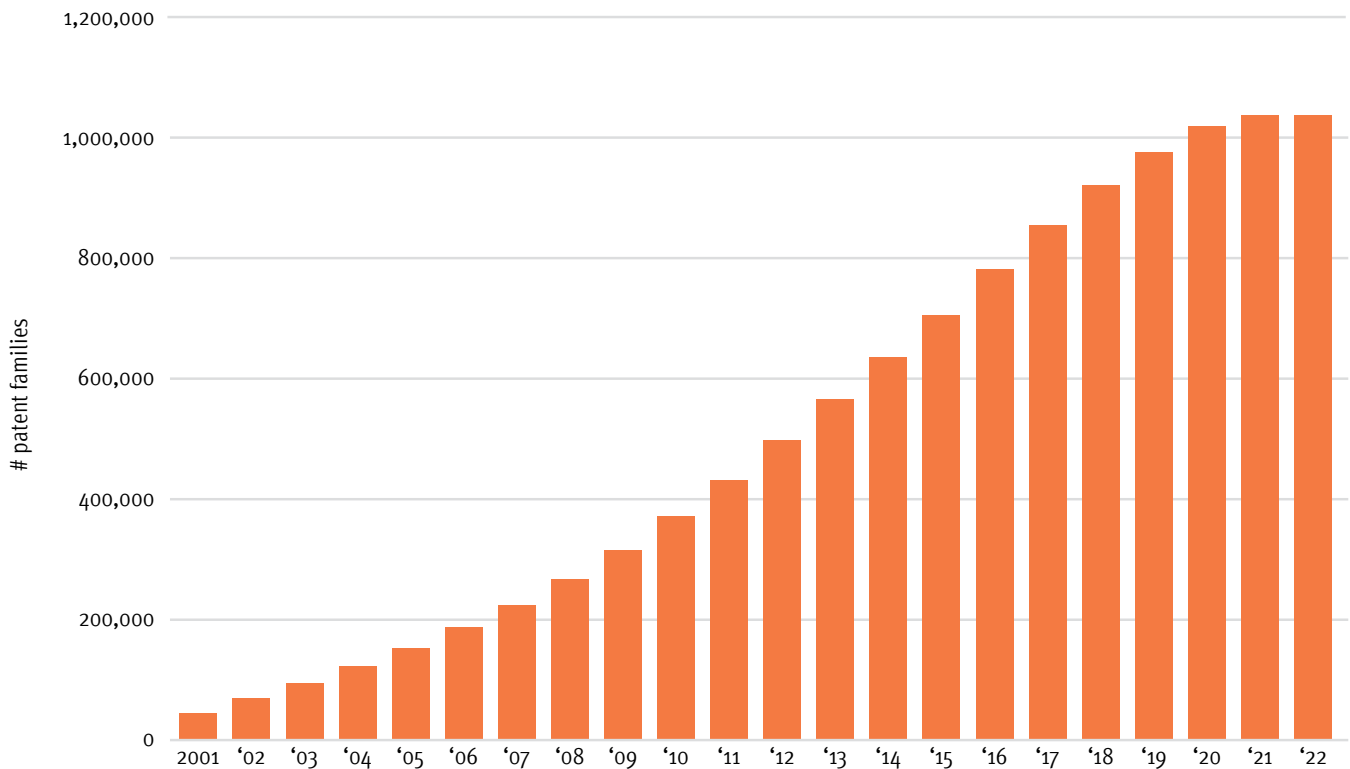
Green technologies -especially those associated with renewable energies- have the potential to drive a new revolution that would also affect most aspects of our lives.

Box 1. What are green patents?

Green patents can broadly be defined as technologies or applications that mitigate or adapt to climate change. Here, we identify them through the specific code Yo2 assigned by the European Patent Office (EPO)⁵. The Yo2 is a tagging scheme for patent documents related to climate change mitigation technologies developed by experienced reviewers who work in the relevant fields in collaboration with external experts. This has introduced an additional classification to the regular classification of such documents. The Yo2 class covers selected technologies that control, reduce or prevent anthropogenic emissions of GHG within the framework of the Kyoto Protocol and the Paris Agreement, as well as technologies that allow for the adaptation to the adverse effects of climate change.

A steady rise in the development of green patents in the last 20 years is evident (see Figure 1). Such patents increased 20-fold during this period, growing from around 50 000 to over 1 million. Their share in total global patenting (that is, in all technological fields) has also increased significantly, doubling between 2000 and 2021. This set of technologies presently accounts for about 10 per cent of all patent applications. It is expected that the green revolution will accelerate as governments implement ambitious programmes⁶ for a green recovery from the multiple crises currently affecting the global economy.

FIGURE 1: GLOBAL CUMULATIVE NUMBER OF GREEN TECHNOLOGIES (2001–2022)



Source: Authors' elaboration based on PATSTATS (autumn 2022 edition)

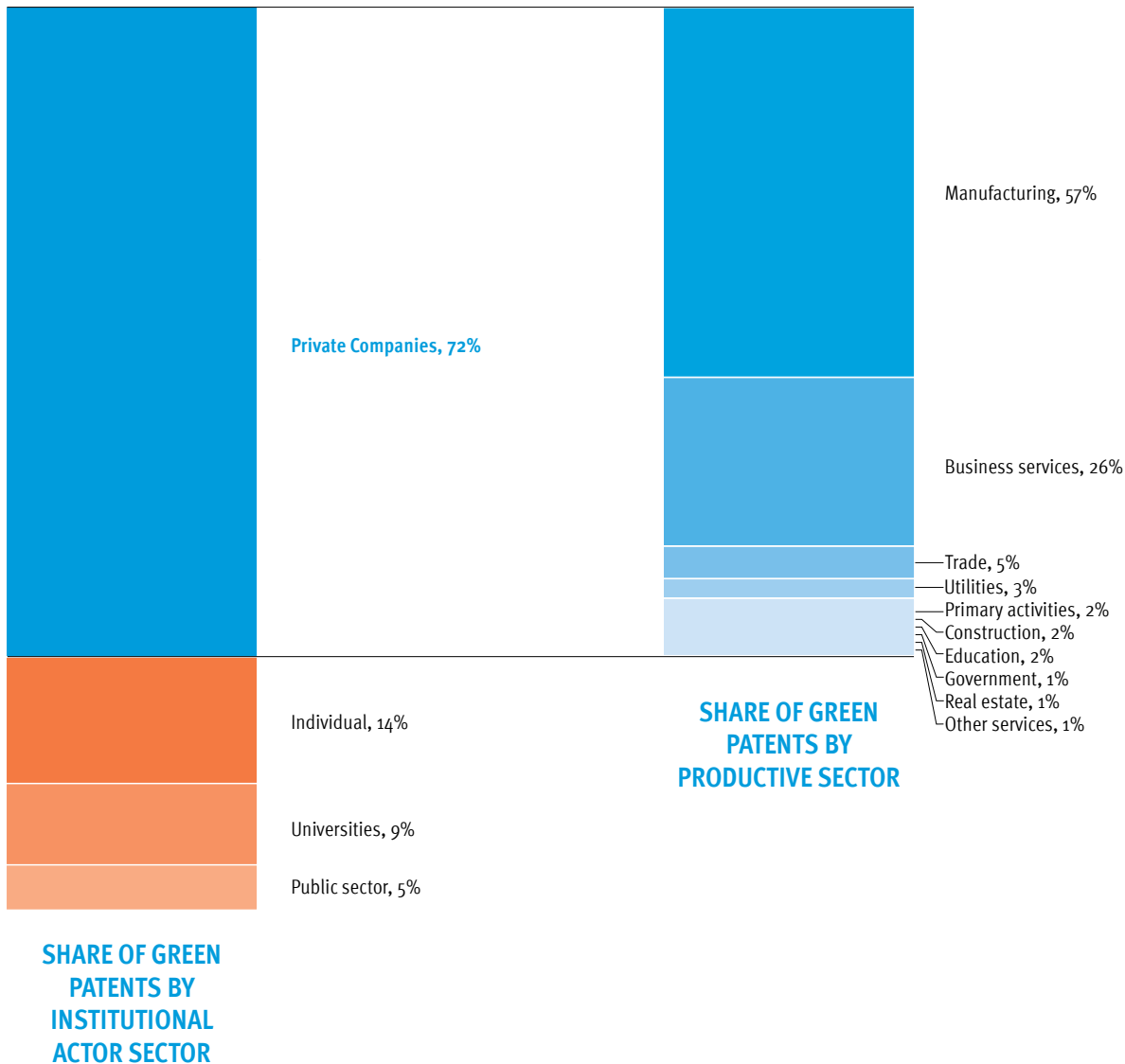
Engines of change

Green patents have been steadily growing since the early 2000s. We combine data from two globally recognized sources to identify the main engine of the green revolution: private sector companies operating in manufacturing industries (see Figure 2).

First, in terms of institutional actors, the lion's share of patents is held by private sector companies. According to PATSTATS data, private firms held over two-thirds of all

green technology patents submitted between 2000 and 2022. This was followed (at a considerable distance) by individuals, who held 14 per cent of all green patents, while universities ranked third at 9 per cent. Collaborations between companies and other institutional actors such as universities, government and non-profit organizations represented less than 1 per cent of all green patent applications.

FIGURE 2: GREEN PATENTS BY INSTITUTIONAL ACTOR AND PRODUCTIVE SECTOR IN 2022



Source: Authors' elaboration based on PATSTATS (Autumn 2022 edition) and ORBIS-IP

Second, the vast majority of private sector companies that hold green patents operate in the manufacturing sector. The specific sub-sectors the patenting firms operate in are unfortunately not recorded in the patent offices' datasets. Building on the Bureau Van Dijk (BvD) ORBIS-IP dataset, we can obtain additional information on green patenting firms, including on the sub-sector they operate in (see Box 2). Our estimates indicate that

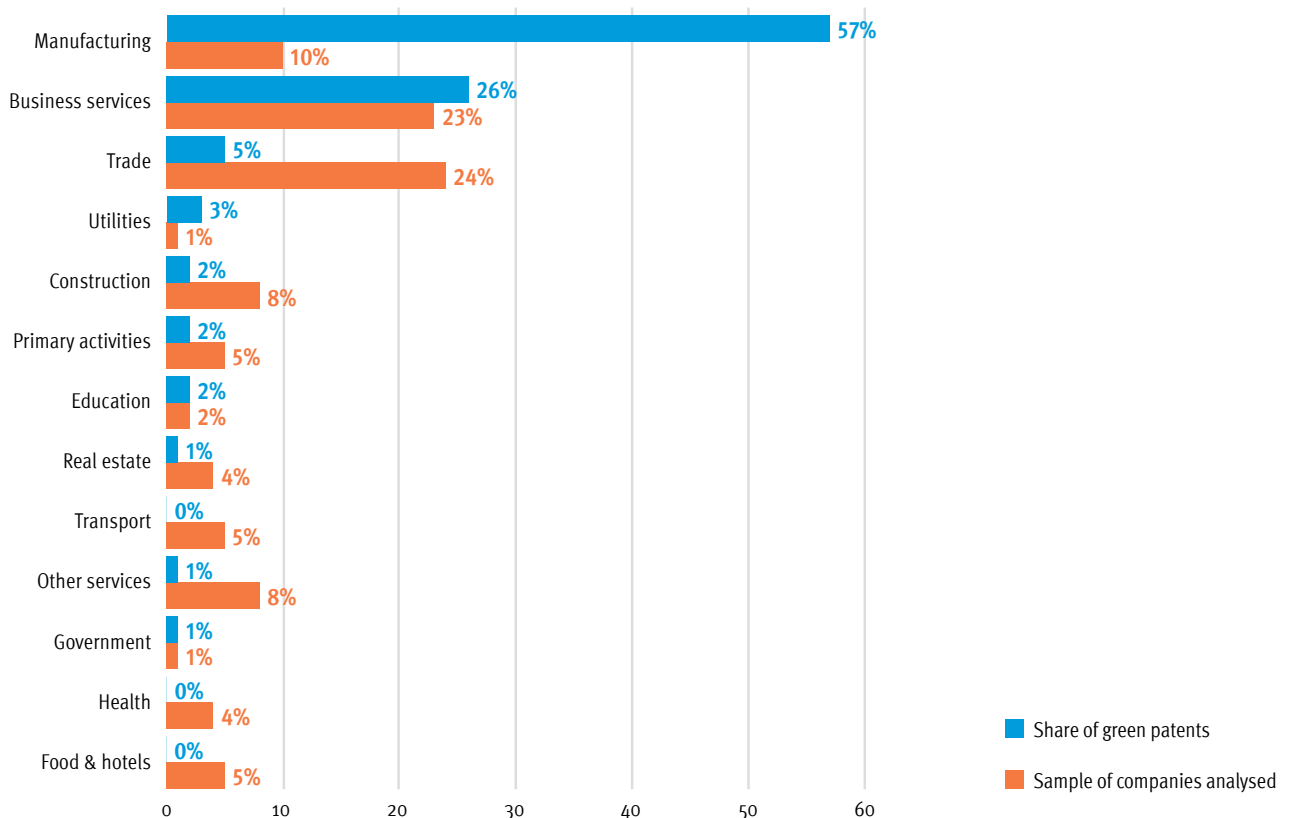
by 2022, 57 per cent of green patents from private sector companies were held by manufacturing firms. Green innovation activity was second highest in business services,⁷ which held 26 per cent of green patents, followed by trade (5 per cent). Other sub-sectors held negligible shares in total green patenting. The manufacturing industry clearly leads the green technology race among the various economic sub-sectors.

Box 2.
Identifying the sub-sectors green patenting companies operate in

We use data from the Bureau Van Dijk (BvD) ORBIS Intellectual Property dataset, which merges data on companies and patents, to identify the sub-sectors green patenting firms operate in. The dataset contains information on nearly 2.4 million companies, as well as data associated with over 140 million patents from 154 patent offices worldwide. The dataset also includes information on industry codes such as NAIC, NACE and SIC, as well as technology classifications such as IPC, CPC and USPC. Building on this dataset, we are able to determine the main sector of activity of firms holding a green patent.

The special significance of manufacturing in driving green innovation becomes clearer when we consider the relative size of this sector in the sample of private companies analysed (see Figure 3). Whereas manufacturing firms hold 57 per cent of all green patents, it only represents 10 per cent of the total population of firms in the ORBIS-IP dataset. This disproportionate participation in green innovation underscores the greater potential the manufacturing industry has in driving technological change compared to other sectors of the economy. In fact, the second largest green patent holder (business services) comprises a share of patents that is nearly equal to its share in the total population of firms in the dataset.

FIGURE 3: GREEN PATENTS AND NUMBER OF COMPANIES (PATENTING OR NOT), IN SHARES



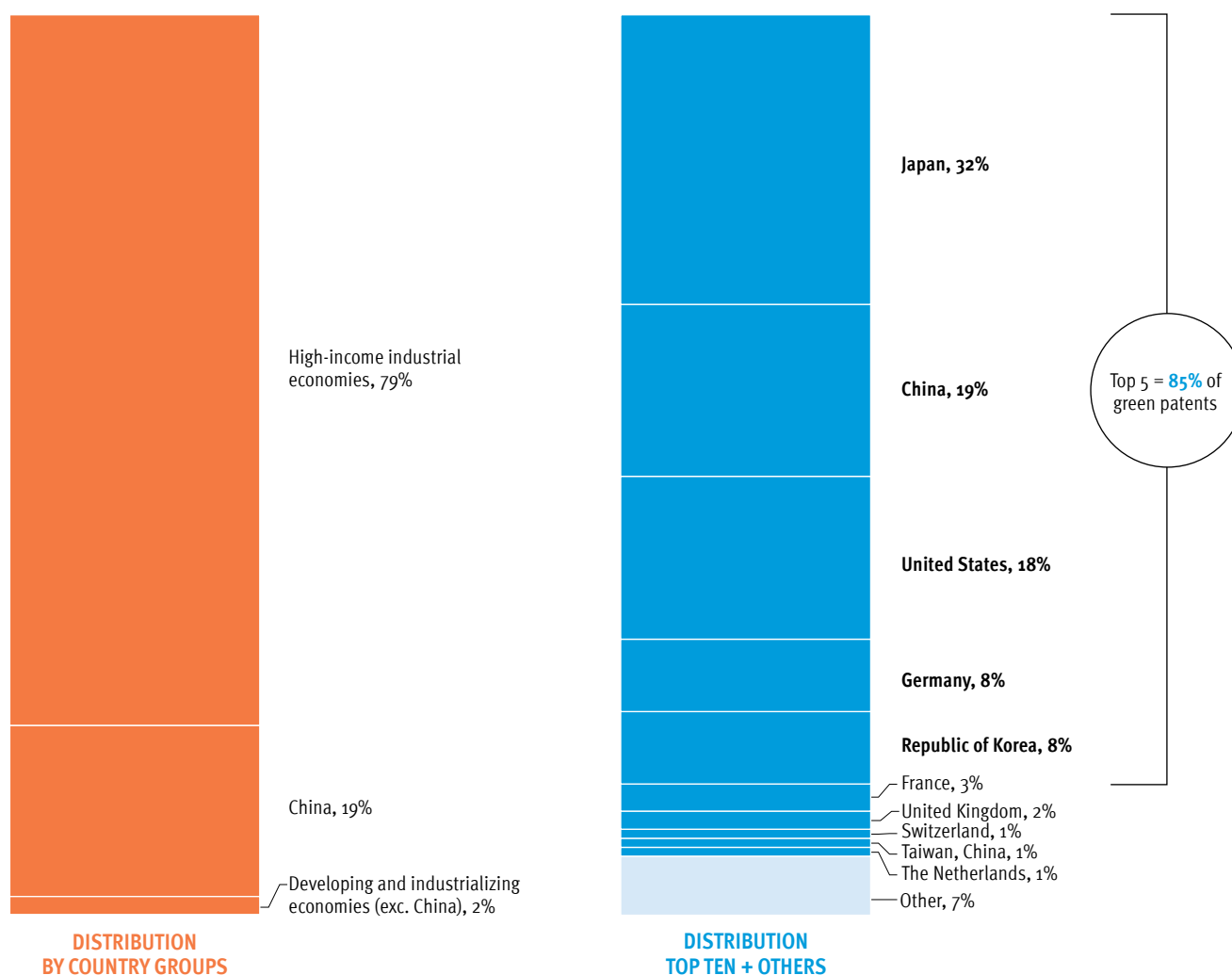
Source: Authors' elaboration based on ORBIS-IP

This finding highlights an important aspect of industry in driving sustainable development, which is often overlooked. Besides being the main engine of economic growth and productive job creation, the industrial sector is also the prime hub of global innovation and the leading engine of green technology creation. Once the source of the problem, industry is becoming a key contributor to the solution to climate change.

A new global divide

One notable characteristic of the global green technology landscape is its significant concentration. When examining the geographical distribution of companies currently holding green patents, we find that 85 per cent of industrial companies involved in green patent activity are concentrated in only five countries (see Figure 4). Japan's manufacturing firms occupy a leading position in this field with 32 per cent of patents, followed by China (19 per cent) and the USA (18 per cent). The remaining top-10 countries are all high-income industrial economies. Industrial firms from developing countries (excluding China) hold less than 2 per cent of green patents.

FIGURE 4: GREEN PATENTING SHARES BY COUNTRIES OF CURRENT OWNERS. MANUFACTURING FIRMS, 2022



Source: Authors' elaboration based on ORBIS-IP

This finding is a matter of concern. Climate change is a global phenomenon and can consequently only be tackled at the global level. This implies that all countries should be ready to participate in the new technological revolution and to possess sufficient capabilities not only to absorb but also to develop and adapt green technologies to their own contexts, needs and circumstances.

Addressing climate change requires urgent efforts to enhance developing countries' green industrial innovation capabilities. This entails building a domestic

knowledge base, including skills, expertise and institutions to fully exploit their potential. Without the necessary industrial and innovation capabilities in developing countries, the concentrated patent landscape depicted in Figure 4 will not change. This will make it more difficult to amass global efforts to address climate change. Developing countries should therefore take a leading role in the race towards sustainable development – for this to become a reality, they must implement SDG-driven, mission-oriented and innovative industrial policies.⁸

Endnotes

- ¹ See Anzolin, G. and A. Lebdioui (2023). “Policy action for greening industrial development”. UNIDO IID Policy Brief No. 5.
- ² Meckling, J. (2021). “Making industrial policy work for decarbonization”. *Global Environmental Politics*, 21(4), 134–147. Scopus.
- ³ See UNIDO (2021). “Industrial Development Report 2020. Industrializing in the Digital Age”.
- ⁴ See Fagerberg and Verspagen (2021). “Technological Revolutions, Structural Change, and Catching up”. *New Perspectives on Structural Change: Causes and Consequences of Structural Change in the Global Economy*.
- ⁵ See Angelucci, S., Hurtado-Albir, F. J., and Volpe, A. (2018). *Supporting global initiatives on climate change: The EPO's “Yo2-Yo4S” tagging scheme*.
- ⁶ See OECD (2023). *Patents on environment technologies*.
- ⁷ This aggregate includes the following sectors (ISIC code in parenthesis): Information and communication (I), Financial and insurance activities (K), Professional, scientific and technical activities (M), Administrative and support service activities (N).
- ⁸ See Mazzucato M. and R. Kattel (2023). “Mission-oriented industrial strategy”. UNIDO IID Policy Brief No. 2.



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