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Measuring and benchmarking the green industrial performance of countries and economies: the GIP index

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Measuring and benchmarking the green industrial performance of countries and economies: the GIP index

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Abstract

This paper discusses the basic concepts of green industrial products and activities that underpin the Green Industrial Performance (GIP) index. It presents the most recent version of the GIP index which allows policymakers and practitioners to analyse and compare countries' performance in green manufacturing over time. We construct a unique database derived exclusively from international data sources such as UNIDO's industrial statistics database (INDSTAT) and UN COMTRADE. We use our GIP database to compute the GIP composite index and to rank and analyse the green industrial performance of a set of 112 countries for the period 2000–2017. We find that five industrialized economies—all European, namely Switzerland, Denmark, Germany, Czechia and Austria—top the GIP index in 2017. We also find that changes in GIP performance are not very frequent and take time. This paper serves to illustrate the various uses of the GIP index to analyse and compare the green industrial performance of economies in different country groups. We also put forward recommendations for future research and analysis of the green performance of countries' manufacturing sector.

Keywords: Green economy; industrial development; Sustainable Development Goals (SDGs); composite index

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1. Introduction

Recent years have witnessed an increasing interest among policymakers and the international community at large in developing ways to ensure sustainability, i.e. to achieve sustainable development. The adoption of the 2030 Sustainable Development Agenda (UN General Assembly, 2015) in September 2015 corroborates the efforts being made to integrate the economic, environmental and social aspects of development. These efforts are reflected in the introduction of the Sustainable Development Goals (SDGs) and their emphasis on environmental and sustainability issues we are facing, such as climate change. The SDGs constitute a significant departure from a more traditional focus on poverty reduction as was observed, for instance, in the Millennium Development Goals (UN General Assembly, 2000 and UNDESA, 2016). The adoption of the SDGs in 2015 was coupled with increasing attention being paid to the introduction of proper monitoring mechanisms that allow the tracking of progress towards achieving the SDGs. An inter-agency expert group established by the United Nations proposed a set of indicators which were endorsed by the UN Statistical Commission to monitor the progress made towards the 17 SDGs and the related 169 targets (UN ECOSOC, 2016). Researchers (for instance, MacFeely, 2020) emphasize the high complexity and significant statistical challenges associated with the measurement of the SDGs. The Global SDG Indicators Database (UN, 2020) provides updated data on each SDG and country for the period 2000–2019 and constitutes the foundation of the United Nations' regular reports on progress being made towards achieving the SDGs. The most recent report (UN ECOSOC, 2020) reveals that progress towards the SDGs has been fairly uneven. Other organizations have proposed alternative indicators to measure achievement towards the SDGs; for instance, the Sustainable Development Solutions Network (SDSN, 2015) has developed a set of 100 global indicators. Concerted action also lies at the core of the Paris Agreement to respond to climate change threats by reducing global greenhouse gas emissions and limiting the global temperature increase to below 2 degrees Celsius above pre-industrial levels (UNFCCC, 2015).

With a view to measuring and explaining complex realities, researchers and international organizations have increasingly relied on composite indices (see, for instance Saltelli, 2007). The literature contains a number of updated lists of such indices, including Bandura's identification of over 400 such composite indices covering different domains ranging from economic to environmental issues (2011) compared to 178 in his previous analysis (Bandura, 2008). Such indices should be used with caution, however, and should even be viewed critically. In his review of indices, Ravallion (2011) emphasizes the importance of clearly defining *what* the composite index is to measures, while Saisana and Saltelli (2011) conclude that composite indices represent

a useful tool to attract general interest and spur discussion in line with Lall's earlier work (2001), underscoring that such (competitiveness) composite indices might be useful in informing policymakers, provided the appropriate methodology and measures are selected. The work of a number of researchers centres on how composite indices are constructed (Booysen, 2002) and how different methodological approaches are used in the construction of composite indices (Greco et al., 2019). The urgency of achieving the SDGs has not escaped this trend, hence researchers and practitioners have developed several composite indices to measure progress towards all or specific SDGs and to rank countries' performance. Kroll (2015) initially developed the SDG index to explore the performance and progress of OECD countries in achieving the SDGs. Following further refinement, the latest edition of the SDG composite index (Sachs et al., 2020) ranks the performance of 166 countries and comprises 115 indicators – 85 for all countries and 30 for OECD countries. The Sustainable Development Report series builds on the SDG index; other analyses confirm the uneven progress made by countries towards the SDGs. The inclusive sustainable transformation (IST) index (Lin et al., 2019), in turn, aims to measure countries' progress towards developing a modern economy that respects the environment and is gender inclusive. The IST index thus focuses on a number of SDGs only.

The publication of "Our Common Future" (Brundtland et al., 1987) raised a high level of awareness about the importance of ensuring sustainable development to meet today's needs without jeopardizing the ability of future generations to meet theirs. In recent years, notably following the 2008 financial crisis, calls for a shift towards a green economy and green growth have grown louder.

The seminal work of Pearce et al. (1989) introduced the concept of 'green economy' in the *Blueprint for a Green Economy* for the Environment Department in the United Kingdom. While many authors have put forward different definitions of green economy, Georgeson et al. (2017) provide a useful review of the leading definitions of and methodologies related to the green economy. A strong emphasis on reconciling the social, economic and environmental pillars of sustainable development can be traced back to the Rio Declaration (UNGA, 1992). UNEP's definition of green economy (UNEP, 2011, p. 2) is often used as a reference, defining it as an economy "that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities". In their review of the green economy and related concepts, Loiseau et al. (2016) introduce a framework to assess the influence of those concepts on the transition to sustainability.

UNDESA (2012a) reviews the concept of green economy as well as of other green-related concepts such as green growth. The latter is defined by the OECD (2011, p. 4) as "fostering economic growth and development, while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies". The World Bank's definition (2012) stresses that green growth efficiently uses natural resources and minimizes pollution and the environmental impact, hence the concept places a strong emphasis on investment and innovation; Bowen and Hepburn (2014) assert that green growth enhances well-being and continued gross domestic product (GDP) growth while at the same time preserving aggregate natural capital. Although the concepts of green growth and green economy and even their various definitions, are not identical, some authors point out their similarities, such as Jacobs (2013), who argues that the different concepts all purport that growth *can* in fact be compatible with environmental protection and are discussed and promoted by the same organizations. According to UNDESA (2012b), however, the differences between the concepts have become unclear and Barbier (2012) suggests that the terms are increasingly being used interchangeably.

Measuring progress towards the green economic growth is paramount for guiding the work and focus of policymakers and practitioners. Examples worth mentioning include, for instance, OECD (2017), which proposes a framework comprising 26 indicators to measure the key components of green growth, such as an economy's environmental and resource productivity, while UNEP (2014) provides guidance on the use of indicators to design and implement green economic policies at the national level. The Green Growth Knowledge Platform (2013) has developed a framework for green growth and green economy indicators, which measures the links between the economy and the environment. More recently, a measurement framework on progress towards the green economy, which comprises a set of individual indicators and the Green Economy Progress index, has been put forward by UN Environment (PAGE, 2017a). It covers 105 countries for the period 2004–2014 (PAGE, 2017b).

We focus our attention on SDG-9 and more specifically on inclusive and sustainable industrial development (ISID). Industrial development, i.e. the role of the manufacturing sector in development with its increasing returns of scale, is essential for driving economic growth (see, for instance, Kaldor 1960, 1967 and 1981). Moreover, it is worth noting that the manufacturing sector's significance in the world economy has grown over the years, demonstrated by an increase in the share of manufacturing value added (MVA) in global GDP from 15.2 per cent in 1990 to 16.4 per cent in 2018 (UNIDO, 2019a). In addition, recent research confirms that industrial development can be sustainable and environmentally friendly (UNIDO, 2020f). Recalling UNIDO's definition of green industry, namely industrial production which substantially limits

the negative impact on the environment and human health, serves to underline the links to the green concepts previously addressed in this paper, and highlights selected commonalities, notably with green growth and the green economy. UNIDO takes a twofold approach, one to existing "green" industries and one to create new green industries (UNIDO, 2011).

Several composite indices explore the key "green" components of green industry, for instance, the Green Economy Progress Index (PAGE, 2017a; PAGE 2017b) which examines the progress of over 100 countries from 2004–2014, the Environmental Performance Index (Wendling et al., 2020), which uses 32 performance indicators to rank 180 countries on environmental health and ecosystem vitality, and the Green Growth Index (Acosta et al., 2020), which measures and benchmarks efficient and sustainable resource use, natural capital protection, green economic opportunities and social inclusion in 117 countries based on 36 indicators, just to name a few. Relevant composite indicators that primarily focus on countries' industrial performance exist as well, such as the Competitive Industrial Performance (CIP) index (UNIDO, 2019b), which assesses and benchmarks the national industrial competitiveness of 150 countries based on 8 indicators or the Inclusive and Sustainable Development (ISID) index (Fang Chin Cheng and Cantore, 2020), which analyses the progress of 118 countries towards the achievement of ISID in the period 2005–2015. To the best of our knowledge, there is no indicator that measures green industrial performance at the national level. Therefore, this paper summarizes and presents research we initiated in 2016 to address this gap in the existing body of knowledge, namely how to measure economies' green industrial production and compare it over time. Our previous work resulted in the publication of several research papers (Moll de Alba and Todorov, 2018a, 2018b, 2020a, and 2020b), which form the methodological backbone of this new piece of work.

The remainder of the working paper is organized as follows: Section 2 describes our methodology and introduces the Green Industrial Performance (GIP) index. In Section 3, we carry out an analysis of the green industrial performance of economies and countries, as well as of several country groupings. We summarize the key findings of our research in Section 4 and discuss ideas for future research, as well as on the use of the GIP index.

2. Methodology

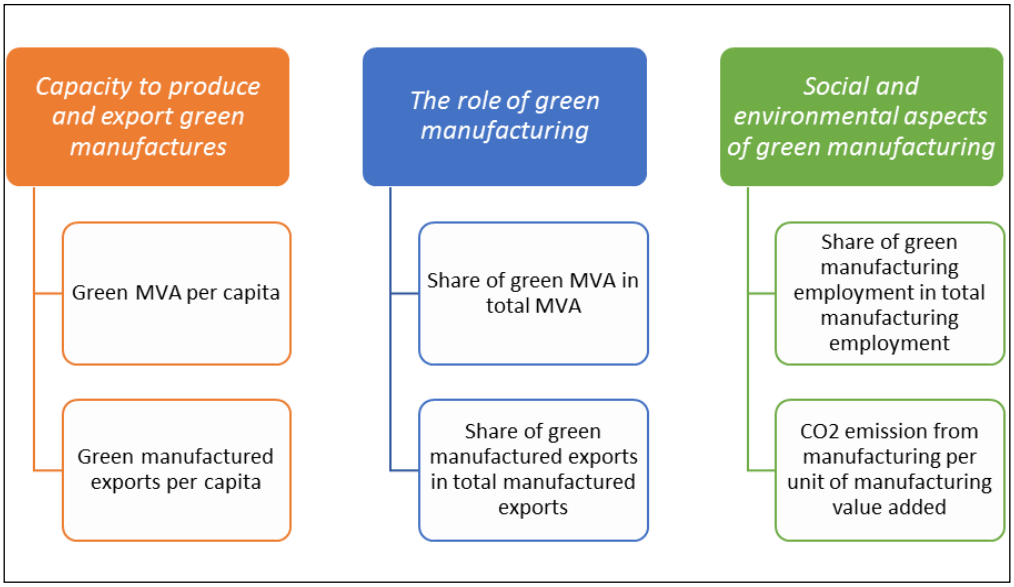
UNIDO's Competitive Industrial Performance index (CIP) (UNIDO, 2017) is based exclusively on objective data measures and comprises eight indicators drawn from recognized international sources normally used to benchmark countries' industrial performance and competitiveness. Inspired by the leading index developed by UNIDO for measuring competitive manufacturing performance (CIP), we construct a composite index to gain a general understanding of the status

of green industry at the country level. Our index can be used as a complementary tool to the CIP index for analysing the progress of ISID at the country level.

2.1. The indicator framework

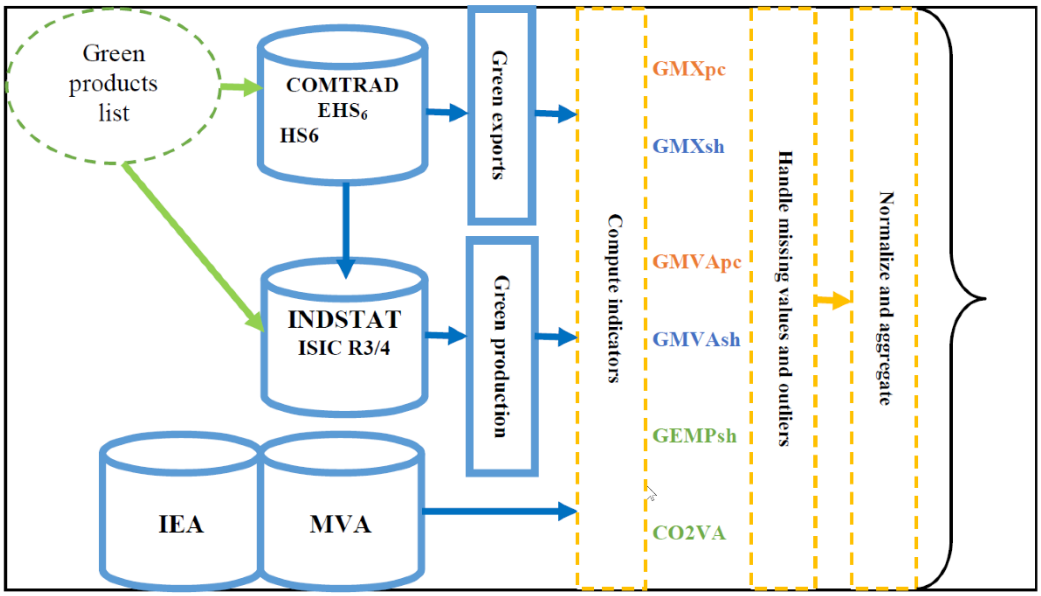
The selection of indicators for the Green Industrial Performance index is based on a large body of work carried out by organizations such as the European Commission (2009), the Green Growth Knowledge Platform (2013), the OECD (2009 and 2014) and UNEP (2012), which attempt, with varying degrees of success, to fill the lack of a robust and comprehensive set of indicators that capture the various facets of green growth. Two equally important aspects of economic development must be considered: (i) the domestic production of goods, and (ii) their international trade. Measuring the relative importance of green industrial production, i.e. the share of green industrial production in overall manufacturing production, is of particular relevance. Another important concept in our analysis is green jobs. The latter can be defined as "work in agricultural, manufacturing, research and development, administrative, and service activities that contribute substantially to preserving or restoring environmental quality" (UNEP/ILO/IOE/ITUC, 2008, p. 3). These concepts can be wrapped up into a simple, straightforward framework that captures different aspects of a country's green industrial performance through three key dimensions. The framework is presented in Figure 1 and details on the indicators used are provided in the remainder of this chapter.

Figure 1: The framework of the Green Industrial Performance (GIP) index



The definition and computation of the Green Industrial Performance index follows several steps presented in Figure 2.

Figure 2: The computation of the Green Industrial Performance (GIP) index



2.1.1 The green products list

There is no universally agreed definition of environmental good. Various approaches to comprehensively and exhaustively list goods that qualify as environmental goods have been developed for research purposes and to facilitate trade negotiations by reducing or removing tariffs. As pointed out by Sugathan (2013), one of the biggest challenges has been that the majority of environmental goods, particularly at the six-digit subcategory of the Harmonized System (HS)—which customs codes are harmonized under—often include products that have both environmental as well as non-environmental end uses. To define the methodology of our proposal, we will consider the OECD's list of environmental goods (Steenblik, 2005), the World Bank's classification of 43 environmental goods (World Bank, 2007) and APEC's classification of 54 environmental goods (Steenblik, 2005). Our main source, however, will be the renowned report "Measuring the green economy" by the U.S. Department of Commerce (2010). The latter uses a remarkable approach to identify and assess green products and services based on both energy conservation and environmental goals. Accordingly, a product or service is considered green if it serves predominantly one or both of the following goals: (i) conserve energy and other natural resources, reduce fossil fuel use and promote water, raw material, land and species and ecosystem conservation; or (ii) reduce pollution, i.e. include products and services that provide clean energy or prevent, treat, reduce, control or measure environmental damage to air, water and soil; those products and services related to remediation, abatement, removal, transportation or storage of waste and contaminants also fall into this category. The report classifies green products and

services into five environmental activities: 1. resource conservation, 2. environmental assessment, 3. energy conservation, 4. renewable/alternative energy, and 5. pollution control.

2.1.2 Measuring green exports

For the purpose of calculating the share of green products in total manufacturing products exported by a country, we use the UN COMTRADE database (United Nations Statistics Division, 2020) and convert the NAICS manufacturing product codes listed in the report of the U.S. Department of Commerce (2010) into the HS codes. Within the scope of this conversion, we consult the OECD's and APEC's lists (Steenblik, 2005) and add the products identified by the World Bank as being "climate-friendly technologies" (World Bank, 2007). Details on the product list are described in Section 2.2, which also entails a preliminary analysis of its features and discusses its limitations. We refer to this list as the *UNIDO green product list*. The complete product list is available in Appendix C.

The UN COMTRADE database contains detailed import and export statistics reported by the statistical authorities of approximately 200 countries or regions. It comprises annual trade data from 1962 to the most recent year and is considered the most comprehensive database on international merchandise trade statistics (IMTS). The database only covers the trade of goods. The statistics are compiled on a customs basis (i.e. administrative data) but can be supplemented by survey data. Data are stored in current US dollar values (using an average annual exchange rate) according to the HS, the six-digit product classification maintained by the World Customs Organization (WCO, 2012).

Applying the resulting list of "green products", we can compute the two indicators we used in our index related to exports: share of green exports in total manufactured exports (*GMXsh*) and value of green manufactured exports per capita (*GMXpc*) in current US dollars.

2.1.3 Measuring green production

As in the case of export indicators, we use the list compiled by the U.S. Department of Commerce. These products are mapped according to manufacturing industries, identified at the four-digit ISIC Revision 3.1 or ISIC Revision 4 code (United Nations, 2002 and 2008), that produce them. We acknowledge that such a mapping exercise is not precise, as we move from 10-digit product codes to six-digit HS product codes and further to four-digit economic activities codes. If one or several green products are produced in a factory classified by a four-digit ISIC, it does not necessarily imply that this four-digit ISIC is green, since other products might be produced in the same factory or in others that are classified in the same four-digit ISIC code. For example, "Parts for bicycles, unicycles and adult tricycles (3369912105)" are classified as green and fall into NAICS (2007)

“336991=Motorcycle, Bicycle, and Parts Manufacturing”, which in turn is classified as “3591=Manufacture of motorcycles” in ISIC Revision 3. Clearly, only part of ISIC 3591 can be considered green. Ideally, access to the survey microdata would be available and the share of green products in the factory’s total production computed and subsequently aggregated to the corresponding activity code. However, this type of data is rarely available to researchers.

There is a strong relationship between domestic production and international trade, which allows us to measure a country’s overall economic performance and growth by measuring its export diversification (Fotros et al., 2013, Romeu et al. 2011). For this purpose, the Herfindahl index is usually used. These two components of diversification are equally important; however, the latter, international trade, is often used as a proxy for economic growth since international trade data are more readily available than data on domestic industrial production. Inspired by this relationship, Moll de Alba and Todorov (2018) propose a methodology using the share of exports of a given green product in the total exports of the corresponding economic activity to which this product belongs.

MVA and employment (number of employees) in the manufacturing sector are suitable indicators to measure the size of the green manufacturing sector. These two indicators are readily available from annual industrial surveys or censuses of manufacturing. UNIDO maintains a global industrial statistics database, INDSTAT (UNIDO 2020d), which includes these two indicators together with six other variables, namely (i) the number of establishments, (ii) gross output, (iii) wages and salaries, (iv) gross fixed capital formation, (v) number of female employees, and (vi) index of industrial production. The current edition of the INDSTAT database contains data on production and employment for over 140 countries in the last 20 years.

Using UNIDO’s INDSTAT databases and applying the shares calculated for green exports as proposed in Moll de Alba and Todorov (2018), we can compute the next three indicators that explore the role of green manufacturing: (i) the share of green manufacturing value added in total value added (*GMVAsh*), (ii) green manufacturing value added per capita (*GMVApc*) in current US dollars, and (iii) share of green manufacturing employment in total manufacturing employment (GEMPsh).

2.1.4 Social and environmental aspects

One important component in our analysis is social inclusiveness, which is measured by the share of green employment in total manufacturing employment *GEMPsh*. The computation method for this indicator was described in the previous section, as it shares common data sources with the indicator that measures green production.

Carbon dioxide (CO_2) emission accounts for around 80 per cent of all greenhouse gas emission from manufacturing processes. It is thus an important measure not only for emissions but also for use and type of energy consumed. CO_2 emission mainly refers to fossil fuel-based energy. This measure reflects the progress made by countries in terms of shifting from fossil-fuel based to renewable energy sources.

The indicator we use to construct the composite index is carbon dioxide (CO_2) emission per unit of MVA (*CO2VA*). This is a universal indicator for measuring the environmental impact of industrial production. It captures the intensity of energy use, the energy efficiency of production technology and most importantly fossil fuel use. The data necessary to compute this indicator comes from the IEA's "CO_2 Emissions from Fuel Combustion Statistics" (OECD, 2020) and UNIDO's MVA database.

2.1.5 Indicators of green industrial performance: Summary

Table 1 lists the selected indicators we use in this study to build and introduce the composite index of green industrial performance. One of these indicators is closely related to SDG-9 indicator "9.2.1: Manufacturing value added as a proportion of GDP and per capita" and another indicator that is identical to SDG-9 indicator "9.4.1: CO_2 emission per unit of value added".

Table 1: Summary of GIP indicators

		Indicator	Description	Countries[a)]	Source
		First dimension: *Capacity to produce and export green manufactures*			
	1	*GMVApc*	Green MVA per capita (current USD)	134	UNIDO INDSTAT[c)]
	2	*GMXpc*	Green manufactured exports per capita (current USD)	189	UN COMTRADE[d)]
		Second dimension: *Role of green manufacturing*			
	3	*GMVAsh*	Share of green MVA in total MVA (%)	134	UNIDO INDSTAT[c)]
	4	*GMXsh*	Share of green manufactured exports in total manufactured exports (%)	189	UN COMTRADE[d)]
		Third dimension: *Social and environmental aspects of green manufacturing*			
	5	*GEMPsh*	Share of green manufacturing employment in total manufacturing employment (%)	133	UNIDO INDSTAT[c)]
	6	*CO2VA*[b)]	CO_2 emission from manufacturing per unit of manufacturing value added (tonne/USD)	138	IEA[e)], UNIDO MVA[f)]

Notes:

a) The number of countries for which a given indicator is available varies from year to year; the number presented in the table is the total number of countries, throughout all years from 2000 to 2017.

b) Indicators for which higher values indicate lower performance in the measured phenomenon

c) UNIDO (2020d)

d) United Nations Statistics Division (2020)

e) OECD (2020)

f) UNIDO (2020e).

2.2. The UNIDO green product list

2.2.1 UNIDO extensions of the green product list

The primary source for creating our list of green products is the U.S. Department of Commerce's renowned report on measuring the green economy (2010). The report uses a remarkable approach to identify and assess green products and services based on both energy conservation and environmental goals. A product or service is considered green if it serves predominantly one or both of the following goals: (i) to conserve energy and other natural resources, and (ii) to reduce pollution. DC-ESA analysts applied this definition to over 22,000 product codes from the 2007 Economic Census and identified 732 green products and services (using the so-called broad green category). Excluding services, 87 green products remain. As a general rule, a product is considered green based on its usage, not on the good's production process or the environmental consequences associated with its disposal. This represents a first limitation due to the fact that the product codes used do not allow for an investigation of these aspects, neither do they distinguish between similar goods produced using different techniques, some of which might contribute to the conservation of energy or natural resources or be less polluting. The report categorizes green products and services into five environmental activities as follows: (i) (RC) resource conservation; (ii) (EA) environmental assessment; (iii) (EC) energy conservation; (iv) (RE) renewable/alternative energy; and (v) (PC) pollution control. The category EA is not relevant for manufacturing products, only for services; therefore, we exclude it from our model.

The product codes are in line with the North American Industry Classification System (NAICS) codes (United States Census Bureau, 2017). The six-digit NAICS codes used to classify manufacturing or services industries are further disaggregated into individual 10-digit product/service codes. The first challenge we encountered was translating the NAICS codes into six-digit HS codes, allowing us to use the international trade data from the UN COMTRADE database. We admit that this translation cannot be precise and further work will be necessary to better validate and align the DC-ESA product codes with those of the HS. Following this first step, we derived a total of 148 HS subgroups, which are distributed across the environmental activities presented in Table 2.

Table 2: List of green products by environmental activity

Categories of main environmental activities		Number of sub-headings				
		DC-ESA	***World Bank***	***OECD***	***APEC***	***Our list***
RC	Resource conservation	51	3	14	1	69
EC	Environmental control	42	4	24	18	65
RE	Renewable/alternative energy	11	17	8	12	34
PC	Pollution control	44	19	80	23	112
Total		**147**	**43**	**126**	**54**	**280**

Sources: Authors' elaboration based on U.S. DC-ESA (2010), Steenblik (2005) and World Bank (2007) and Reinvang (2014).

Next, we review the widely accepted list of climate-friendly products developed by the World Bank (World Bank, 2007). This list contains 45 goods described by HS subheadings, allowing us to directly add them to our initial list. The products included in the World Bank's list help stabilize greenhouse gas emissions and are classified into the following environmental activities: (i) renewable energy (e.g. wind and solar power); (ii) energy efficiency (e.g. energy-efficient appliances); and (ii) waste management technologies (e.g. filters and membranes that keep contaminated matter separated – important for use in clean technologies). These activities can be directly integrated into our categories listed in Table 2.

Merging the DC-ESA and World Bank lists and removing the duplicate subheadings, we obtain a list of 184 products, which we refer to as List Version 3 (V3). This is the list we used in our previous research (Moll de Alba and Todorov, 2018b).

In this paper, we extend the product list by including the environmental products contained in the OECD's list (126 entries) and the APEC's list (54 entries) (Steenblik, 2005; Reinvang, 2014). The two lists were intended to serve different purposes. The OECD list is the result of an exercise to illustrate—primarily for analytical purposes—the scope of the "environment industry". It was developed as a framework for conducting economic analyses, in general, and analyses of trade flows and tariff barriers, in particular. Since adding products to the list does not have any specific policy consequences, the OECD's list contains broad categories of goods. On the other hand, the purpose of APEC's list is to contribute to policy negotiations and its contents is therefore a reflection of political decisions rather than a conceptual exercise to identify a comprehensive list

of goods. It mostly encompasses goods that reduce environmental damage (end-of-pipe pollution treatment and monitoring equipment). The two lists have less than 30 per cent in common (34 products out of a total of 126). The products included in the OECD's and APEC's lists are grouped into categories and subcategories and presented in Table 3. We classify the products into four categories, which we have borrowed from DC-ESA's list. Table 3 shows the number of products (subheadings) in each of the four categories of environmental activities for each list. We then investigate the distribution of the green exports among these categories.

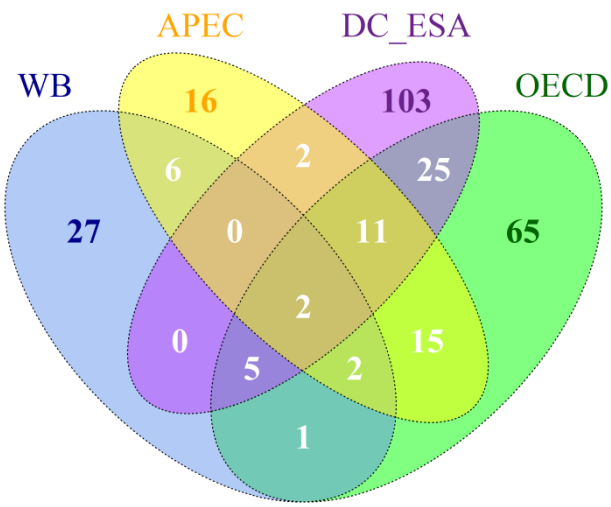
Table 3: Categories of environmental activities in different lists

OECD	APEC	Our list
A. Pollution management		
1. Air pollution control	1. Air pollution management	PC
2. Wastewater management	9. Wastewater management	PC
3. Solid waste management	8. Solid/hazardous waste	PC
4. Remediation and clean-up	7. Remediation/clean-up	PC
5. Noise and vibration management	4. Noise, vibration abatement	PC
6. Environmental monitoring, analysis and assessment	3. Monitoring/analysis	EC
B. Cleaner technologies and products		RC
1. Cleaner/resource efficient technologies and processes		RC
2. Cleaner/resource efficient products		RC
C. Resource management group		
1. Indoor air pollution control		PC
2. Water supply	6. Potable water treatment	RC
3. Recycled materials	5. Other recycling systems	RC
4. Renewable energy plant	10. Renewable energy plant	RE
5. Heat/energy savings and management	2. Heat/energy management	RC
6. Sustainable agriculture and fisheries		-
7. Sustainable forestry		-
8. Natural risk management		-
9. Eco-tourism		-
10. Other		-

Sources: Authors' elaboration based on U.S. DC-ESA (2010), Steenblik (2005) and World Bank (2007) and Reinvang (2014).

Figure 3 illustrates the overlap between the four lists using a Venn diagram. The DC-ESA list contains 103 unique products, followed by the OECD with 65, the World Bank with 27 and APEC with 16 unique products. The two largest lists, namely those of DC-ESA and OECD, have 43 products in common, while DC-ESA's and the World Bank's have only 7 products in common. Ten of the products on the World Bank's list are also found in the lists of APEC and the OECD.

Figure 3: Illustration of the overlap between the four lists in a Venn diagram



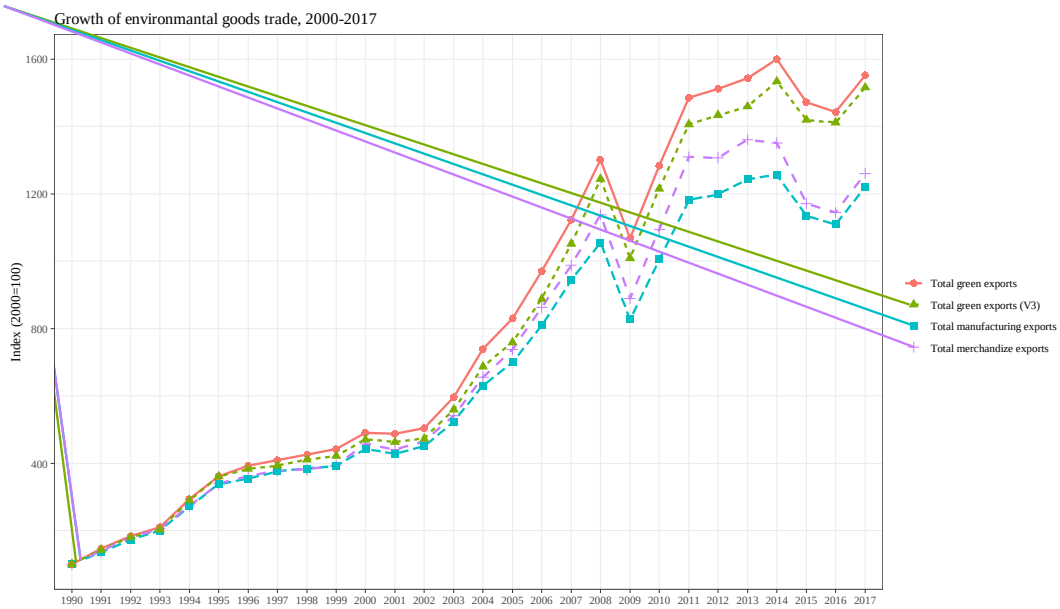
Sources: Authors' elaboration based on U.S. DC-ESA (2010), Steenblik (2005) and World Bank (2007) and Reinvang (2014).

After adding the two new lists and removing duplicate entries, our list consists of 280 products (this list is referred to as V5 in the remainder of this paper).

2.2.2 Analysis of the green product list

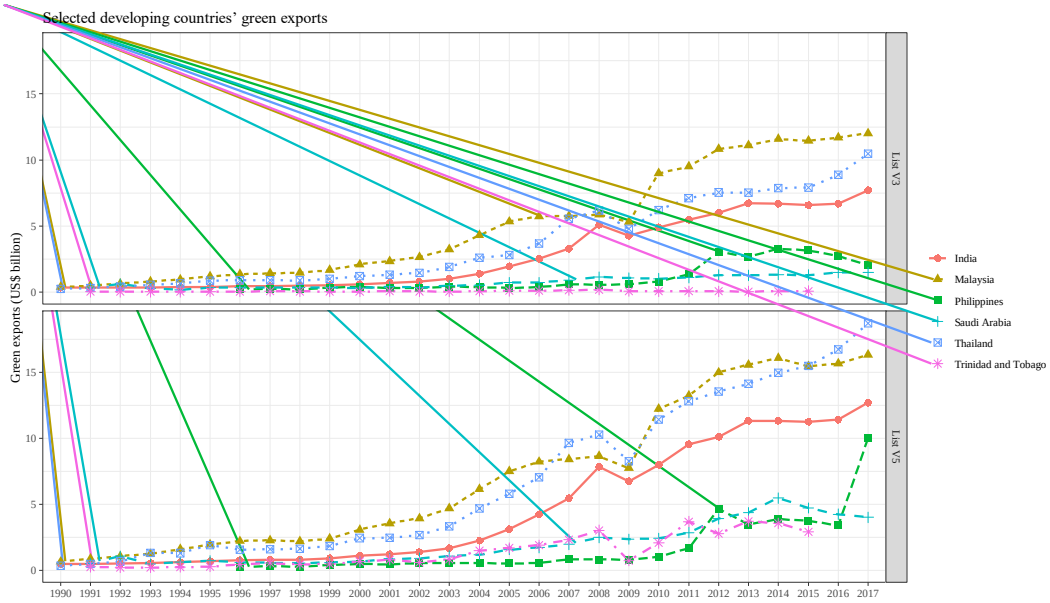
The export of environmental products has grown faster than total exports and manufactured exports, as shown in Figure 4. The difference between total green exports in the two versions of our list is not significant, especially in more recent years; the impact in different countries varies, however, as illustrated in Figure 5. The figure's two panels show the amount of green exports from selected developing countries calculated on the basis of the product list's initial version (upper panel) and its current version (lower panel). In absolute values, the amount of green exports from all countries is higher in the new list, however, their growth differs significantly in some countries. According to the new list, Thailand surpasses Malaysia, which is the leading exporter of green products in the initial list; the performance of Trinidad and Tobago and the Philippines improves significantly in the new list as well.

Figure 4: Growth of trade in environmental products, 2000–2017



Source: Authors' calculations based on United Nations Statistics Division (2020).

Figure 5: Exports of green products from developing countries 2000–2017 (US$ billion)

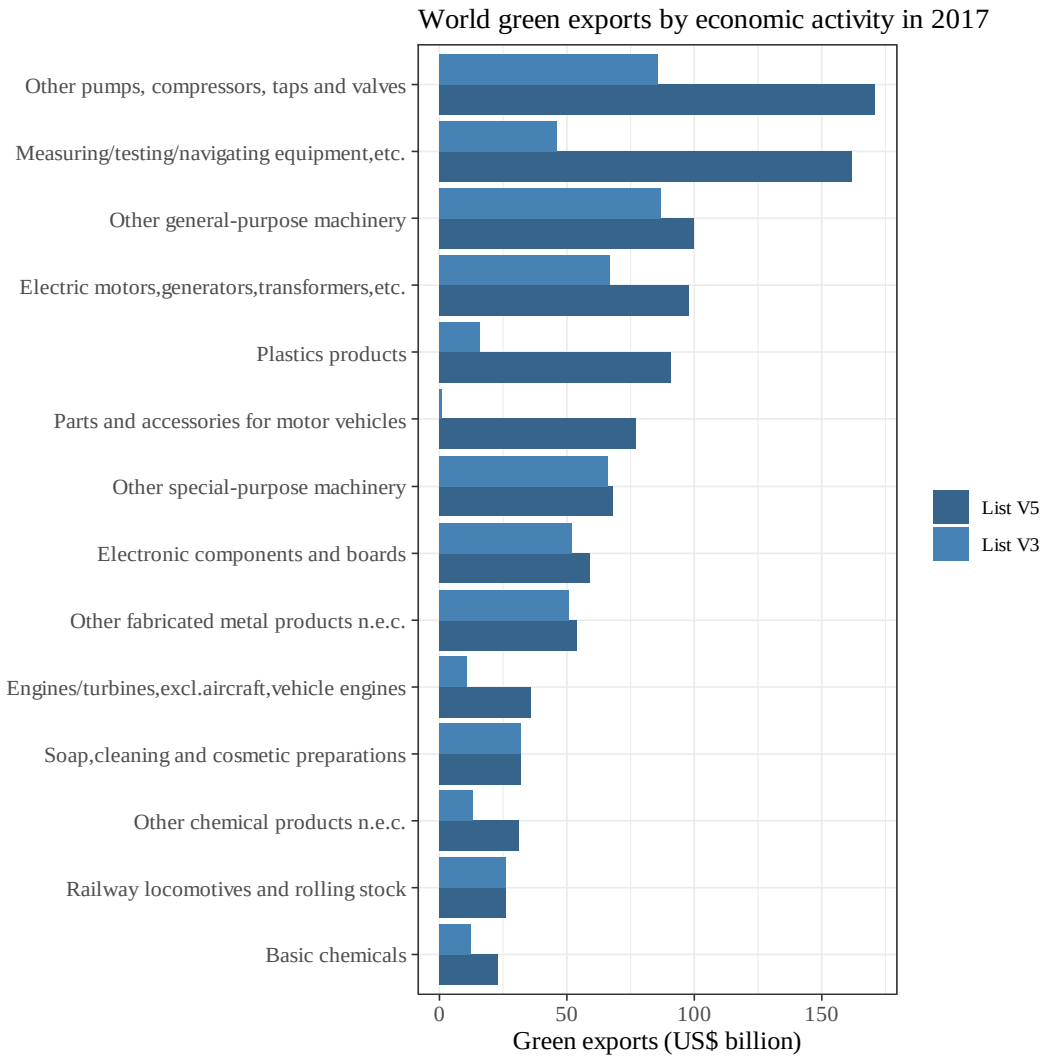


Source: Authors' calculations based on United Nations Statistics Division (2020).

When considering the manufacturing industries that produce green goods (at the four-digit ISIC Revision 4), we can compare the effect of expanding the list of green products. Green production (in US$ billion) for 2017 is presented in Figure 6 by economic activity according to the two versions of our green product list. The largest share of products newly added to the list were those from the "greenest" industries (largest according to the value of green products), such as "Other

pumps, compressors, taps and valves", "Measuring/testing/navigating equipment/etc.", "Other general purpose machinery" and "Electric motors, generators, transformers, etc.", whereas the increase in the green share of industries "Measuring/testing/navigating equipment/etc.", "Plastic products", "Parts and accessories for motor vehicles" was particularly significant. The products that increased these industries' green value were: 903180 = "Other instruments, appliances and machines" (under 9031 = "Measuring or checking instruments, appliances and machines, not specified or included elsewhere)", 902780 = "Instruments and apparatus for physical or chemical analysis", 840999 = "Parts for diesel and semi-diesel engines", 840991 = "Parts for spark-ignition type engines not elsewhere specified (n.e.s.)", 392690 = "Other articles of plastics, n.e.s.".

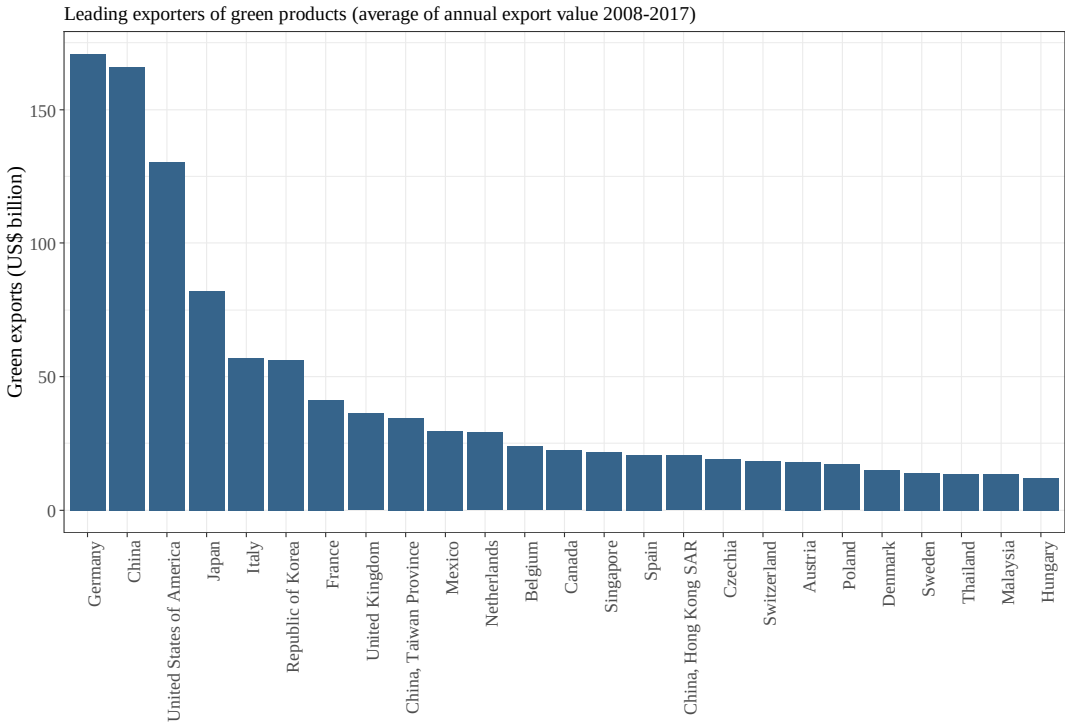
Figure 6: World green exports by economic activity in US$ billion, 2017



Source: Authors' calculations based on United Nations Statistics Division (2020).

Figure 7 shows that trade in green products predominantly takes place between industrialized countries – European countries, the United States of America, Japan and the Republic of Korea are the main exporters of green products globally. At the same time, some emerging economies, especially in East Asia and among the BRICS, are already important exporters. China, the Republic of Korea, Mexico, Brazil, Malaysia, the Russian Federation and Thailand are major global players.

Figure 7: Leading exporters of green products (average of annual export value 2008–2017)



Source: Authors' calculations based on United Nations Statistics Division (2020).

2.2.3 Issues and limitations of the product list

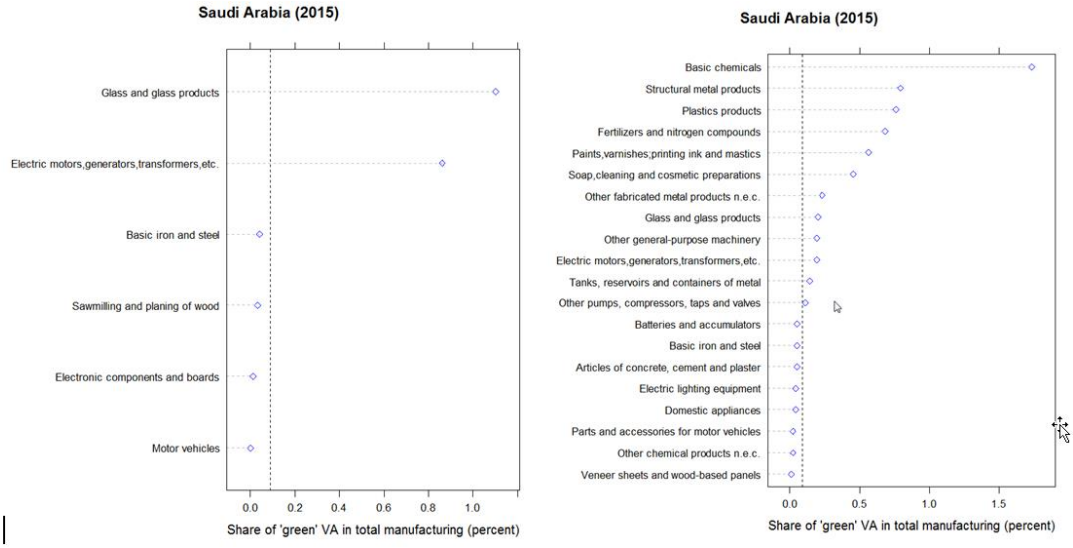
One of the biggest challenges related to these lists, as highlighted by Sugathan (2013), has been that most environmental goods, particularly at the six-digit subcategory of the HS—under which customs codes are harmonized—often comprise products that have environmental as well as non-environmental end uses. DC-ESA addresses this issue by classifying the products into narrow and broad definitions and the results for the two definitions are presented separately. We experimented with the two definitions and found that for our purpose, the differences were not too significant. APEC addresses this issue by specifying a so-called "ex-heading" to provide a duty-free treatment of a specific product. This approach is not applicable to our methodology.

The share of green products computed for exports based on COMTRADE data are mapped to the manufacturing industries that produce them, identified at the four-digit ISIC Revision 3.1 or ISIC Revision 4 code. Some of the products will be lost during this process, since recycling, sewerage and waste treatment are not part of manufacturing in ISIC Revision 4 and we cannot obtain data from INDSTAT. In the future, we will try to obtain data from the mining and utilities database, MINSTAT (UNIDO, 2020h).

Another drawback of our analysis is the limited data coverage which meant we had to drop a number of countries, namely those countries that did not report any data during the period considered. To calculate the composite index, the values for all six sub-indicators must be available; we use imputation to fill in missing values prior to normalization and aggregation. The procedures used to fill in missing data and to deal with outliers are described in Annex 2 of Moll de Alba and Todorov (2018b). Some economies do not report value added (Armenia, China, Panama, Ukraine) and this indicator was estimated using the data on output (where available). This procedure cannot be used, however, if the necessary data for computing an indicator was not reported during the considered period. Those economies are excluded from the analysis: no data are available for CO_2 emissions for the State of Palestine and Eritrea; and no employment data were reported by Serbia, the United Arab Emirates, Zimbabwe and Namibia. We investigate the possibilities of obtaining data from alternative sources to calculate the index for these economies.

Although some economies report data on manufacturing production and data may be available in INDSTAT, they are reported at a higher level of aggregation (two-digit of ISIC) and our procedure, which is based on the mapping of the six-digit HS codes to four-digit ISIC codes, cannot calculate the share of green production. If this is only the case in specific years, it is possible to estimate the share of green production using data from a neighbouring year (Saudi Arabia in 2015, Ireland in 2015). However, if detailed data were never reported, the resulting indicators will be significantly underestimated (Belarus, Mauritius, Mongolia, Tunisia, South Africa, Uruguay, Japan after 2010). In those cases, we amend the procedure to also consider the two-digit data. Figure 8 presents the resulting green value-added shares calculated from the reported two-digit INDSTAT data for Saudi Arabia in 2015 (left panel) and the results estimated from the four-digit data (right panel).

Figure 8: Effect of the disaggregation of INDSTAT data on index calculation



Note: Left panel: data were reported at the 2-digit level of ISIC revision 4; right panel: data were correctly estimated at the 4-digit level of ISIC revision 4.

Sources: Authors' calculations based on UNIDO (2020e, 2020d) and United Nations Statistics Division (2020).

2.3. Statistical analysis and computation of the index

The "raw" data we use to construct the index are drawn from recognized international series. Data are available for 205 countries from 1990 to 2017, but they are quite unbalanced. The coverage of indicators from the INDSTAT database before 2000 is quite low, partially due to the fact that in the early 1990s, many countries were still reporting in ISIC Revision 2. The coverage of exports was also not very high, which means that the classification of green products we use cannot be extended so far into the past. To limit the impact of these coverage issues, we do not consider periods before 2000. Table 4 shows the number of available observations per year for each of the six indicators. The complete data set covering the period 2000 to 2017 is used in the preliminary analysis and in the construction of the index, but the analysis presented in the next chapter focuses on the most recent year (2017).

Table 4: Coverage of input data for GIP (number of observations per year for each indicator)

Year	GMVApc	GMVAsh	GEMPsh	GMXsh	GMXpc	CO2VA
2000	94	87	89	158	158	132
2001	96	88	89	160	160	132
2002	95	87	86	162	162	132
2003	97	90	88	164	164	132
2004	98	90	87	166	166	132
2005	98	91	89	165	165	135
2006	102	97	92	162	162	135
2007	99	95	90	168	168	135
2008	104	100	92	165	165	136
2009	100	96	91	166	166	136
2010	107	106	99	170	170	136
2011	106	104	98	166	166	136
2012	104	102	99	167	167	138
2013	105	104	103	166	166	138
2014	104	101	98	164	164	138
2015	102	98	100	159	159	138
2016	98	92	96	155	155	138
2017	87	79	76	152	152	138

Sources: Authors' calculations based on UNIDO (2020e, 2020d), United Nations Statistics Division (2020) and OECD (2020).

Table 5 reports the summary statistics on input data. The minimum and maximum value for each indicator across all available countries and years are used to normalize the indicators within the interval [0, 1]. GMVApc, GMXpc and CO2VA have the highest coefficient of variation (the ratio of standard deviation to the mean), which shows the high variability of these indicators. The distribution of input data for GMVApc, GMXpc and CO2VA is extremely skewed to the right. After normalizing the data with the min-max of each individual series, the skewness in GMVApc, GMXpc and CO2VA is slightly reduced, but is fully not eliminated (see Table 6).

Table 5: Summary statistics of the indicators

Indicator	Min.	1st	Median	Mean	3rd	Max.	CV	Skewness
GMVApc	0.00	3.61	30.78	138.23	165.70	2,505.75	1.82	4.10
GMVAsh	0.00	0.02	0.05	0.05	0.07	0.25	0.74	0.71
GEMPsh	0.00	0.03	0.05	0.05	0.08	0.26	0.67	0.47
GMXsh	0.00	0.02	0.05	0.06	0.08	0.58	0.89	3.20
GMXpc	0.00	5.26	47.01	359.13	404.79	4,630.44	1.85	2.69
CO2VA	0.02	0.24	0.44	0.74	0.95	17.88	1.21	5.90

Sources: Authors' calculations based on UNIDO (2020e, 2020d), United Nations Statistics Division (2020) and OECD (2020).

Table 6: Median and mean of the normalized data by the min-max method indicators

Indicator	Median	Mean	Skewness
GMVApc	0.02	0.10	2.90
GMVAsh	0.27	0.29	0.64
GEMPsh	0.32	0.33	0.46
GMXsh	0.15	0.18	1.94
GMXpc	0.02	0.11	2.43
CO2VA	0.91	0.85	-2.50

Sources: Authors' calculations based on UNIDO (2020e, 2020d), United Nations Statistics Division (2020) and OECD (2020).

Table 7 shows the year-average correlation between the normalized indicators. The six indicators have an average bivariate correlation of 0.52, and five of the six indicators have a correlation coefficient higher than 0.39 (most of the correlations are above 0.47). CO2VA is an exception and has a lower correlation with all other indicators. The higher the correlation between the normalized sub-indicators, the lower the impact of changing the weights (Foster et al., 2012).

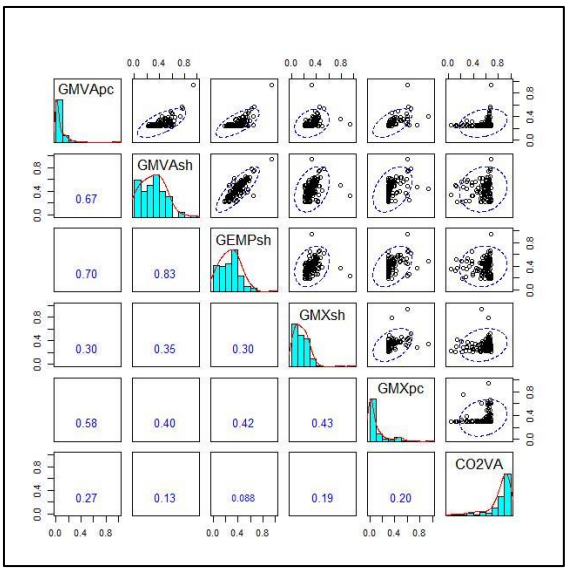
Table 7: Year-average correlation between the indicators for the period 2000 to 2017

Indicator	GMVApc	GMVAsh	GEMPsh	GMXsh	GMXpc	CO2VA
GMVApc	1.00					
GMVAsh	0.65	1.00				
GEMPsh	0.64	0.82	1.00			
GMXsh	0.47	0.54	0.47	1.00		
GMXpc	0.63	0.39	0.39	0.50	1.00	
CO2VA	0.29	0.18	0.08	0.14	0.21	1.00

Sources: Authors' calculations based on UNIDO (2020e, 2020d), United Nations Statistics Division (2020) and OECD (2020).

Figure 9 presents the six normalized indicators in 2017 with their distribution, the correlation between them and the bivariate distribution of the pairs of indicators with 0.975 tolerance ellipses. The one-year (2017) correlations follow the year average correlation shown in Table 7. The histogram and the density of each indicator shown on the diagonal visualize the skewness of the three indicators identified in Table 5.

Figure 9: Correlation analysis of the normalized indicators



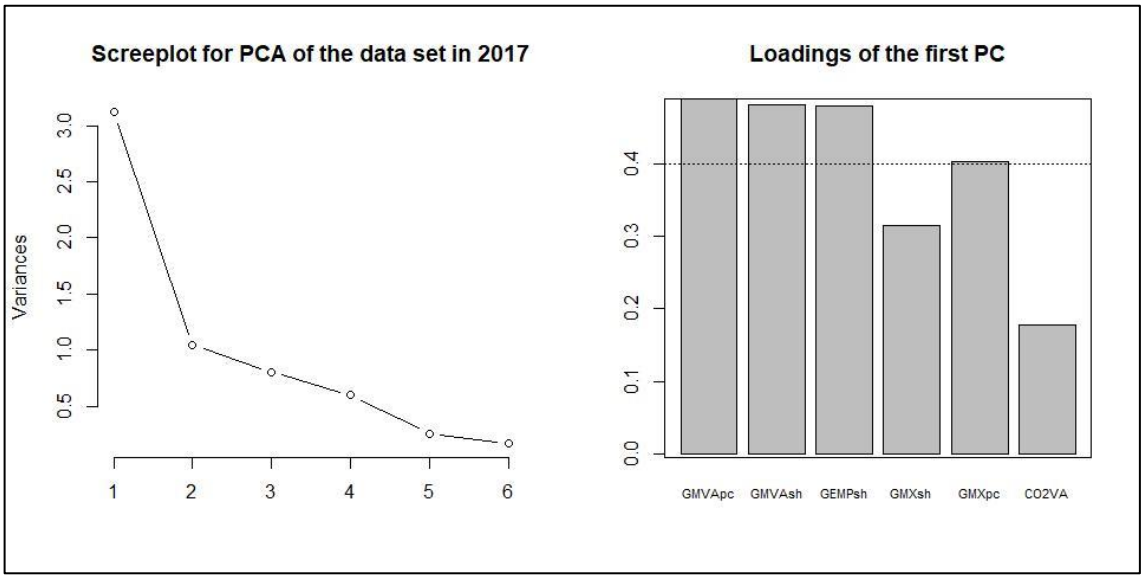
Sources: Authors' calculations based on UNIDO (2020e, 2020d), United Nations Statistics Division (2020) and OECD (2020).

The correlation of the sub-indicators can be further investigated using principle component analysis, which is a multivariate statistical technique to reduce the dimensionality of a data set. This is achieved by representing the analysed data set (with, say, p variables) through k components (linear weighted combinations of the original variables), where k is much smaller than p. The weights are given by the eigenvectors of the data's correlation matrix (or the covariance matrix, if the data have been standardized). The variance explained by each component is given by the corresponding eigenvalue, and by ordering the components in decreasing order of the eigenvalues' magnitude, we can determine how many components are sufficient for adequate presentation of the data set. The mathematics behind the principal component analysis (PCA) is described in any textbook on multivariate statistics (see, for example, Jonson and Wichern, 2008). Performing PCA on the correlation matrix of our data set results in decomposition for which at least four components are needed to account for at least 90 per cent of the variation (see Table 8). The left panel of Figure 10 presents the *screeplot* of the PCA, the standard tool for selecting the most important components, which confirms this finding. This result shows that the phenomenon represented by the data is truly multidimensional. The right panel in Figure 10 shows the loadings (the weights) on the first principal component. Four of the indicators with moderate to high loading (> 0.4) are accounted for by the first PC. The second PC (not shown here) is dominated by *CO2VA*.

Table 8: Results of the principal component analysis

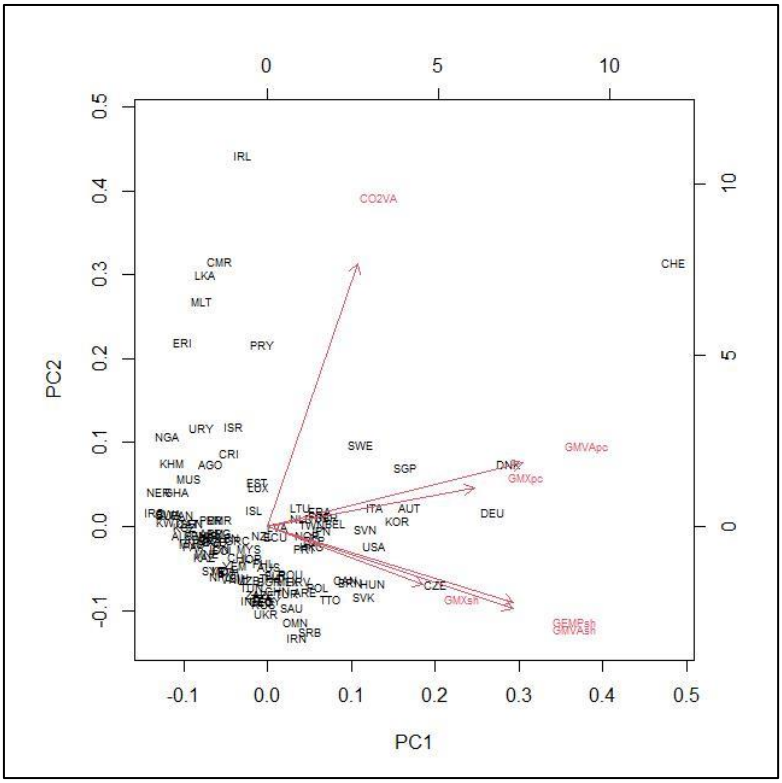
	PC1	PC2	PC3	PC4	PC5	PC6
Standard deviation	1.77	1.02	0.90	0.78	0.51	0.41
Proportion of variance	0.52	0.17	0.13	0.10	0.04	0.03
Cumulative proportion	0.52	0.69	0.83	0.93	0.97	1.00

Figure 10: Screeplot and loadings plot of the first PC



Another useful result obtained by the PCA is the presentation of the data in the form of a biplot. A biplot is a multivariate generalization of the two-variate scatterplot which allows both the variables (indicators) and the objects (countries) to be presented in the same plot (see Figure 11). The variables are represented by arrows and the countries – by their 3-character ISO code. Some of the results presented in the next sections are already visible in this preliminary exploratory plot: Denmark's performance in *MXpc* is strong, Germany, the Republic of Korea and Taiwan, Province of China also show very high values on several indicators. Paraguay's performance in *CO2VA* is very good, however, this does not suffice to rank high on the composite index – this is a result of our choice of geometric mean as an aggregation method, which does not allow full compensability, as will be explained later.

Figure 11: Biplot of the data set



2.3.1 Normalization and aggregation

To calculate the composite index, the values for all six sub-indicators must be available and use imputation to fill in missing values prior to normalization and aggregation. The procedures used to fill in missing data and to deal with outliers are described in Annex 2.

Each of the six indicators is normalized into the range [0, 1], with higher scores representing better outcomes. Normalization is carried out using the min-max method, taking the minimum and maximum values of each indicator's sample values:

$$I_{ijt} = \frac{X_{ijt} - \min_j X_{ijt}}{\max_j X_{ijt} - \min_j X_{ijt}} \quad \textbf{(1)}$$

$$I_{ijt} = \frac{\max_j X_{ijt} - X_{ijt}}{\max_j X_{ijt} - \min_j X_{ijt}} \quad \textbf{(2)}$$

where X_{ijt} is the value of the j-th country on the i-th performance variable in year t, and I_{ijt} represents the i-th score (country) of the i-th individual performance index in year t. This is done

to enable aggregation, as the indicators have different measurement units. For any index, the country with the highest score will be given a value of 1, and the country with the lowest a value of 0. Equation (1) is used for "positive" indicators, i.e. for indicators where the higher values signify better performance, and Equation (2) is used for the one "negative" indicator, CO_2 emissions by MVA, where lower values denote better performance.

Our aggregation method of choice is geometric aggregation. Under the geometric aggregation method, the index is constructed as a weighted geometric average of q sub-indicators, using equal weights for each indicator and each country. The following formula is used:

$$GIP_{jt} = \left(\prod_{i=1}^{q} I_{ijt} \right)^{1/q} \quad \textbf{(3)}$$

with the GIP_{jt} values also lying in the range [0,1].

Equation (15) can be equivalently represented using logarithms, i.e. the geometric mean is equal to the exponential of the logarithms' arithmetic mean. This formula allows multiplications to be expressed as a sum and the power as a multiplication.

$$GIP_{jt} = exp\left[\frac{1}{q}\sum_{i=1}^{q} \ln I_{ijt}\right] \quad \textbf{(4)}$$

The reasoning for choosing equal weights is that the higher the correlation between the normalized sub-indicators, the lower the impact of changing the weights (Foster et al., 2012). Preliminary tests of the GIP index show that the year-average correlations between nearly all normalized indicators are relatively high. Using equal weights is only justified if disaggregated statistics included in each composite indicator are also shown and the composite's transparency is maintained.

2.3.2 Filling in missing values and dealing with outliers

To calculate the composite index, values for all six sub-indicators must be available. Data for some countries in certain years may be missing in the databases being used. While methods for imputation of data gaps and the now-casting of the missing most recent year(s) are applied to some of UNIDO's databases, e.g. the MVA and INDSTAT 2 databases, before they are published on the UNIDO data portal http://stat.unido.org, no such procedures are used for INDSTAT 4, which is the main source for our index, and a high number of missing values is observed in the calculated GIP's "raw" indicators. If this is not the case, all observations are missing in the series, although information from the available data can be extracted to impute values to the missing

observations. Filling in missing values through imputation takes place prior to normalization and aggregation.

A very simple procedure is applied: missing observations are filled in with the most recent available observation (Last Observation Carried Forward, LOCF). This method has the disadvantage that observations at the beginning of the time series cannot be imputed. Furthermore, in some cases it is better to use a nearer future observation instead of a very distant past one. For example, if data for a specific indicator for a given country are missing from 2006 to 2013 (but 2005 and 2014 are available), the simple LOCF would fill in all the gaps using the value from 2005. The improved method (nearest neighbour) will fill in the information for 2006 to 2009 using the value from 2005, while the value from 2014 will be used to fill in the data for 2010 to 2013. If no value is available for an indicator in the past or future 25 years, none will be imputed. Also, any past values used are limited to 1990.

The missing data is not the only problem we face when constructing our index. The sub-indicator data may have outlying values that could distort the GIP measurement of the country's performance. There are several approaches to dealing with outliers. We consider a simple but effective univariate outlier identification rule, which can be described as follows. Observations that are more than 3 (resp. minus 3) times the median absolute deviation (MAD) from the median are winsorized and replaced by the median plus (resp. minus) 3 times the median absolute deviation (NOTE: winsorization refers to the transformation of statistics by limiting the occurrence of extreme values in a dataset, thus reducing the effect of potentially spurious outliers). To account for time variation in the data's location and scale, the median is computed on a local window of 5 observations. In the practical compilation of GIP, this outlier detection rule is only used as a diagnostic rule: i.e. data are not automatically winsorized, but if drastic outliers are detected, they are treated manually. For example, the outlier can be removed and replaced by a missing value for which the above described imputation method will suffice. More details on these procedures can be found in UNIDO (2017c).

3. Analysis of green industrial performance using the GIP index

In Section 2 of this paper, we introduced the GIP index and the methodological approach adopted to compute its value. We then calculated the GIP index for the period covering the years from 2000 to 2017, and computed the GIP components for 112 economies in 2017.

The GIP index provides policymakers, stakeholders and researchers vast opportunities to analyse and compare the green industrial performance of economies and countries. The relative green industrial performance of economies and its evolution over time can be analysed. The contribution

of the various components contained in the GIP, namely green manufacturing value added, green manufactured exports, green manufacturing employment, and CO_2 emissions, can be reviewed. In this section, we carry out several analyses that illustrate both economies' performance at a given point in time, namely in 2017, the year for which a full set of comparable data allows us to compute the GIP index, as well as their evolution over a given period, i.e. 2014–2017, to identify changes in their GIP values and rankings. We also look at the various GIP components and analyse the performance of selected economies, including the top performers and the BRICS. We furthermore carry out analyses of green industrial performance, making use of several country groupings, namely regional groupings and groupings of countries by stage of industrial development, as well as per GIP index quintile. To undertake the above analyses, we first construct a database containing the GIP index and its six components for 112 countries covering the period 2000–2017.

3.1. GIP ranking

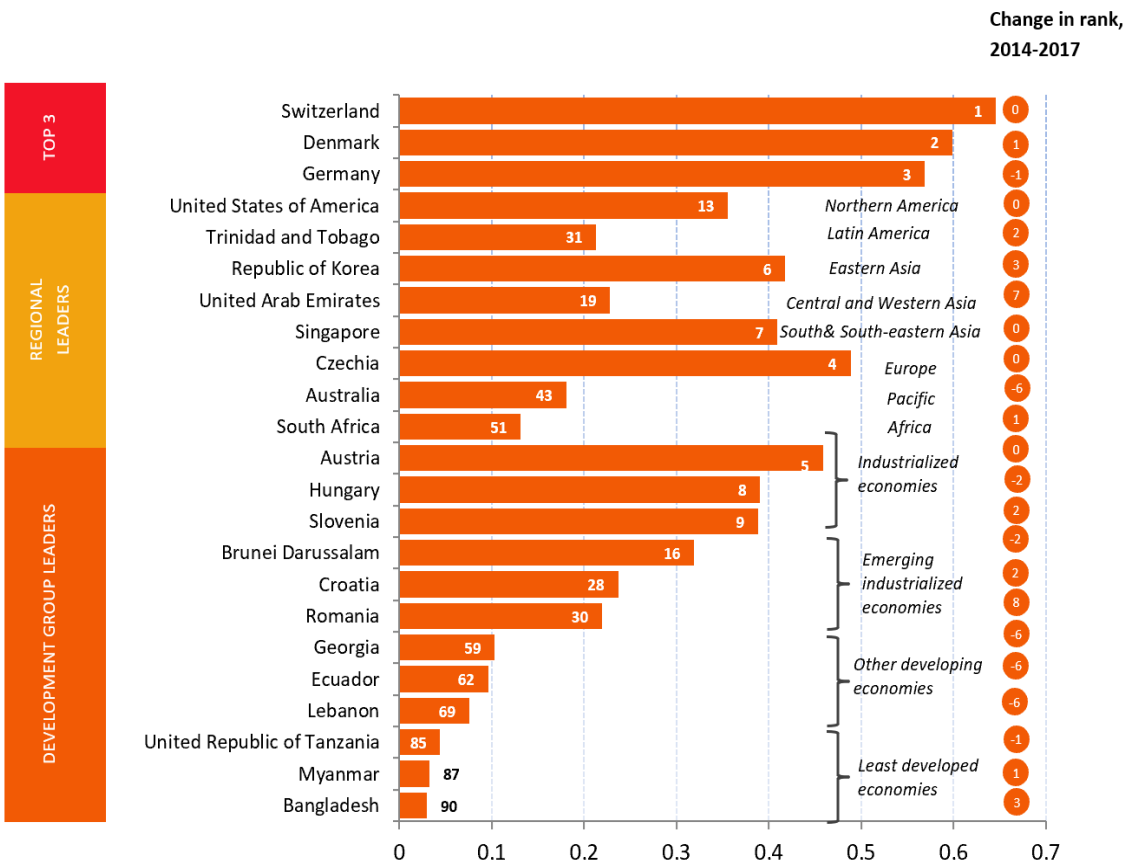
Table 9: Green Industrial Performance index, edition 2020

	RANK 2017		Country	Score 2017	RANK 2014	
TOP	1	IND	Switzerland	0.646	1	↔
TOP	2	IND	Denmark	0.599	3	↑
TOP	3	IND	Germany	0.569	2	↓
TOP	4	IND	Czechia	0.489	4	↔
TOP	5	IND	Austria	0.459	5	↔
TOP	6	IND	Republic of Korea	0.418	9	↑
TOP	7	IND	Singapore	0.410	7	↔
TOP	8	IND	Hungary	0.391	6	↓
TOP	9	IND	Slovenia	0.388	11	↑
TOP	10	IND	Italy	0.381	10	↔
TOP	11	IND	Sweden	0.370	8	↓
TOP	12	IND	Slovakia	0.361	16	↑
TOP	13	IND	United States of America	0.356	13	↔
TOP	14	IND	Belgium	0.332	15	↑
TOP	15	IND	Canada	0.329	19	↑
TOP	16	EIE	Brunei Darussalam	0.319	14	↓
TOP	17	IND	Japan	0.310	17	↔
TOP	18	IND	China, Taiwan Province	0.305	18	↔
TOP	19	IND	Finland	0.296	12	↓
TOP	20	IND	France	0.294	21	↑
TOP	21	IND	United Kingdom	0.292	20	↓
TOP	22	IND	Norway	0.289	22	↔
TOP	23	IND	Poland	0.278	23	↔
U-MID	24	IND	Spain	0.269	25	↑
U-MID	25	IND	Netherlands	0.267	24	↓
U-MID	26	IND	Portugal	0.266	29	↑
U-MID	27	IND	Lithuania	0.256	27	↔
U-MID	28	EIE	Croatia	0.237	30	↑
U-MID	29	IND	United Arab Emirates	0.228	36	↑
U-MID	30	EIE	Romania	0.219	38	↑
U-MID	31	IND	Trinidad and Tobago	0.213	33	↑
U-MID	32	IND	Latvia	0.208	35	↑
U-MID	33	EIE	Mexico	0.205	34	↑
U-MID	34	IND	Estonia	0.199	26	↓
U-MID	35	EIE	Serbia	0.198	40	↑
U-MID	36	EIE	China	0.190	32	↓
U-MID	37	EIE	Bulgaria	0.190	41	↑
U-MID	38	EIE	Saudi Arabia	0.189	43	↑
U-MID	39	EIE	Thailand	0.185	46	↑
U-MID	40	EIE	Turkey	0.183	42	↑
U-MID	41	IND	Malaysia	0.183	28	↓
U-MID	42	EIE	Oman	0.182	47	↑
U-MID	43	IND	Australia	0.181	37	↓
U-MID	44	IND	Belarus	0.180	48	↑
U-MID	45	IND	China, Hong Kong SAR	0.178	45	↔
MID	46	IND	New Zealand	0.171	44	↓
MID	47	IND	Iceland	0.152	102	↑
MID	48	IND	Israel	0.149	49	↑
MID	49	IND	Luxembourg	0.146	31	↓
MID	50	EIE	Iran (Islamic Republic of)	0.132	51	↑
MID	51	EIE	South Africa	0.131	52	↑
MID	52	EIE	Greece	0.128	50	↓
MID	53	EIE	Bosnia and Herzegovina	0.123	57	↑
MID	54	EIE	Tunisia	0.120	54	↔
MID	55	EIE	Philippines	0.118	60	↑
MID	56	EIE	Jordan	0.113	59	↑

	RANK 2017		Country	Score 2017	RANK 2014	
MID	57	IND	Chile	0.110	75	↑
MID	58	EIE	Viet Nam	0.105	69	↑
MID	59	DEV	Georgia	0.103	53	↓
MID	60	IND	Russian Federation	0.100	58	↓
MID	61	IND	Ireland	0.097	39	↓
MID	62	DEV	Ecuador	0.097	56	↓
MID	63	EIE	Costa Rica	0.096	55	↓
MID	64	EIE	Egypt	0.094	61	↓
MID	65	EIE	Cyprus	0.092	66	↑
MID	66	EIE	Brazil	0.082	62	↓
MID	67	EIE	Argentina	0.079	65	↓
L-MID	68	EIE	Ukraine	0.076	101	↑
L-MID	69	DEV	Lebanon	0.076	63	↓
L-MID	70	EIE	Peru	0.070	67	↓
L-MID	71	EIE	Indonesia	0.070	64	↓
L-MID	72	EIE	Colombia	0.067	70	↓
L-MID	73	DEV	Azerbaijan	0.064	76	↑
L-MID	74	EIE	India	0.063	73	↓
L-MID	75	EIE	Uruguay	0.061	71	↓
L-MID	76	DEV	Republic of Moldova	0.060	77	↑
L-MID	77	DEV	Morocco	0.057	85	↑
L-MID	78	DEV	Uzbekistan	0.056	108	↑
L-MID	79	EIE	Panama	0.052	79	↔
L-MID	80	EIE	Mauritius	0.049	80	↔
L-MID	81	DEV	Montenegro	0.048	82	↑
L-MID	82	DEV	Armenia	0.048	74	↓
L-MID	83	DEV	Paraguay	0.047	72	↓
L-MID	84	DEV	Bolivia (Plurinational State of)	0.047	78	↓
L-MID	85	LDC	United Republic of Tanzania	0.044	84	↓
L-MID	86	EIE	Sri Lanka	0.033	68	↓
L-MID	87	LDC	Myanmar	0.032	88	↑
L-MID	88	IND	Malta	0.031	91	↑
L-MID	89	IND	Kuwait	0.030	89	
BOTTOM	90	LDC	Bangladesh	0.030	87	↓
BOTTOM	91	LDC	Angola	0.028	111	↑
BOTTOM	92	DEV	Pakistan	0.027	90	↓
BOTTOM	93	DEV	Cameroon	0.027	86	↓
BOTTOM	94	DEV	Ghana	0.027	96	↑
BOTTOM	95	DEV	Kyrgyzstan	0.024	92	↓
BOTTOM	96	DEV	Kenya	0.023	107	↑
BOTTOM	97	DEV	Albania	0.022	95	↓
BOTTOM	98	LDC	Senegal	0.021	93	↓
BOTTOM	99	IND	Qatar	0.020	99	↔
BOTTOM	100	LDC	Ethiopia	0.014	97	↓
BOTTOM	101	DEV	Mongolia	0.012	94	↓
BOTTOM	102	LDC	Nepal	0.012	98	↓
BOTTOM	103	DEV	Syrian Arab Republic	0.007	100	↓
BOTTOM	104	LDC	Yemen	0.006	83	↓
BOTTOM	105	LDC	Cambodia	0.003	103	↓
BOTTOM	106	EIE	Kazakhstan	0.003	81	↓
BOTTOM	107	DEV	Botswana	0.000	104	↓
BOTTOM	108	DEV	Cuba	0.000	106	↓
BOTTOM	109	DEV	Nigeria	0.000	109	↔
BOTTOM	110	LDC	Niger	0.000	105	↓
BOTTOM	111	LDC	Eritrea	0.000	110	↓
BOTTOM	112	DEV	Iraq	0.000	112	↔

Source: Authors' elaboration based on UNIDO (2020b).

Figure 12: Scores and ranks of the top performing countries in the GIP index, edition 2020

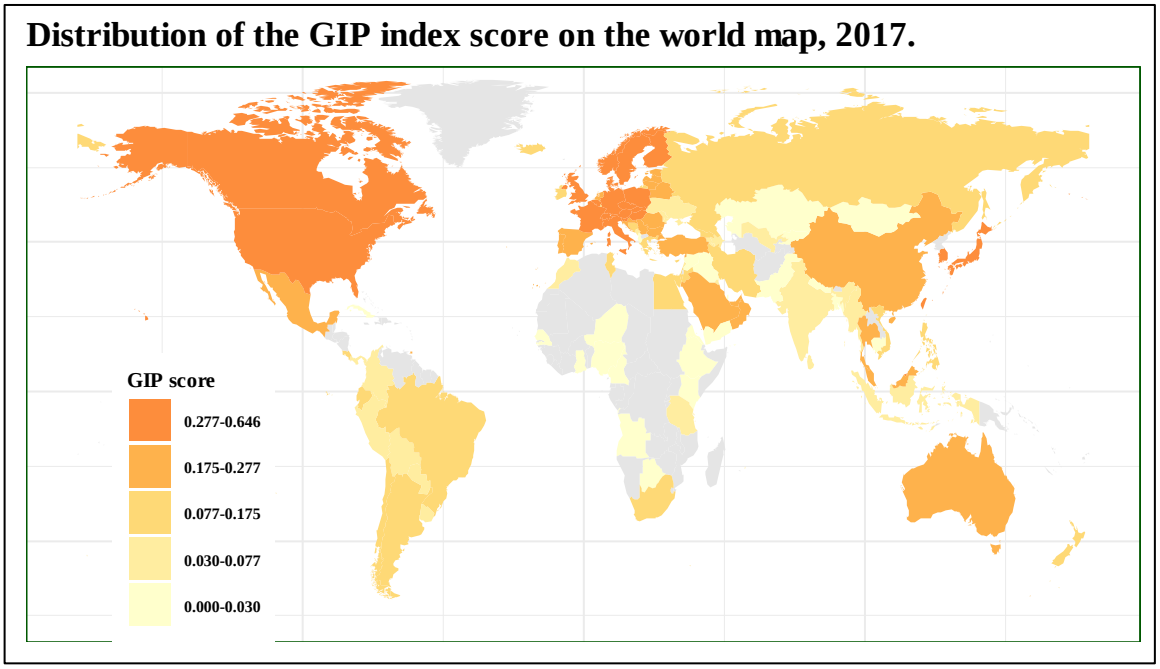


Source: Authors' elaboration based on UNIDO (2020b).

Note: If a country is already listed in the top 3, the runner-up is highlighted in the group of regional leaders. Similarly, if a country is included in the group of regional leaders, the runner-up will come in first among the development group leaders. See Appendix **Table A.1** for country classifications.

When we first look at the GIP values, we immediately observe significant differences from one economy to the next. The GIP values range from 0.646 to 0.000 in 2017 (six countries have an absolute index score of 0.000). We provide the complete ranking of economies according to the GIP index in 2017, as well as its six components in Annex A, Table 18. Figure 13 provides a visual and self-explanatory depiction of the variation of GIP values across the world. The lighter the colour in Figure 13, the lower the GIP score of a given economy. Moreover, the figure serves to identify those economies, mainly in Africa, for which we cannot compute the GIP index due to lack of data (see countries in blank).

Figure 13: Distribution of the GIP index score on the world map, 2017



Source: Authors' elaboration based on UNIDO (2020b).

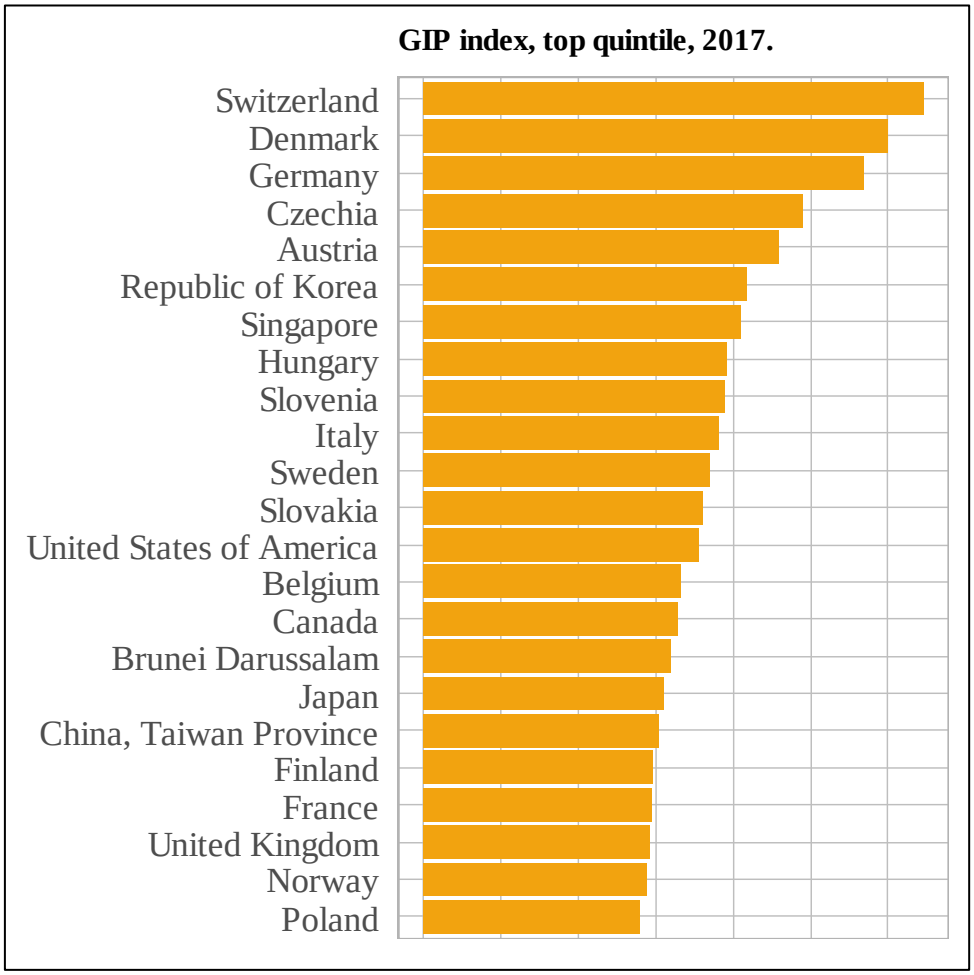
We start our comparative analysis by looking at the top performers in the GIP index. For that purpose, we focus our attention on the top quintile of GIP performers in 2017 (see Table 9).

Five European industrialized economies, namely Switzerland, Denmark, Germany, Czechia and Austria, top the GIP index in 2017. Among the top five performers, we hardly find any changes during the period 2014–2017; only Denmark's and Germany's position shifted while the other three economies' ranking remained unchanged. In 2017, the top 23 GIP quintile economies were industrialized, the only exception being one emerging industrial economy, Brunei Darussalam. This might point to the existence of a relationship between industrialization and the green industrial performance of economies and countries. This statement should be treated with caution, however. In 2017, all other industrialized economies were included in the upper-middle, middle and lower-middle quintiles (Malta and Kuwait are close to the bottom group), except for Qatar, which ranked 99th in the GIP bottom quintile. In addition, some industrialized economies witnessed significant changes during 2014–2017 as illustrated by Ireland, Luxembourg and Malaysia, which lost 22, 18 and 13 positions, respectively, whereas Iceland and Chile made significant improvements and jumped by 55 and 18 positions, respectively, over the same period.

When looking at the period 2014–2017, it is striking that no change has occurred in the list of economies occupying the top quintile. This finding seems to suggest that significant changes in green industrial performance requires time. During 2014–2017, Finland and Sweden, which lost

seven and three positions in the ranking, and Canada and the Republic of Korea, which gained four and three positions, respectively, experienced the most remarkable changes in the top quintile.

Figure 14: GIP index, top quintile, 2017



Source: Authors' elaboration based on UNIDO (2020b).

We now turn our attention to the bottom quintile and also find a certain level of consistency in that group as well. The 19 economies positioned in the bottom quintile remained unchanged during 2014–2017. Four economies, namely Bangladesh, Cameroon, Yemen and Kazakhstan dropped from the lower-middle quintile to the bottom quintile from 2014 to 2017, whereas Iceland (initially middle quintile), Ukraine, Uzbekistan and Malta (initially lower-middle quintile) succeeded in moving to upper quintiles.

In addition to industrialized economies which, as mentioned above, experienced significant changes in ranking during the period 2014–2017, notable changes were also observed in Ukraine, Uzbekistan and Angola, which gained 33, 30 and 20 positions, respectively, whereas Sri Lanka,

Yemen and Kazakhstan lost 18, 21, and 25 positions, respectively, over the same period. Therefore, even if most economies displayed a certain level of consistency in terms of their GIP ranking over the period 2014–2017, a handful of economies underwent significant changes, proving that it is possible for economies to achieve changes in green industrial performance over time. The reasons for these significant changes in ranking (both positive and negative) would need to be further investigated.

Beyond the overall green industrial performance of economies and countries included in the GIP index, exploring their performance in terms of each of the six indicators that are part of our index offers useful insights on the strengths and weaknesses of the economies and countries, as well as on the areas policymakers might wish to address to enhance the green performance of their respective industrial sectors. We will not exhaust all possibilities offered by the wealth of data collected from the six GIP components in this paper, but will instead provide some relevant findings that illustrate how policymakers, analysts and researchers can exploit and use GIP data.

Switzerland, the overall top GIP performer, achieved a remarkable share of 17.63 per cent green manufacturing value added in 2017 compared to 17.33 per cent in 2014. Denmark, Germany, Czechia and Italy followed the ranking in 2017 with 13.67 per cent (10.59 per cent in 2014), 13.12 per cent (13.61 per cent in 2014), 12.54 per cent (15.61 per cent in 2014) and 10.3 per cent (11.20 per cent), respectively. It is worth recalling that four of the five countries with the highest share of green manufacturing value added are also among the top GIP performers in 2017. Moreover, it is interesting to note that the share of green manufacturing value added has decreased among three of the five top performers with only Italy—which does not belong to the top five GIP performers—in this group, demonstrating a significant increase from 2014, and Switzerland displaying only a minor increase. Major differences in the share of green manufacturing value added are evident even among the top five performers, particularly when looking at the comparatively higher share of Switzerland. These differences are much higher when we look at the values of our full sample of economies and countries. Suffice to say that 18 countries of our sample displayed a share of less than 1 per cent green manufacturing value added. Switzerland was also the top performer in terms of green manufacturing value added per capita in 2017, which amounted to an impressive USD 2,315, despite experiencing a decline from USD 2,501 in 2014. Germany (with a green manufacturing value added per capita of USD 1,061 in 2017 compared to USD 1,1154 in 2014), Denmark (USD 984 compared to USD 740 in 2014), the Republic of Korea (USD 830 compared to USD 728 in 2014) and the United States of America (USD 705 compared to USD 714 in 2014) were the other top performers in 2017. Once again, the differences between countries, even when focusing on the top performers, are highly significant. Switzerland's green

manufacturing value added per capita is more than double that of Germany, which is the second-best performer in this indicator in our sample of 112 economies. Moreover, it is worth noting that 30 economies in our sample had green manufacturing value added per capita values that were lower than USD 10 in 2017.

When looking at the two GIP indicators related to green manufactured exports, the picture changes and other, mainly small-sized economies and countries with a long green exports track record, are included among the top performers. Singapore, ranking 7th in the GIP index in 2017, topped the list in terms of green manufactured exports per capita in 2017 at USD 4,473 (USD 4,630 in 2014). Singapore was followed by China, Hong Kong SAR, (USD 3,233 in 2017 compared to USD 3,252 in 2014), Denmark (USD 2,552 compared to USD 2,946 in 2014), Luxembourg (USD 2,343 compared to USD 2,520 in 2014), and Germany (USD 2,214 compared to USD 2,274 in 2014) as the other top green manufacturing exporters per capita in 2017. On the whole, green manufactured exports per capita in 29 economies amounted to less than USD 10 in 2017. Surprisingly, Trinidad and Tobago ranked eighth in terms of green manufactured exports per capita in 2017 at USD 2,131. The small size of the country and its manufacturing sector might explain, at least in part, its relatively good performance. Trinidad and Tobago's green industrial performance would need to be investigated further to arrive at a comprehensive explanation for the country's performance. Trinidad and Tobago achieved the highest share of green manufactured exports in total manufactured exports in 2017 at 40.3 per cent compared to 35.73 per cent in 2014. Brunei Darussalam, which had the 16th highest GIP value in 2017 (31.86 per cent), Denmark (17.49 per cent), the Philippines (15.47 per cent) and Hungary (13.82 per cent) completed the list of top performers according to share of green manufactured exports. It is worth mentioning that the share of green manufactured exports in total manufactured exports was lower than 2 per cent in 20 economies in 2017.

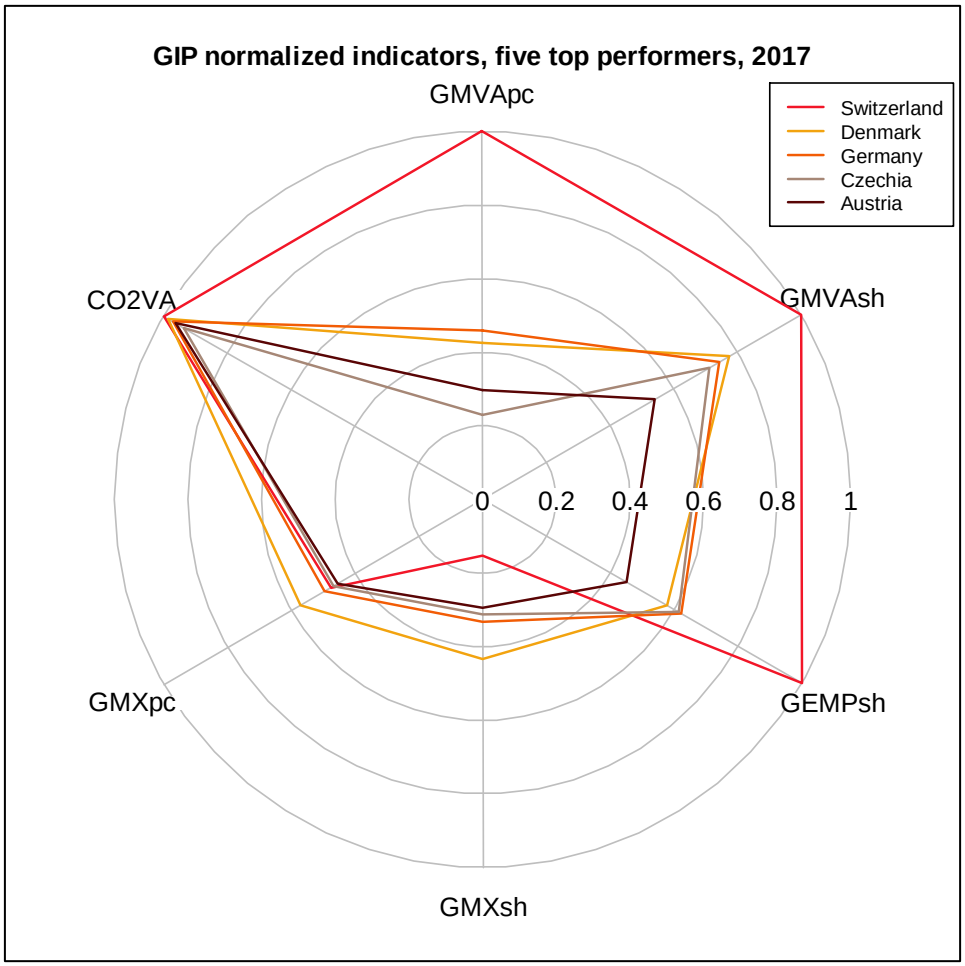
Four of the top five GIP performers, namely Switzerland, Germany, Czechia and Denmark, are among the top economies in terms of share of green manufacturing employment with 20.85 per cent (17 per cent in 2014), 12.97 per cent, 12.81 per cent and 12.61 per cent, respectively. The Russian Federation with a share of green manufacturing employment of 12.03 per cent ranked fourth in 2017. In that same year, 19 economies reported a share of less than 1 per cent of green manufacturing employment in total manufacturing employment.

Finally, we look at the level of CO_2 emissions and find that Ireland (0.0357 kg per unit of manufacturing value added) followed by Switzerland (0.0389), Cameroon (0.0457), Sri Lanka (0.0501) and Paraguay (0.0538) were the lowest emitters in 2017. This compares to comparatively much higher emitters such as Kazakhstan (2.999 kg per unit of manufacturing value added), Nepal

(2.722) and Ukraine (2.642). It is worth noting that Malta had the lowest emissions in 2014 at 0.0363 kg per unit of manufacturing value added, but dropped to sixth position in 2017, with its emissions rising to 0.0584 kg per unit of manufacturing value added.

When analysing the various components of the GIP index, it might be worth looking at the performance of the leading GIP performers. Figure 15 depicts the normalized values of the six GIP components using a radar-type chart for the top five GIP economies in 2017. We immediately find that the top GIP economies display significant differences when looking at the various GIP components. Moreover, such differences might be instrumental for identifying areas for potential improvement.

Figure 15: GIP normalized indicators, five top performers, 2017



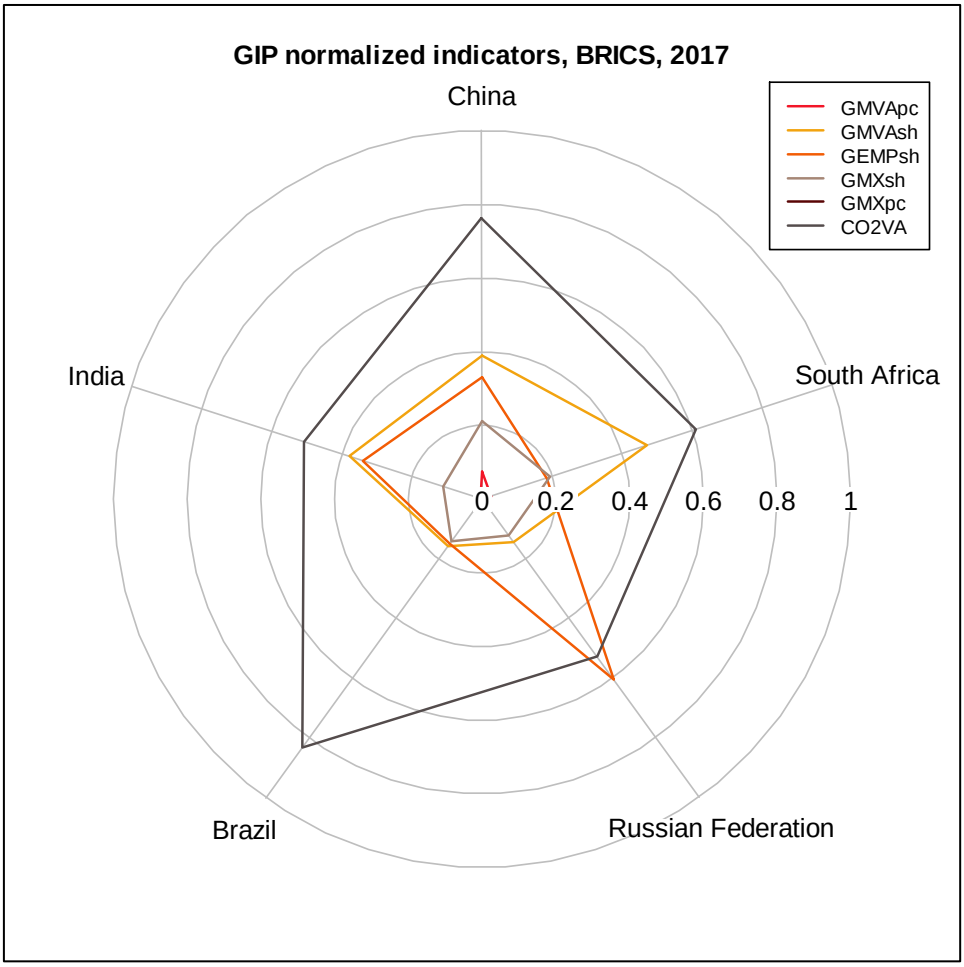
Source: Authors' elaboration based on UNIDO (2020b).

Switzerland remained the top GIP economy over the period 2014–2017. When looking at 2017, it is worth underscoring Switzerland's remarkable performance: it ranks first in the sample in terms of green manufacturing value added both per capita (USD 2,315) and share (17.63 per cent),

as well as in terms of share of green employment in total employment (20.84 per cent). The country also performs well in terms of CO_2 emissions, ranking second in 2017 among 112 economies with 0.0389 kg per unit of manufacturing value added. In terms of green manufactured exports per capita, Switzerland ranks 7th in our sample group in 2017 (USD 2,132). There is room for improvement in Switzerland's other GIP components, notably in the share of green manufactured exports (Switzerland ranked 55th with a share of 6.19 per cent). Denmark, in turn, is among the top five performers for five GIP components. With 0.0809 kg per unit of manufacturing value added and ranking 8th in terms of CO_2 emissions in our sample, this is a component Denmark can make further improvements in in the future. A reduction of CO_2 emissions could also be pursued in Germany (14th position), Austria (19th) and Czechia (36th) in the future.

Next, we turn our attention to the so-called BRICS countries (Brazil, the Russian Federation, India, China and South Africa). We find a relatively diverse performance both at the aggregate level, as well as in terms of the various GIP components. In 2017, China ranked 36th, South Africa 51st, the Russian Federation 60th, Brazil 66th and India 77th according to the GIP index, with values ranging from 0.1899 to 0.063. We present the normalized values of the six GIP components in Figure 16. China outperformed the other economies in this group in green manufacturing value added per capita (USD 172), green manufactured value added share (6.91 per cent) and share of green manufactured exports (8.57 per cent) whereas South Africa was the strongest performer in terms of green manufacturing value added share (8.29 per cent), the Russian Federation in green manufacturing employment share and Brazil in CO_2 emissions (0.534 kg per unit of manufacturing value added). Figure 16 provides insights on which areas each economy could focus on to improve their green industrial performance in the future.

Figure 16: GIP normalized indicators, BRICS, 2017

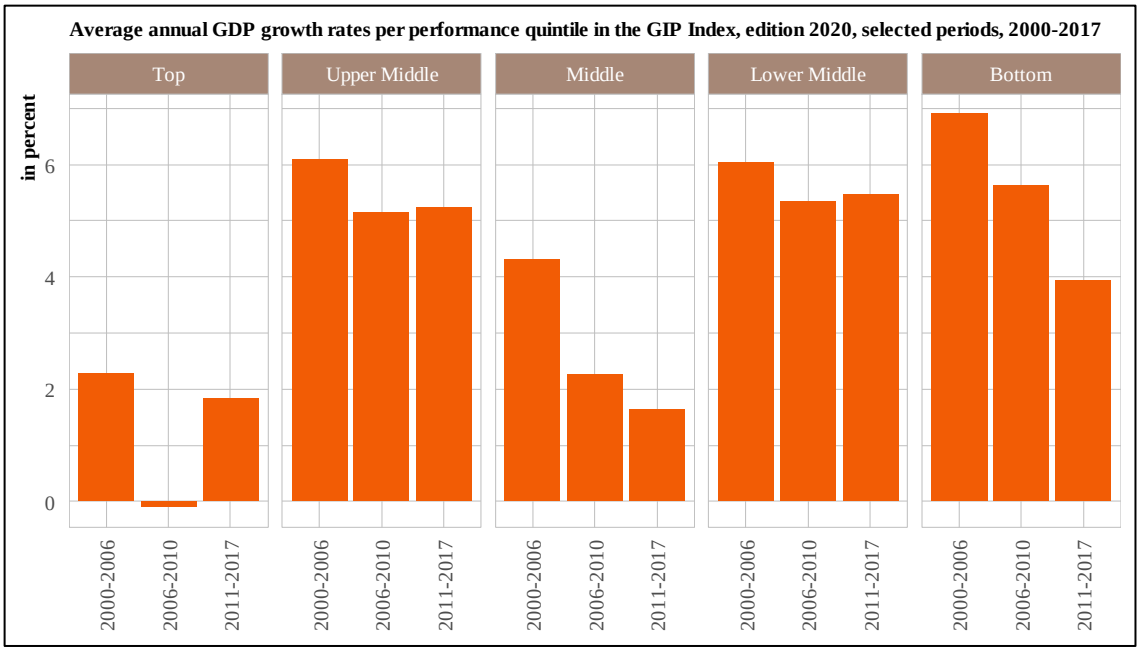


Source: Authors' elaboration based on UNIDO (2020b).

The GIP index offers endless opportunities to analyse and gain an understanding of green industrial performance of economies as well as groupings of economies. In the remainder of this section, we will illustrate selected approaches that policymakers and researchers can take to exploit the full potential of the GIP index.

The performance of economies by GIP index quintile or of the various groups, for instance, in terms of overall economic performance measured by GDP growth over time, can be analysed.

Figure 17: Average annual GDP growth rates per performance quintile in the GIP index, selected periods, 2000–2017



Source: Authors' elaboration based on UNIDO (2020b, 2020e).

Figure 17 presents the economic growth rates of economies grouped in the GIP index for three periods over 2000–2017. While the GDP growth rate decreased for all groupings during 2006–2017 due to the financial crisis, the top GIP quintile, which mainly comprised industrialized economies, experienced negative GDP growth due to the stagnation of their economies. Upper-middle and lower-middle quintiles displayed significant growth rates (above 5 per cent, on average), even during the financial crisis, and their growth increased moderately in the period 2011–2017. The middle and bottom quintiles witnessed a decrease in their GDP growth rates in the three defined periods, even if the growth rates of the economies in the bottom quintile remained comparatively high.

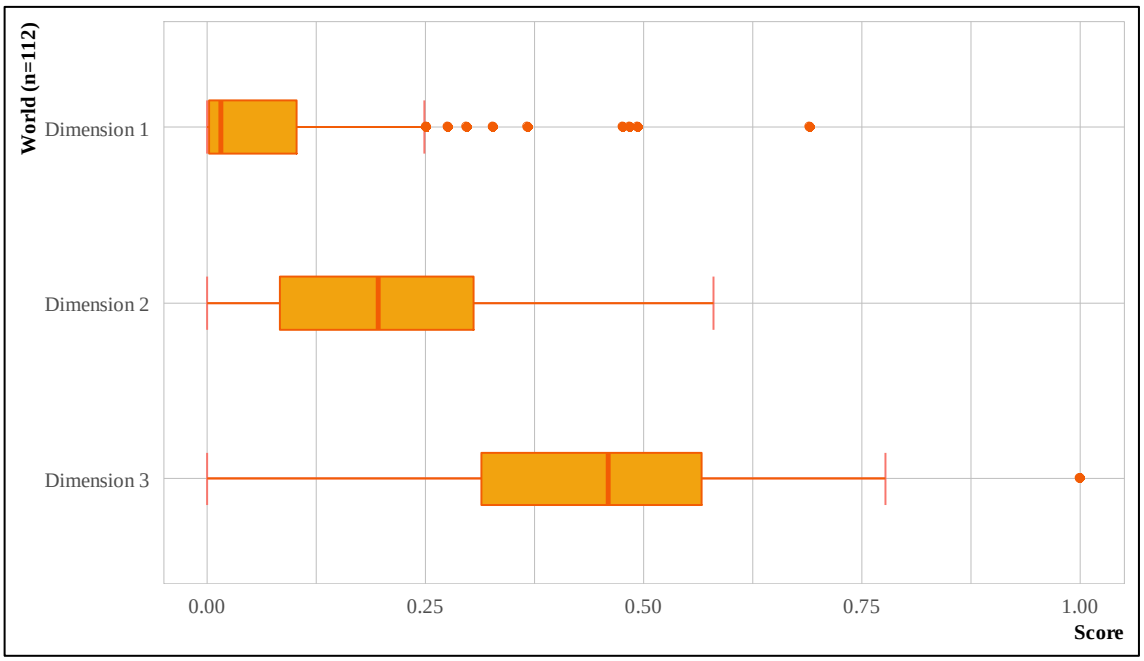
3.2. Main findings by geographical region

It is also worth exploring the GIP performance of economies and countries by geographical region. For that purpose, we compute the GIP index for eight world regions, namely Northern America, Latin America and the Caribbean, Eastern Asia, Central and Western Asia, Southern and South-eastern Asia, Europe, Pacific and Africa, using the UNIDO regional country groupings as presented in the International Yearbook of Industrial Statistics 2021 (UNIDO, 2021).

The results of the GIP regional and global ranking, the position of each of the three dimensions and the absolute change in ranking compared to 2012 for each of the countries in the region are presented below. The scores of the three dimensions are shown in a box plot diagram, providing

information about the distribution of the scores. Figure 18 illustrates an example of such a diagram, presenting the score distributions of all 112 countries in the world.

Figure 18: Score distribution for the three GIP dimensions, world (2017)



Source: Authors' elaboration based on UNIDO (2020b).

Using the geographical regions, we can identify the regional leaders in terms of green industrial performance, as well as common strengths and/or areas of improvement.

3.2.1 Northern America

We present both the global and regional rankings of the two Northern American countries in Table 10, as well as their change in the global ranking over time. Both the United States of America and Canada are part of the GIP top quintile and ranked 13th and 15th in 2017, respectively. Moreover, both countries increased their position in the global GIP ranking during the period 2012–2017, confirming that their green industrial performance improved relative to that of other economies. It is also noteworthy that both countries ranked comparatively higher in terms of the third GIP dimension, i.e. the social and environmental aspects of green manufacturing.

Figure 19 introduces a regional boxplot representation and helps illustrate the score distribution of the countries in the region in each of the three GIP dimensions, i.e. the first dimension on the capacity to produce and export green manufactured products, the second dimension on the role of green manufacturing, and the third dimension on the social and environmental aspects of green manufacturing. Northern America shows a strong capacity to produce and export green manufactured goods with a median score of 0.1707, which is the highest among all regional

groups, driven mainly by its strong performance in terms of green manufacturing value added per capita, with the United States ranking 5th and Canada 11th. Their performance in terms of green manufactured exports per capita is relatively weaker – even if the United States of America ranked 36th in our GIP sample in terms of green manufactured exports in 2017 with an amount of USD 433. It is also notable that with a median score of 0.6665, the two economies in this region ranked significantly better in social and environmental aspects of green manufacturing—owing to their very strong performance in green employment, ranking 9th and 12th, respectively–but only achieved a median score of 0.3535 in terms of the role of green manufacturing due to their comparatively lower share of green manufactured exports in total manufactured exports. The region's median score in the social and environmental aspects of green manufacturing is the highest among all regional groupings.

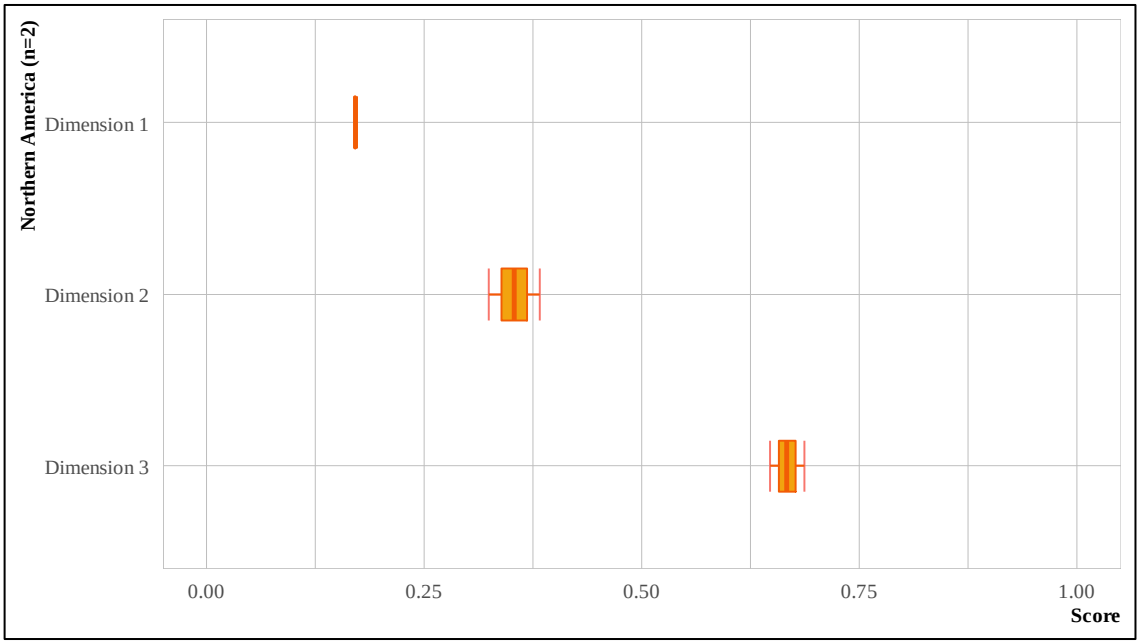
Recent research provides estimates of the overall size of the U.S. green economy and emphasizes its leading role in the country's overall economic growth, highlighting the potential benefits of developing and aligning economic, environmental and education policies (Georgeson and Malin, 2019).

Table 10: GIP ranking: Global, regional and by each dimension, Northern America (2017)

Regional rank	Economy	Global rank	Rank in the first dimension	Rank in the second dimension	Rank in the third dimension	Absolute change compared to 2012
1	United States of America	13	16	9	7	2 ↑
2	Canada	15	17	22	12	5 ↑

Source: Authors' elaboration based on UNIDO (2020b).

Figure 19: Score distribution, Northern America (2017)



Source: Authors' elaboration based on UNIDO (2020b).

3.2.2 Latin America and the Caribbean

The performance of the economies in Latin America and the Caribbean deteriorated during the period 2012–2017 with all countries losing ground with three exceptions, namely Trinidad and Tobago, Mexico and Chile. Both Trinidad and Tobago and Chile belong to the GIP's upper-middle quintile while 11 economies out of a total of 14 rank in the middle or lower-middle quintiles, and Cuba is in the bottom quintile. Chile's progress over the period is remarkable as demonstrated by a jump of 15 positions while Uruguay lost 14 positions over the same period. It is also remarkable that Brazil, the leading green economy in this region with a green manufacturing value added per capita of USD 31 in 2017, ranked 6th among the Latin American and Caribbean economies after having lost seven positions during the 2012–2017 period. These findings seem to suggest that the country has not yet fully tapped the potential offered by green manufacturing.

We present the score distribution of the Latin American and Caribbean economies in Figure 20. The capacity to produce and export green manufactured products is limited in this region, with two economies outperforming the rest, namely Trinidad and Tobago, which ranked 8th in terms of green manufactured exports per capita, and Mexico, which ranked 44th and 41st in terms of green manufacturing value added per capita and green manufactured exports per capita, respectively. The region scores better in terms of the role of green manufacturing where, once again, the same two economies outperform the rest. Trinidad and Tobago tops the rank in terms

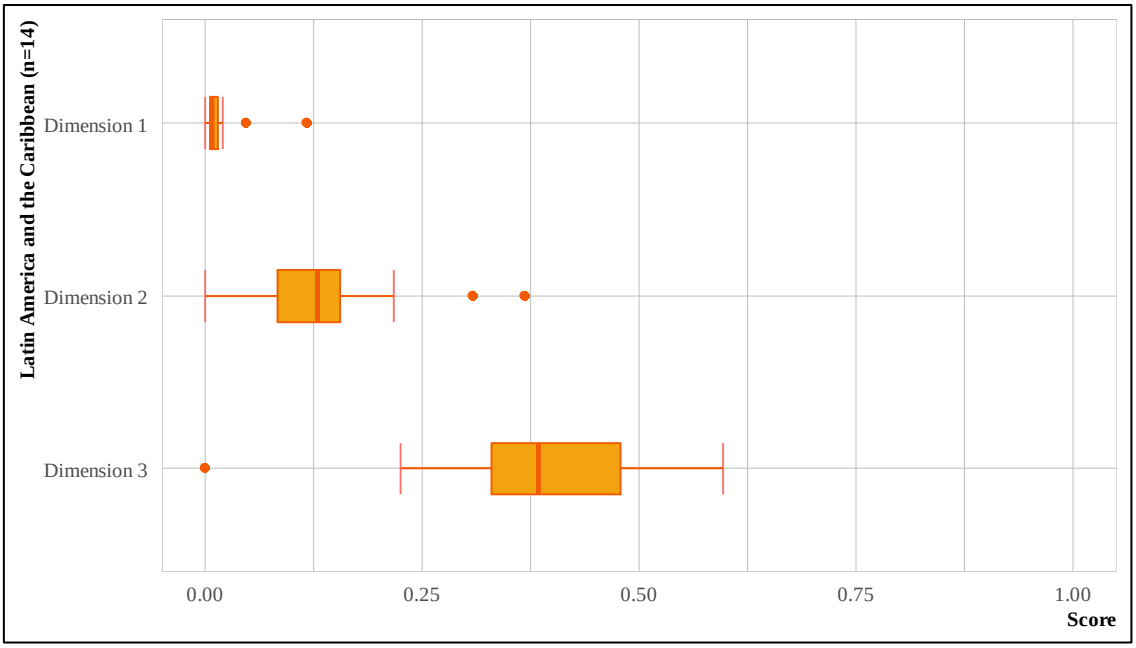
of share of green manufactured exports in total manufactured exports, while Mexico reports a similarly strong performance—relative to that of the region—in terms of share of green manufacturing value added (rank 39th) and of green manufactured exports (rank 30th). The region's performance in terms of social and environmental aspects of green manufacturing is significantly better than in other two GIP dimensions, with the exception of Cuba, which represents an outlier. Mexico scores comparatively high (rank 23rd) in green manufacturing employment, whereas a number of economies in the region show a strong performance in CO_2 emissions, including Paraguay, Uruguay, Costa Rica and Ecuador.

Table 11: GIP ranking: Global, regional and by each dimension, Latin America and the Caribbean (2017)

Regional rank	Economy	Global rank	Rank in the first dimension	Rank in the second dimension	Rank in the third dimension	Absolute change compared to 2012
1	Trinidad and Tobago	31	25	10	98	7 ↑
2	Mexico	33	46	27	21	2 ↑
3	Chile	57	54	70	52	15 ↑
4	Ecuador	62	73	50	25	-8 ↓
5	Costa Rica	63	57	72	56	-8 ↓
6	Brazil	66	63	65	76	-7 ↓
7	Argentina	67	70	62	64	-4 ↓
8	Peru	70	69	76	75	-1 ↓
9	Colombia	72	78	69	57	-1 ↓
10	Uruguay	75	66	88	83	-14 ↓
11	Panama	79	68	94	94	-6 ↓
12	Paraguay	83	86	90	29	-8 ↓
13	Bolivia (Plurinational State of)	84	87	78	74	-8 ↓
14	Cuba	108	107	107	110	-4 ↓

Source: Authors' elaboration based on UNIDO (2020b).

Figure 20: Score distribution, Latin America, and the Caribbean (2017)



Source: Authors' elaboration based on UNIDO (2020b).

3.2.3 Eastern Asia

The region of Eastern Asia has three economies—the Republic of Korea, Japan and Taiwan, Province of China—in the top GIP quintile, two in the upper-middle quintile—China and Hong Kong, SAR of China—and one country in the bottom quintile, namely Mongolia. The Republic of Korea improved its global ranking by two positions during 2012–2017 to rank 6th in the GIP.

In terms of green manufacturing value added per capita, the Republic of Korea (5th) and Japan (12th) belong to the top economies in the region. The performance of China, Hong Kong SAR (2nd), Taiwan, Province of China (16th) and the Republic of Korea (17th) in green manufactured exports per capita was comparatively strong. Eastern Asia on the whole performed better than all other regions, except for Northern America, in terms of its capacity to produce and export green manufactured products with a median score of 0.1362. The region's performance in terms of the role of green manufacturing was also stronger, driven by the share of green manufacturing value added of the Republic of Korea (16th) and China (34th) and by the share of green manufactured exports of Japan (10th) and the Republic of Korea (23rd). Finally, the region's performance in social and environmental aspects of green manufacturing was also stronger, with a median of 0.524, with the Republic of Korea playing a leading role (ranked 7th) in green employment share and 26th in CO_2 emissions. The long-standing efforts of the Republic of Korea—which is a leading example of a successful manufacturing-based economy—to promote green growth and move away from fossil-dependent growth, dates to the promulgation of the 2009–2050 National

Strategy for Green Growth and the 2009–2013 Five-Year Plan. Using a top-down approach led by the government, the above initiatives focused on the reduction of greenhouse gas from industry, the provision of incentives for green products and technologies, and increasing public demand for green products (Kang et al., 2012). The various roles the Government of the Republic of Korea has played to establish the main technology areas, to define the national strategies and to provide the necessary funding represent a distinct characteristic of their successful experience (GGGI, 2015). The experience of the Republic of Korea highlights the importance of continuous political support for green growth and the need to align all sectoral strategies and enhance cross-government coordination (OECD, 2017b).

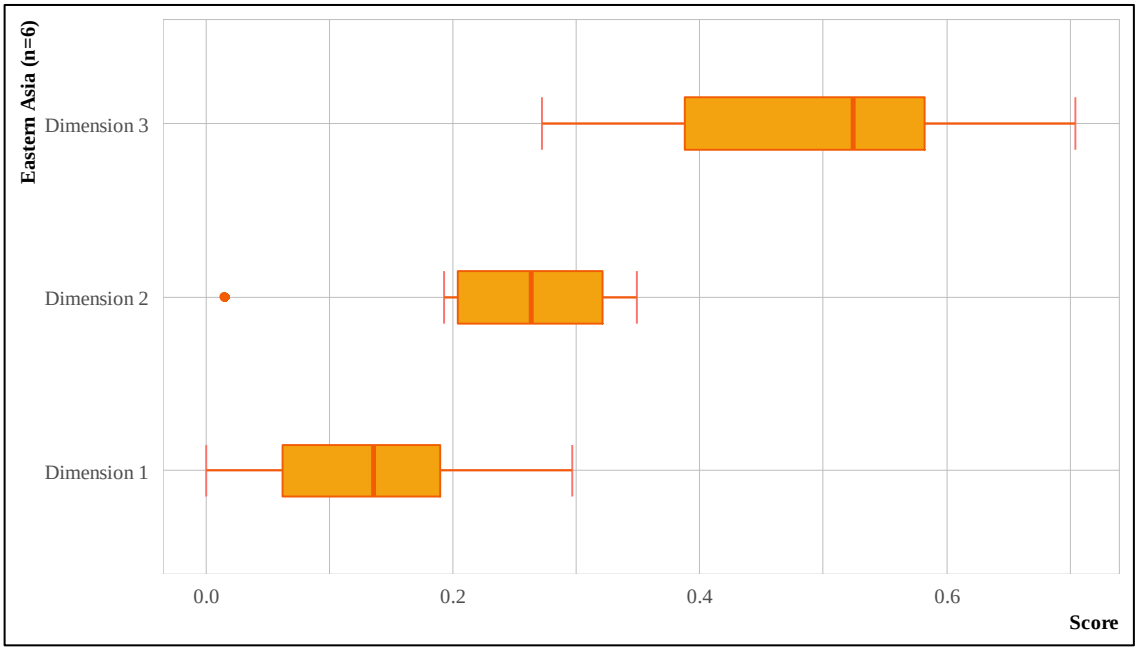
The Republic of Korea, a leading manufacturing economy, has championed the development of green growth policies and strategies worldwide. The country's national strategy is summarized in its 2008 low-carbon green growth strategy underpinned by technological development, the national strategy for green growth for the period 2009–2050, and the Five-year Green Plan for Green Growth (Kang et al., 2012; GGGI, 2015; OECD, 2017b).

Table 12: GIP ranks: Global, regional and by each dimension, Eastern Asia (2017)

Regional rank	Economy	Global rank	Rank in the first dimension	Rank in the second dimension	Rank in the third dimension	Absolute change compared to 2012	
1	Republic of Korea	6	7	16	5	2	↑
2	Japan	17	19	20	37	0	↔
3	China, Taiwan Province	18	13	42	22	-2	↓
4	China	36	45	35	48	0	↔
5	China, Hong Kong SAR	45	26	57	91	-3	↓
6	Mongolia	101	101	103	77	8	↑

Source: Authors' elaboration based on UNIDO (2020b).

Figure 21: Score distribution, Eastern Asia (2017)



Source: Authors' elaboration based on UNIDO (2020b).

3.2.4 Central and Western Asia

No economy of Central and Western Asia is included in the GIP's top quintile in 2017. The United Arab Emirates, Saudi Arabia, Turkey and Oman are positioned in the GIP upper-middle quintile whereas the performance of Kyrgyzstan, Qatar, the Syrian Arab Republic, Yemen, Kazakhstan and Iraq deteriorated at different rates in the period 2012–2017 and are positioned in the GIP's bottom quintile.

The United Arab Emirates jumped 12 positions in the GIP global ranking from 2012 to 2017. The country has a relative strong performance in terms of its capacity to produce (19th) and export (24th) green manufactured products, while the role of green manufacturing, particularly in terms of the share of green manufactured exports in total manufactured exports (71st), is comparatively lower compared to other economies in the region, such as Oman. Saudi Arabia's performance in green value added both in terms of per capita (26th) and share (29th) was relatively strong, but significantly lower in terms of green manufactured exports per capita, which is over five times lower than that of the United Arab Emirates. The performance of all Gulf Cooperation Council countries (GCC) is rather poor in terms of CO_2 emissions, with the United Arab Emirates and Saudi Arabia ranking 103rd and 99th in the GIP sample of 112 economies in 2017. The interest among GCC countries, whose development has been driven by their fossil fuel resources, in transitioning towards a green economy is worth mentioning, although research points towards the necessity to pay particular attention to existing policies and incentives in the areas of energy

subsidies and green jobs (Loumi, 2015). The United Arab Emirates is an interesting example in terms of policy and institutional development in the area of green economy and growth. The country pioneered the development of an overarching nationwide green agenda in the GCC region for the period 2015–2030 (UAE MOCCAE, 2016). Its national climate change plan for the period 2017–2050 (UAE MOCCAE, 2016), in turn, represents an innovative strategy to guide the transition into a climate resilient green economy and enhance the quality of life while its ambitious Energy Strategy 2050 seeks to double the contribution of clean energy to account for 50 per cent of the total energy mix in 2050.

At the other extreme in terms of CO_2 emissions is Israel, which is by far the strongest performer in the region, ranking 10th among the GIP economies. Israel's share of green manufacturing employment (91st) and of green manufacturing value added (87) are comparatively low, particularly when one considers the size of its overall industrial sector. The green industrial performance of economies in Central and Western Asia differ considerably. During 2012–2017, ten economies were able to improve their rank–including Uzbekistan (+28 positions) and Azerbaijan (+13 positions)—while eight lost ground—including Yemen (-25 positions) and Kazakhstan (-24 positions)—and Iraq remained at the bottom of the GIP ranking.

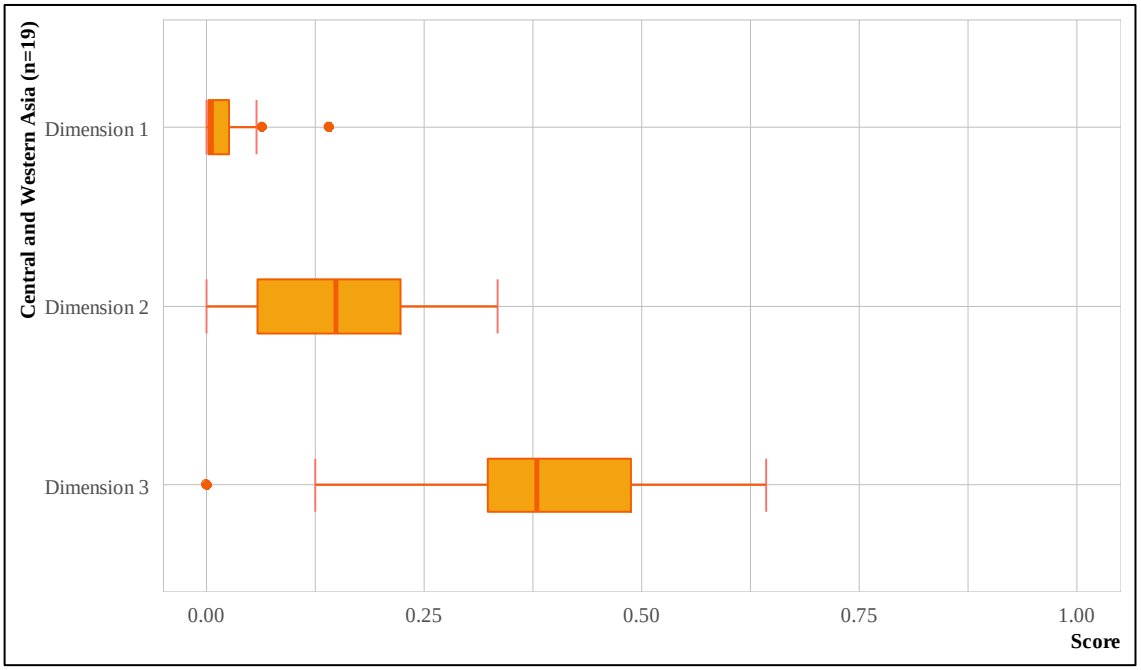
Figure 22 presents the score distribution of Central and Western Asia. The region's performance is comparatively low with the second lowest median scores of all geographical regions in the first and third dimensions of the GIP index. The region performs significantly better in terms of social and environmental aspects of green manufacturing with a median score of 0.3798, while its capacity to produce and export green manufactured products is exceptionally low with a median score of 0.0059. The region's median score in green manufacturing lies between the other two GIP dimensions.

Table 13: GIP ranks: Global, regional and by each dimension, Central and Western Asia (2017)

Regional rank	Economy	Global rank	Rank in the first dimension	Rank in the second dimension	Rank in the third dimension	Absolute change compared to 2012	
1	United Arab Emirates	29	22	49	66	12	↑
2	Saudi Arabia	38	43	34	60	9	↑
3	Turkey	40	49	32	31	5	↑
4	Oman	42	40	19	85	-10	↓
5	Israel	48	36	64	80	4	↑
6	Jordan	56	61	48	49	4	↑
7	Georgia	59	65	26	72	6	↑
8	Cyprus	65	56	75	69	-8	↓
9	Lebanon	69	75	66	50	-2	↓
10	Azerbaijan	73	89	60	14	13	↑
11	Uzbekistan	78	88	73	39	28	↑
12	Armenia	82	84	85	53	14	↑
13	Kuwait	89	71	102	104	8	↑
14	Kyrgyzstan	95	94	98	79	-14	↓
15	Qatar	99	82	105	81	-15	↓
16	Syrian Arab Republic	103	102	104	102	-3	↓
17	Yemen	104	108	47	61	-25	↓
18	Kazakhstan	106	77	93	112	-24	↓
19	Iraq	112	112	112	111	0	↔

Source: Authors' elaboration based on UNIDO (2020b).

Figure 22: Score distribution, Central and Western Asia (2017)



Source: Authors' elaboration based on UNIDO (2020b).

3.2.4 Southern and South-eastern Asia

Southern and South-eastern Asia represent a relatively heterogeneous GIP regional grouping. The region comprises two economies (Singapore and Brunei Darussalam) that are positioned in the GIP's top quintile, Thailand and Malaysia are in the upper-middle, three countries are in the middle, and four countries each in the lower-middle and bottom quintiles of the GIP index. Five economies out of a total of 15 improved their GIP ranks over the period 2012–2027, namely Viet Nam (+10 positions), Thailand and the Philippines (+7 positions), Singapore (+5 positions) and Pakistan (+2 positions). Malaysia (-13 positions), Nepal (-12 positions) and Brunei Darussalam (-6 positions) lost positions during 2012–2107. Singapore tops the region's green industrial performance ranking 7th in the GIP global ranking; the country also ranks 7th in terms of green manufactured exports per capita (USD 4,473), and 3rd for its capacity to produce and export green manufactured products with a value added per capita of USD 543. Singapore's performance is comparatively weaker when we look at the role of green manufacturing in the country, suggesting that there is room for improvement. The country ranks 2nd in the region following the Islamic Republic of Iran in terms of the share of green employment and 3rd in CO_2 emissions after Sri Lanka and Brunei Darussalam. Brunei Darussalam's high share of green manufactured exports in total manufactured exports (31.86 per cent) places the country 2nd worldwide and 33rd for share of green manufacturing value added. The Philippines ranks 5th globally in terms of share of green manufactured exports (15.46 per cent). Several of the region's large industrial economies such as

Pakistan (97th), India (100th), the Islamic Republic of Iran (102nd) and Viet Nam (104th) perform comparatively low in terms of CO_2 emissions.

Table 14: GIP ranks: Global, regional and by each dimension, Southern and South-eastern Asia (2017)

Regional rank	Economy	Global rank	Rank in the first dimension	Rank in the second dimension	Rank in the third dimension	Absolute change compared to 2012	
1	Singapore	7	3	43	20	5	↑
2	Brunei Darussalam	16	23	2	54	-6	↓
3	Thailand	39	47	39	42	7	↑
4	Malaysia	41	37	54	59	-13	↓
5	Iran (Islamic Republic of)	50	58	17	62	-2	↓
6	Philippines	55	62	25	51	7	↑
7	Viet Nam	58	55	56	89	10	↑
8	Indonesia	71	74	68	68	-5	↓
9	India	74	83	55	63	-4	↓
10	Sri Lanka	86	85	92	101	2	↑
11	Myanmar	87	93	95	36	0	↔
12	Bangladesh	90	91	84	90	-5	↓
13	Pakistan	92	98	80	92	2	↑
14	Nepal	102	103	87	103	-12	↓
15	Cambodia	105	104	106	106	-3	↓

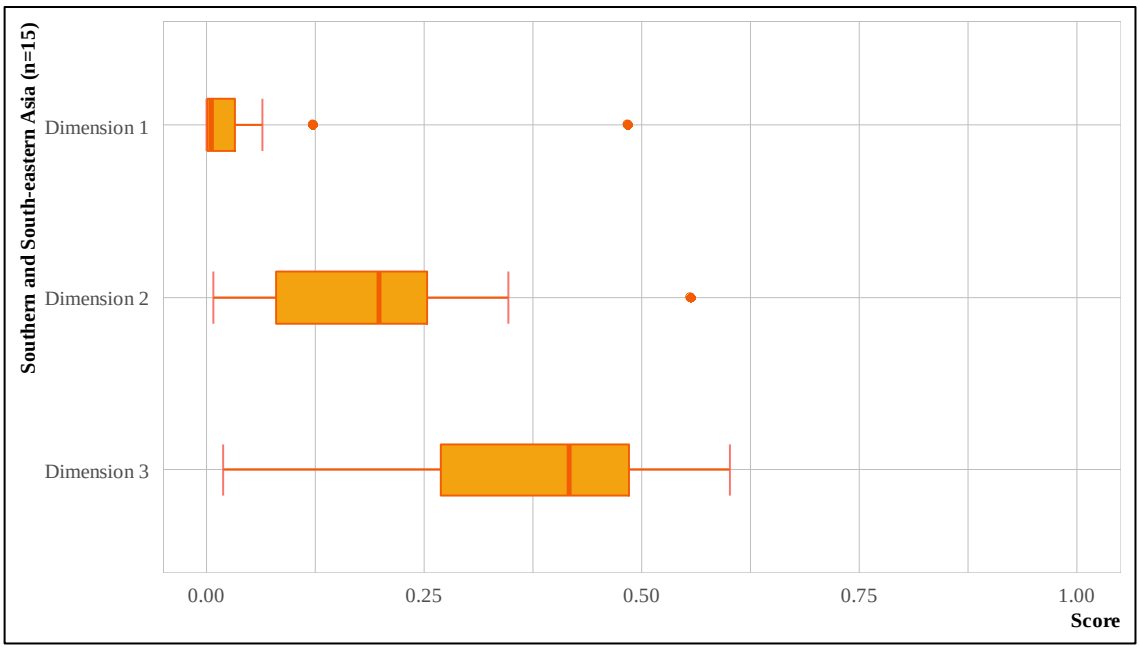
Source: Authors' elaboration based on UNIDO (2020b).

There are certain similarities between Southern and South-eastern Asia's regional scores and those of Western and Central Asia, despite being consistently higher. The region's median score (0.4160) in social and environmental aspects of green manufacturing is higher than its median score in role of green manufacturing (0.1981). While the regional median score of the capacity to produce and export manufactured products is low (0.006039), it is worth noting two outperformers, namely Singapore with 0.4843 and Brunei Darussalam with 0.1230. Building on a long tradition to enhance sustainability (see, for instance, MEWR and MND, 2014), Singapore has developed an ambitious plan, i.e. the Singapore Green Plan 2030 (Ministry of Education et al., 2021) to accelerate national efforts towards achieving sustainability and hence to fight climate change. The city in nature, sustainable living, an energy reset, green economy and a resilient

future are the main pillars of the Plan. The green economy pursues, among others, the creation of good jobs in sustainable industries, as well as the ambition to become the world's green finance centre.

Singapore's Sustainable Blueprint of 2015 highlights the national objective to reconcile economic growth with sustainability, for instance, by greening existing industries and boosting future green growth, notably by introducing and diffusing green technologies (MEWR and MND, 2014).

Figure 23: Score distribution, Southern and South-eastern Asia (2017)



Source: Authors' elaboration based on UNIDO (2020b).

3.2.5 Europe

The GIP's top five regional economies, namely Switzerland, Denmark, Germany, Czechia and Austria, were also the best global performers in 2017. Moreover, eight European economies are among the GIP's top ten in the world. A certain degree of consistency is observable, particularly among the world's best performers. Switzerland ranks 1st in terms of the capacity to produce and export green manufactured products and in social and environmental aspects of green manufacturing. Switzerland is the leading economy worldwide in green manufacturing value added per capita, share of green manufacturing value added and share of green manufacturing employment, while Denmark tops the rank in terms of the role of green manufacturing. Switzerland has focused considerable attention on sustainable development and the green economy for many years. The country's Fourth Sustainable Development Strategy for the period 2012–2015 (Federal Council, 2012) aimed, among others, to decouple economic productivity from resource and energy use while the Green Economy Plan of 2013 (FOE, 2013) and its

extension for the period 2016–2019 (BAFU, 2016) focused on consumption and production patterns, raw material and waste, the Cleantech Master Plan and greening the tax system.

During the period 2012–2017, significant declines in performance by Luxembourg (-23 positions)—despite the country performing well in terms of green manufactured exports per capita—Ireland (-21 positions), which is the best global performer in terms of CO_2 emissions, and Finland (-10 positions) are notable. On the other hand, Iceland (+54) and Ukraine (+31) significantly improved their global ranking.

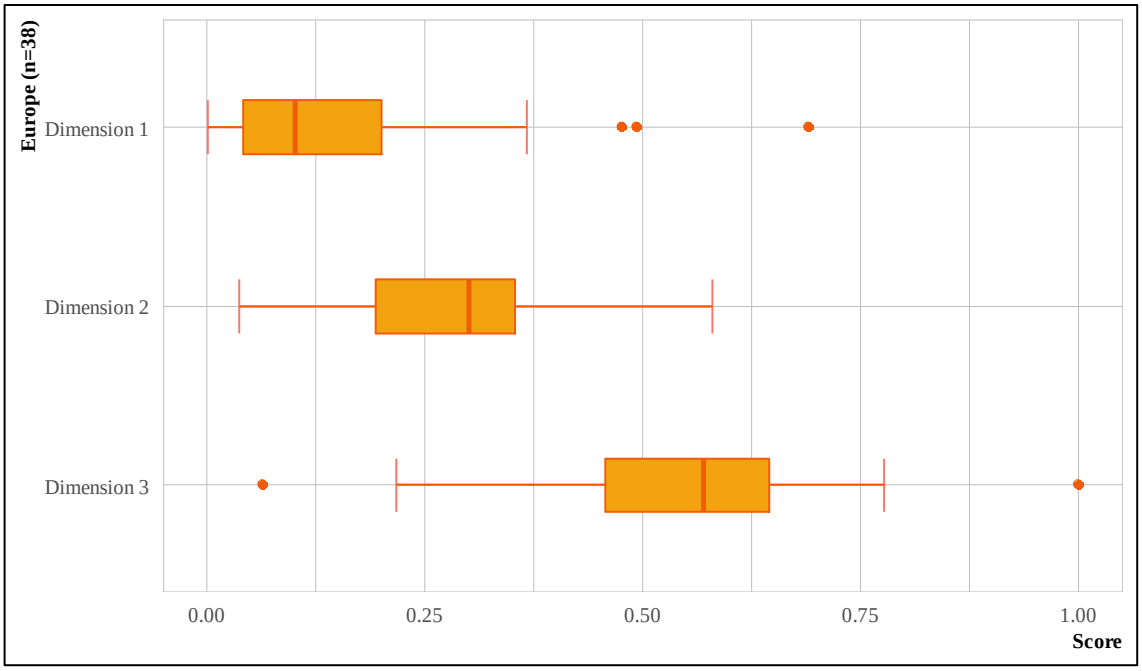
Table 15: GIP ranks: Global, regional and by each dimension, Europe (2017)

Regional rank	Economy	Global rank	Rank in the first dimension	Rank in the second dimension	Rank in the third dimension	Absolute change compared to 2012	
1	Switzerland	1	1	8	1	1	↑
2	Denmark	2	2	1	4	-1	↓
3	Germany	3	4	3	2	0	↔
4	Czechia	4	6	4	3	0	↔
5	Austria	5	5	7	11	0	↔
6	Hungary	8	12	5	9	-1	↓
7	Slovenia	9	10	11	15	-1	↓
8	Italy	10	11	6	10	1	↑
9	Sweden	11	9	23	16	2	↑
10	Slovakia	12	14	13	6	7	↑
11	Belgium	14	8	41	35	3	↑
12	Finland	19	18	45	8	-10	↓
13	France	20	21	29	23	2	↑
14	United Kingdom	21	24	24	13	0	↔
15	Norway	22	20	33	27	-6	↓
16	Poland	23	30	14	18	2	↑
17	Spain	24	28	28	17	-1	↓
18	Netherlands	25	15	59	26	-1	↓
19	Portugal	26	29	21	33	3	↑
20	Lithuania	27	27	30	41	4	↑
21	Croatia	28	35	18	28	2	↑
22	Romania	30	42	15	34	6	↑
23	Latvia	32	38	36	43	5	↑

Regional rank	Economy	Global rank	Rank in the first dimension	Rank in the second dimension	Rank in the third dimension	Absolute change compared to 2012
24	Estonia	34	32	51	65	-7 ↓
25	Serbia	35	50	12	19	7 ↑
26	Bulgaria	37	44	37	44	6 ↑
27	Belarus	44	48	40	24	6 ↑
28	Iceland	47	34	82	58	54 ↑
29	Luxembourg	49	31	77	88	-23 ↓
30	Greece	52	51	61	55	-3 ↓
31	Bosnia and Herzegovina	53	53	44	71	5 ↑
32	Russian Federation	60	60	71	30	-4 ↓
33	Ireland	61	33	101	87	-21 ↓
34	Ukraine	68	67	52	97	31 ↑
35	Republic of Moldova	76	80	63	70	-2 ↓
36	Montenegro	81	81	81	82	-3 ↓
37	Malta	88	64	99	105	3 ↑
38	Albania	97	92	100	99	-5 ↓

Source: Authors' elaboration based on UNIDO (2020b).

Figure 24: Score distribution, Europe (2017)



Source: Authors' elaboration based on UNIDO (2020b).

3.2.6 Pacific

The lack of data is a serious drawback for depicting the Pacific's regional performance. Only having the necessary data to compute the GIP index for two economies, namely Australia and New Zealand, risks presenting a biased picture of the region's performance. Australia and New Zealand are by far the largest economies in the region and have a similar green industrial performance, ranking 43rd and 46th globally in the GIP index. Both lost ground during the period 2012–2017, with Australia dropping 9 positions and New Zealand 13 positions. The capacity to produce and export green manufactured goods is higher in Australia than in New Zealand, while the contrary is the case when looking at the role of green manufacturing. Both economies rank comparatively better in terms of green manufacturing value added than in green manufactured exports. Similarly, they achieve higher rankings in terms of their share of green employment than in CO_2 emissions, with Australia ranking 70th.

Unsurprisingly, the score distribution of these two Pacific economies computed for the GIP index (Figure 25) does not reveal major differences. With a median of 0.587 in the first dimension, the Pacific is far from both the top regions Northern America, Eastern Asia and Europe and from all lower performers. Although the region's median score of the role of green manufacturing is higher than that of the first GIP dimension, the Pacific with 0.1794 lags behind other regions, including Southern and South-eastern Asia. The Pacific's median score in social and environmental aspects

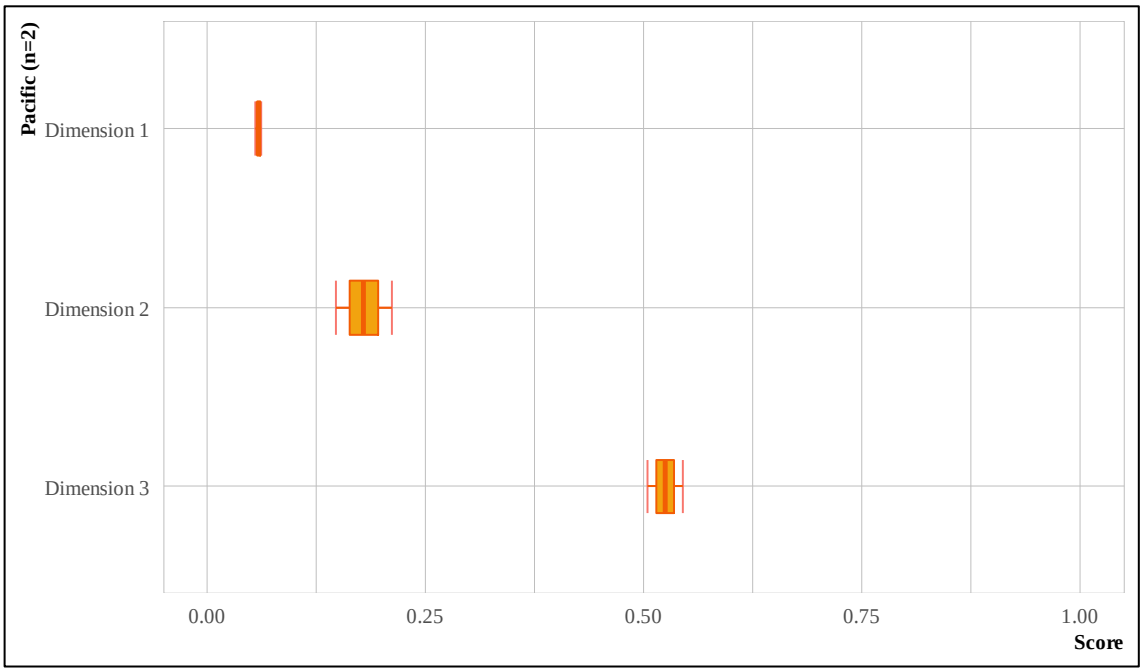
of green manufacturing (0.5245) positions the region in 3rd place only behind Northern America and Europe.

Table 16: GIP ranks: Global, regional and by each dimension, Pacific (2017)

Regional rank	Economy	Global rank	Rank in the first dimension	Rank in the second dimension	Rank in the third dimension	Absolute change compared to 2012
1	Australia	43	41	53	47	-9 ↓
2	New Zealand	46	39	67	38	-13 ↓

Source: Authors' elaboration based on UNIDO (2020b).

Figure 25: Score distribution, Pacific (2017)



Source: Authors' elaboration based on UNIDO (2020b).

3.2.7 Africa

Similarly to the Pacific, there is a lack of adequate and complete data to compute the GIP index for all African economies. Our sample of 16 African economies shows a relatively weak performance in the GIP index. Ten economies are included in the GIP's bottom quintile, and 11 African economies lost ground during 2012–2017. While placing in the middle of the global GIP ranking in 51st position, South Africa tops the GIP regional ranking, driven mainly by the role of green economy (31st in the global GIP ranking), its comparatively high share of green manufacturing value added of 8.29 per cent (22nd) whereas its performance in the social (76th) and

particularly environmental aspects of green manufacturing (95th) are significantly weaker. Tunisia ranks 2nd in the region 54th worldwide in terms of its GIP score with a similar performance in all three dimensions of green manufacturing. Angola, although still placed in the GIP's bottom quintile, performed relatively well in terms of share of green manufactured exports and CO_2 emissions and Morocco made significant jumps during 2012–2017, gaining 20 and 18 positions, respectively.

Table 17: GIP ranks: Global, regional and by each dimension, Africa (2017)

Regional rank	Economy	Global rank	Rank in the first dimension	Rank in the second dimension	Rank in the third dimension	Absolute change compared to 2012	
1	South Africa	51	52	31	78	0	↔
2	Tunisia	54	59	46	45	-1	↓
3	Egypt	64	76	38	32	0	↔
4	Morocco	77	79	74	84	18	↑
5	Mauritius	80	72	89	95	-3	↓
6	United Republic of Tanzania	85	95	58	40	-5	↓
7	Angola	91	96	83	86	20	↑
8	Cameroon	93	97	79	96	-4	↓
9	Ghana	94	90	97	100	-11	↓
10	Kenya	96	99	91	67	9	↑
11	Senegal	98	100	96	73	-5	↓
12	Ethiopia	100	105	86	46	-2	↓
13	Botswana	107	106	110	93	-4	↓
14	Nigeria	109	110	109	108	-2	↓
15	Niger	110	109	111	109	-1	↓
16	Eritrea	111	111	108	107	-3	↓

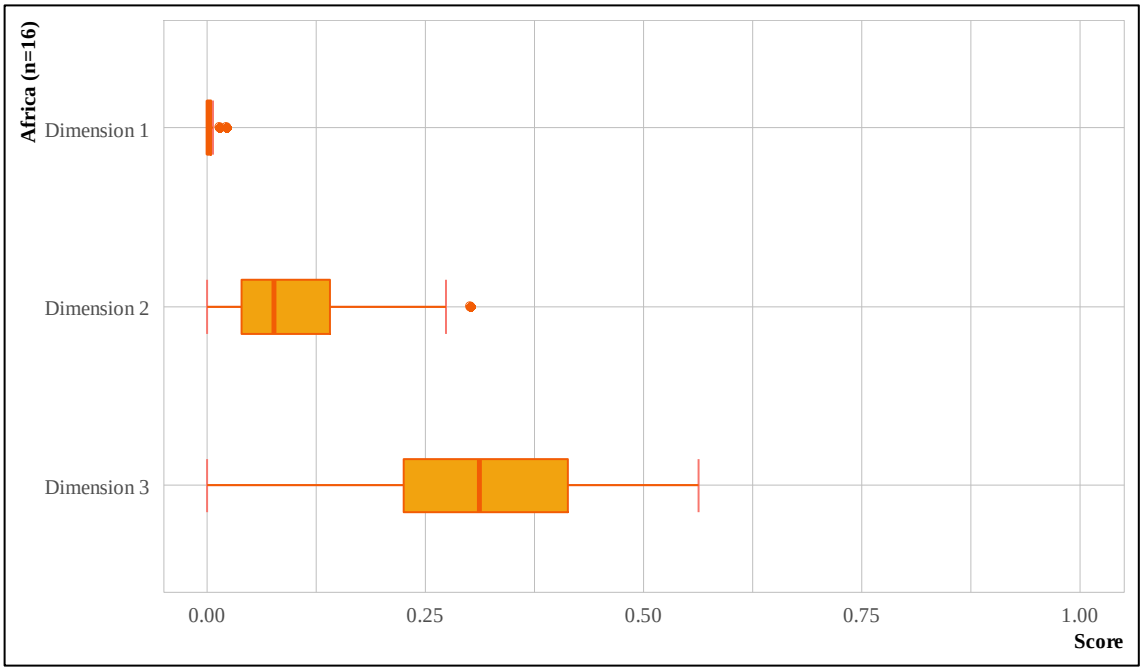
Source: Authors' elaboration based on UNIDO (2020b).

When looking at the score distribution in Africa, the first conclusion we can derive from Figure 26 is the region's poor performance in all three dimensions of green manufacturing as it lags behind all other seven geographical groupings. The region's capacity to produce and export green manufactured products is dismal, demonstrated by its meagre median score of 0.000814, which is far from Central and Western Asia's already low median score. Although the region's median

scores in terms of the role of green manufacturing and social and environmental aspects of green manufacturing are higher, Africa's performance is significantly lower compared to other regions.

Despite the limited coverage of economies in Africa, the poor performance in all three dimensions of green manufacturing indicates the existence of ample opportunities to tap into the region's vast potential.

Figure 26: Score distribution, Africa (2017)



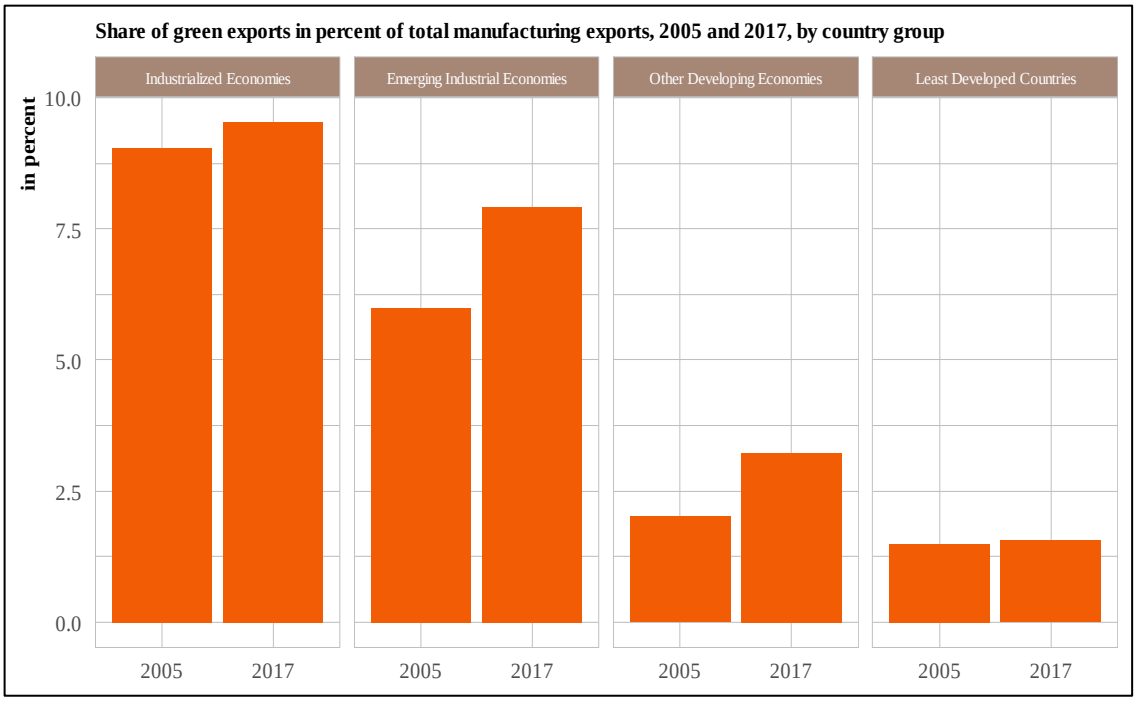
Source: Authors' elaboration based on UNIDO (2020b).

3.3. Key findings by stage of development

We analyse green industrial performance using the country and economy groupings based on stage of industrialization. For this purpose, we use four categories of countries – (i) industrialized economies, (ii) emerging industrial economies, (iii) other developing economies, and (iv) least developed countries in accordance with the definition of country groupings of Upadhyaya (2013).

The first conclusion we can draw when looking at the performance of the four groupings is that no general pattern emerges. Industrialized economies remain the top performers during the period 2005–2017, but experienced either a minor decline or at best, made moderate progress in terms of the various GIP indicators. Industrialized economies' share of green manufacturing value added was highest in 2017 at 8.81 per cent compared to 8.78 per cent in 2005, whereas this group's green manufacturing value added per capita of dropped to USD 432 from USD 437 in 2005. This compares, for instance, with the group of emerging industrial economies where a decrease to 4.92 per cent in the share of green manufacturing value added was observed in 2017 (from 5.47 per cent in 2005) while at the same time more than doubling its green manufacturing value added per capita from USD 20 to USD 56. Other developing economies, in turn, reported a green manufacturing value added share of 1.58 per cent and a green manufacturing value added per capita of USD 2 in 2017. Industrialized economies also topped the various groupings in terms of green manufactured exports (both per capita and share thereof). Industrialized economies' green manufactured exports per capita increased considerably from USD 488 in 2005 to USD 740 in 2017, whereas their share of green manufactured exports grew only moderately, accounting for 9.54 per cent in 2017. The share of green manufactured exports of emerging industrial economies amounted to 7.92 per cent and USD 79 per capita in 2017. This compares to USD 1.34 and 1.56 per cent in LDCs and USD 6.03 in other developing economies.

Figure 27: Share of green manufactured exports in per cent of total manufactured exports, 2005 and 2017, by level of industrial development



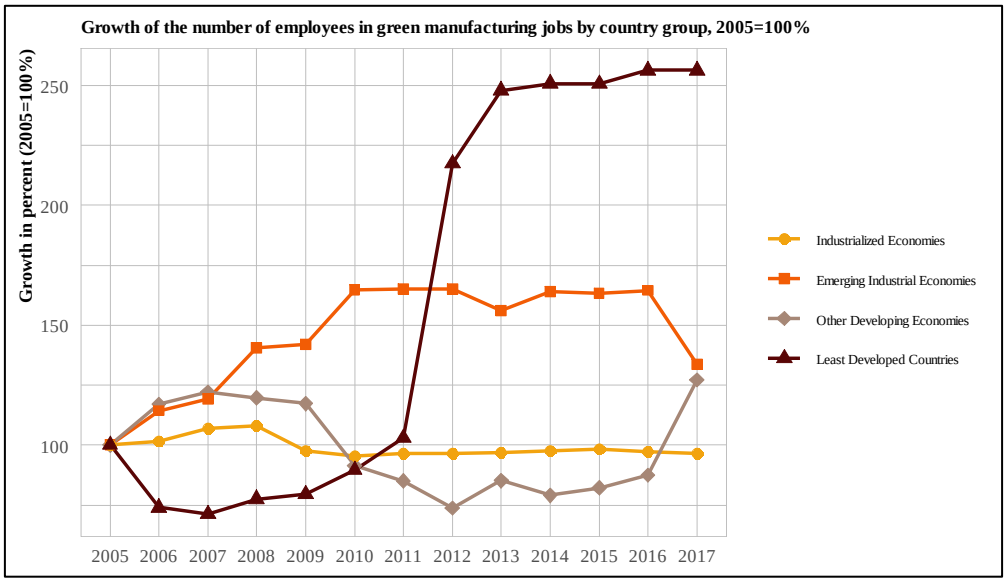
Source: Authors' elaboration based on UNIDO (2020b).

It is worth noting that industrialized (44.2 per cent) and emerging industrial economies (53.8 per cent) accounted for 98 per cent of total green manufacturing employment in the world in 2017. Industrialized economies had the largest share of green manufacturing employment in 2017 at 8.81 per cent after experiencing a trivial increase from 8.78 per cent in 2005. Emerging industrial economies, in turn, reported a decline in their share of green manufacturing employment from 6.17 per cent in 2005 to 5.16 per cent in 2017. LDCs experienced a minor decrease to 2.08 per cent whereas other developing economies' share was as low as 0.744 per cent in 2017.

Another interesting factor is that industrialized economies experienced a negative growth rate of 3.05 per cent in the number of green manufacturing jobs from 2005 to 2017, whereas emerging industrial economies witnessed a growth rate of 36.72 per cent despite registering a decline from 2016 to 2017. This compares to the high growth rate of other developing economies (80.5 per cent) and the LDCs' impressive growth rate. It is mostly attributable to the dramatic increase of green jobs in Bangladesh, which grew from around 12,000 in 2006 to over 90,000 in 2012. Figure 28 presents the growth of green employment in selected LDCs and illustrating the impressive growth in Bangladesh, but the number of green jobs in Ethiopia also grew by 300 per cent from 2009 to 2013. Please note that Figure 28 also includes countries not covered in the GIP index (Madagascar, Malawi and Burundi) due to missing data in some of the other indicators. The figure also reveals the data quality of this indicator – data for Bangladesh was only available for two

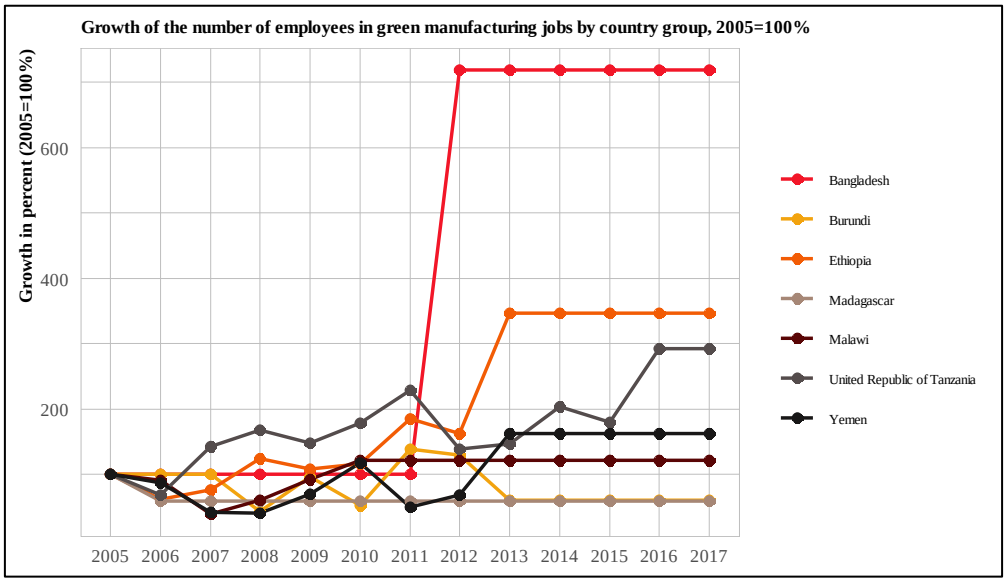
years (2006 and 2012) and the rest were imputed using the "last observation carry forward" (LOCF) method; therefore, the growth is presented as straight lines between 2005 and 2011 and between 2012 and 2017. Countries which only had one value throughout the period 2005–2017 were removed from the plot.

Figure 28: Growth of number of employees in green manufacturing jobs, by level of industrial development grouping, 2005–2017



Source: Authors' elaboration based on UNIDO (2020b).

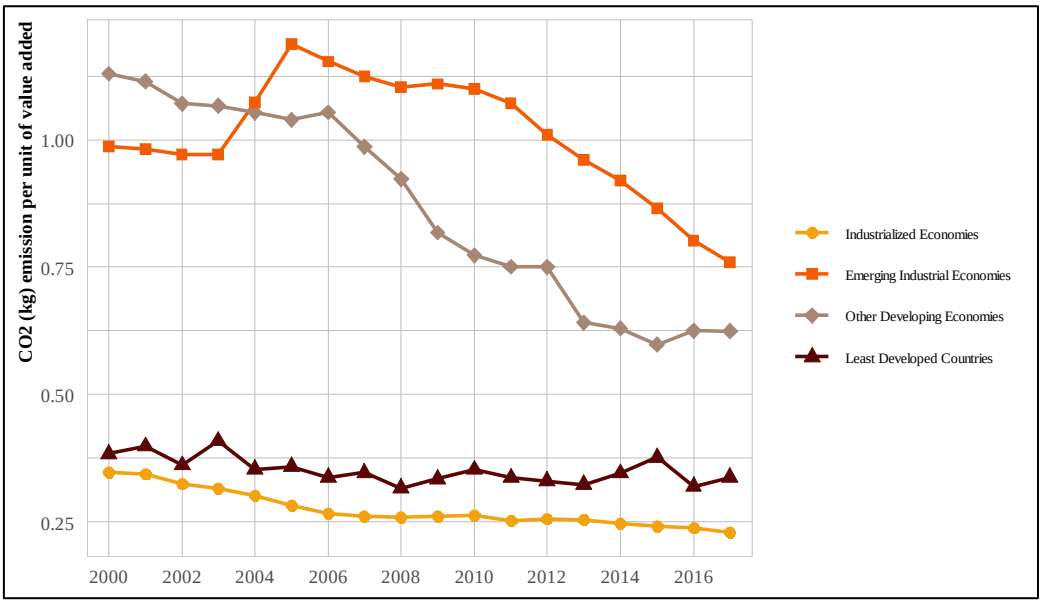
Figure 29: Growth of number of employees in green manufacturing jobs, selected countries, 2005–2017



Source: Authors' elaboration based on UNIDO (2020b).

When we look at CO_2 emissions per unit of manufacturing value added (Figure 30), we find that industrialized economies' efficiency improved, reducing their CO_2 emissions from 0.347 in 2000 to 0.23 in 2017. While the level of CO_2 emission also decreased in emerging industrial economies from 0.987 in 2000 to 0.759 in 2017, with a steady decline after a peak in 2005, emissions in this country group remain comparatively high. CO_2 emissions in LDCs experienced a slight reduction from 2000 to 0.337 in 2017. Other developing economies' performance improved significantly to reach 0.625 in 2017, performing better than emerging industrial economies, thereby inverting the performance of both groupings in 2000.

Figure 30: CO_2 emission (kg) per unit of value added at constant 2010 prices by level of industrial development grouping, 2000–2017



Source: Authors' elaboration based on UNIDO (2020b).

4. Discussion and concluding remarks

The belief that economic growth inevitably has a negative impact on the environment was very widespread in the past. The Rio Declaration (UNGA, 1992) represents a turning point as it put the importance of reconciling the various components of development, i.e. economic, social and environmental, on the international agenda. More recently, particularly in periods of crisis, we have witnessed the emergence of various concepts related to the greening of the world economies. Concepts such as green growth (OECD, 2011; World Bank, 2012) and the green economy (UNEP, 2011) constitute a significant change as they emphasize the economic opportunities that sustainability offers rather than the threats it supposedly posed, which were highlighted by the traditional narrative about economic growth. The transition towards the green economy was at the core of the debate and recommendations of the United Nations Conference on Sustainable Development held in 2012 in Rio de Janeiro, reiterating that it is an important tool for achieving sustainable development (UN, 2012). The adoption of the 2030 Sustainable Development and its SDGs (UNGA, 2015) as well as the Paris Agreement on Climate Change (UNFCCC, 2015) further underpin the centrality of sustainability in the development discourse. Our world is still in the midst of an unprecedented health crisis unleashed by COVID-19, which has resulted in a serious economic downturn of the world economy. The IMF (2021) estimates that the global economy contracted by 3.5 per cent in 2020. Industrial production was hit particularly hard by the pandemic, with most countries and industrial sectors facing a protracted downturn according to UNIDO's latest analysis (UNIDO, 2020g). This unparalleled crisis has resulted in the EU's COVID-19 recovery plan (EC, 2020) building on the EU Green Deal (European Commission, 2019), which seeks to make Europe climate-neutral by 2050 whereas the Republic of Korea has included a New Green Deal in its recovery plan to enable the country to move towards sustainability as a critical component of the Republic of Korea's New Deal for recovery post-COVID-19 (Government of the Republic of Korea, 2020). These initiatives coupled with multiple calls to ensure that COVID-19 recovery plans include sustainability might give new impetus to the shift towards the green economy. Our research is therefore particularly timely, as it aims to fill the gap in the state-of-the-art, namely the lack of a mechanism to measure and benchmark the green industrial performance of countries and economies. As we have demonstrated, green industrial performance can play a leading role in accelerating the achievement of inclusive and sustainable industrial development by supporting countries in driving the structural transformation of their economies and, at the same time, preserving the environment.

In this paper, we introduce our latest, refined methodology to compute the Green Industrial Performance index. The GIP offers policymakers and development practitioners an effective tool to monitor and compare national green industrial performance and the progress made towards the achievement of the 2030 Sustainable Development Agenda. This tool complements UNIDO's CIP index by benchmarking and analysing not only countries' industrial performance but also their level of inclusive and sustainable development. We follow the methodology developed for the CIP index and expand it by devising indicators that measure the level of green industry at the country level. All six indicators selected are quantitative, based on internationally comparable data available from recognized international data sources. This preliminary analysis guides us through the selection of the indicators, data processing, indicator coverage, filling in missing data and dealing with outliers, normalization and aggregation. To achieve a common scale, the indicators are normalized in the interval [0, 1] by the *min-max* method and aggregated using geometric mean and equal weights. The advantage of the geometric mean as an aggregation method over the linear aggregation method is that it does not allow full compensability (poor performance in some indicators can be compensated for by other indicators being sufficiently high) as is the case with the linear approach. A further important contribution of this paper is the refinement of the list of 'green' products, which lies at the core of the methodology we use to estimate the size and contribution of green industrial development. We expand our list to comprise a total of 280 green products based in the OECD's and APEC's list of environmental products. To illustrate the impact of the use of such an expanded list, we carry out a comparative analysis of the exports of green products using the expanded and non-expanded lists of green products. We conclude that while the expanded list of green products systematically results in higher green exports, the rate of their growth differs from one economy to another, and that the trade of green products remains concentrated among developed economies. When conducting a similar analysis with green activities, we conclude that the expanded list of green products results in higher increases in the largest green activities.

After having constructed an updated GIP index database for 112 countries for the period 2000–2017, we first look at green industrial performance in 2017. We find that industrialized economies top the GIP index ranking in 2017, with European economies, namely Switzerland, Denmark, Germany, Czechia and Austria holding the top five positions. We also find that it takes time to make any significant moves in the GIP index's ranking, demonstrated by the fact that the economies in the GIP's top quintile remain unchanged in the period 2014–2017. Similarly, the bottom quintile—with four exceptions—also remains relatively consistent over the same period. Performing an analysis of the GIP index's various components helps identify specific areas of improvement for the economies contained in our sample. One general conclusion we can make is

that the performance of economies in the various areas covered by our GIP index, as well as the vast room for improvement of most economies relative to the top performers. The GIP index offers endless opportunities to conduct analyses using different groupings of economies, such as top performers, BRICS, GIP index quintile groupings, and industrial development stage groupings. Such analyses allow us to identify the green industrial performance of such groupings.

Our analysis also provides valuable insights on several methodological limitations of our approach, which, in turn, offer interesting avenues for future research. The limited data coverage forced us to drop a number of countries which had not reported data on specific indicators during the considered period. Industrial production data have lower coverage than international trade data. Employment and CO2 emissions data are also fully missing for some countries. One approach to deal with this problem is to look for alternative sources, and we chose methods to impute missing data, particularly multiple imputations, which gives rise to many different estimates for each missing observation. The final result is obtained as an average of all trials. The preliminary results look promising, and we intend to further explore this approach in our future research. As pointed out in the methodological section, some of the green products (as HS subheadings) fall outside manufacturing (Group C in ISIC Revision 4). In the future, we aim to use data from UNIDO's mining and utilities database MINSTAT.

Our research on green industrial performance and the GIP index in recent years (see Moll de Alba and Todorov 2018a, 2018b, 2020a, and 2020b) has influenced the work of other researchers and institutions. Kolomeytseva (2020), for instance, uses the GIP index to carry out an analysis and benchmark the industrial performance of the Eurasian Economic Union countries. The Green Growth Index (Acosta et al., 2019) published by the Global Green Growth Institute to measure four different green growth dimensions of a sample of 117 countries, includes one component of our GIP index, namely the share of green employment in total manufacturing employment under the green economic opportunities dimension of green growth. Not only does the Green Growth Index use our GIP green employment indicator, it also makes use of the data contained in our GIP index database. We use the GIP index to cover not only the green but also the inclusive performance of economies by introducing the inclusive and green industrial performance (IGIP) index (Halkos, Moll de Alba & Todorov, 2021), which we use to analyse and benchmark the performance of 83 economies in 2016 to conclude that industrialized economies outperform other economies in line with the findings derived from our work using the GIP index.

The timing is ripe for an open debate on the feasibility of boosting industrial development which not only drives economic growth but also advances sustainability. Our research and the GIP index provide policymakers and development practitioners with a novel tool to measure and benchmark

economies' green industrial performance and thus helps them make informed decisions to enhance the complementarity of industrial and environmental policies. The green industrial performance of most developing countries in our sample suggests that they have not fully tapped the opportunities offered by green manufacturing, which calls for further support from the international community to accelerate the transition to a green world.

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6. Annex A: GIP index edition 2020

Table 18: GIP index edition 2020

Rank 2017	Country	GDP score	GMVApc	GMVAsh	GEMPsh	GMXsh	GMXpc	CO2VA
1	Switzerland	0.646	2,316	0.176	0.208	0.062	2,132	0.039
2	Denmark	0.599	985	0.137	0.120	0.175	2,553	0.081
3	Germany	0.569	1,061	0.131	0.130	0.134	2,215	0.125
4	Czechia	0.489	530	0.125	0.128	0.126	2,093	0.230
5	Austria	0.459	687	0.095	0.094	0.119	2,032	0.150
6	Republic of Korea	0.418	830	0.088	0.108	0.098	1,098	0.173
7	Singapore	0.410	543	0.054	0.080	0.073	4,473	0.215
8	Hungary	0.391	283	0.101	0.100	0.138	1,494	0.251
9	Slovenia	0.388	385	0.085	0.090	0.114	1,665	0.171
10	Italy	0.381	463	0.103	0.094	0.116	931	0.112
11	Sweden	0.370	484	0.077	0.082	0.097	1,350	0.090
12	Slovakia	0.361	292	0.100	0.112	0.089	1,327	0.385
13	United States of America	0.356	705	0.092	0.103	0.113	433	0.188
14	Belgium	0.332	368	0.066	0.069	0.063	2,136	0.304
15	Canada	0.329	456	0.091	0.098	0.083	654	0.372
16	Brunei Darussalam	0.319	363	0.069	0.050	0.319	432	0.209
17	Japan	0.310	447	0.064	0.066	0.123	631	0.210

Rank 2017	Country	GDP score	GMVApc	GMVAsh	GEMPsh	GMXsh	GMXpc	CO2VA
18	China, Taiwan Province	0.305	323	0.043	0.079	0.095	1,266	0.238
19	Finland	0.296	279	0.040	0.101	0.094	1,020	0.167
20	France	0.294	336	0.080	0.075	0.082	619	0.143
21	United Kingdom	0.292	280	0.079	0.090	0.092	540	0.132
22	Norway	0.289	292	0.064	0.072	0.098	728	0.215
23	Poland	0.278	181	0.087	0.087	0.102	576	0.325
24	Spain	0.269	225	0.084	0.083	0.081	486	0.172
25	Netherlands	0.267	168	0.036	0.075	0.070	1,920	0.274
26	Portugal	0.266	188	0.078	0.070	0.099	568	0.207
27	Lithuania	0.256	142	0.079	0.061	0.083	792	0.138
28	Croatia	0.237	134	0.081	0.074	0.104	358	0.311
29	United Arab Emirates	0.228	304	0.084	0.080	0.040	680	1.853
30	Romania	0.219	69	0.064	0.071	0.135	437	0.274
31	Trinidad and Tobago	0.213	66	0.024	0.014	0.403	2,131	0.764
32	Latvia	0.208	97	0.072	0.057	0.076	437	0.175
33	Mexico	0.205	78	0.067	0.082	0.101	294	0.319
34	Estonia	0.199	97	0.038	0.035	0.087	894	0.155
35	Serbia	0.198	73	0.097	0.098	0.099	173	0.703

Rank 2017	Country	GDP score	GMVApc	GMVAsh	GEMPsh	GMXsh	GMXpc	CO2VA
36	China	0.190	172	0.069	0.069	0.086	135	0.738
37	Bulgaria	0.190	73	0.059	0.065	0.091	337	0.554
38	Saudi Arabia	0.189	221	0.078	0.081	0.080	121	1.467
39	Thailand	0.185	75	0.063	0.068	0.083	270	0.431
40	Turkey	0.183	103	0.088	0.076	0.073	132	0.414
41	Malaysia	0.183	82	0.037	0.049	0.083	521	0.435
42	Oman	0.182	137	0.082	0.083	0.097	248	2.266
43	Australia	0.181	213	0.068	0.063	0.047	148	0.502
44	Belarus	0.180	85	0.068	0.079	0.067	189	0.346
45	China, Hong Kong SAR	0.178	37	0.061	0.051	0.044	3,233	2.092
46	New Zealand	0.171	216	0.054	0.068	0.029	186	0.289
47	Iceland	0.152	344	0.051	0.047	0.014	189	0.279
48	Israel	0.149	88	0.023	0.024	0.074	489	0.103
49	Luxembourg	0.146	41	0.008	0.020	0.106	2,344	0.304
50	Iran (Islamic Republic of)	0.132	64	0.090	0.095	0.095	37	1.766
51	South Africa	0.131	60	0.083	0.039	0.078	86	1.188
52	Greece	0.128	61	0.050	0.050	0.042	113	0.308
53	Bosnia and Herzegovina	0.123	37	0.057	0.044	0.069	120	0.982

Rank 2017	Country	GDP score	GMVApc	GMVAsh	GEMPsh	GMXsh	GMXpc	CO2VA
54	Tunisia	0.120	25	0.048	0.072	0.079	90	0.776
55	Philippines	0.118	12	0.047	0.055	0.155	95	0.251
56	Jordan	0.113	53	0.064	0.058	0.053	34	0.318
57	Chile	0.110	78	0.055	0.058	0.024	57	0.490
58	Viet Nam	0.105	39	0.053	0.045	0.053	113	1.867
59	Georgia	0.103	25	0.097	0.041	0.071	38	0.889
60	Russian Federation	0.100	27	0.026	0.126	0.050	67	1.434
61	Ireland	0.097	82	0.004	0.019	0.028	808	0.036
62	Ecuador	0.097	30	0.089	0.073	0.038	18	0.158
63	Costa Rica	0.096	46	0.035	0.046	0.032	52	0.113
64	Egypt	0.094	20	0.068	0.081	0.078	15	0.595
65	Cyprus	0.092	40	0.038	0.036	0.029	73	0.544
66	Brazil	0.082	31	0.028	0.031	0.057	37	0.534
67	Argentina	0.079	12	0.034	0.039	0.052	52	0.330
68	Ukraine	0.076	24	0.064	0.091	0.051	35	2.642
69	Lebanon	0.076	21	0.036	0.056	0.044	17	0.308
70	Peru	0.070	36	0.042	0.028	0.025	18	0.299
71	Indonesia	0.070	27	0.049	0.036	0.031	14	0.519
72	Colombia	0.067	24	0.039	0.051	0.034	10	0.476
73	Azerbaijan	0.064	10	0.049	0.106	0.044	6	0.581

Rank 2017	Country	GDP score	GMVApc	GMVAsh	GEMPsh	GMXsh	GMXpc	CO2VA
74	India	0.063	10	0.067	0.071	0.045	9	1.493
75	Uruguay	0.061	27	0.019	0.022	0.021	32	0.111
76	Republic of Moldova	0.060	8	0.046	0.048	0.038	17	1.140
77	Morocco	0.057	14	0.043	0.024	0.026	16	0.465
78	Uzbekistan	0.056	18	0.067	0.075	0.017	4	0.569
79	Panama	0.052	15	0.017	0.014	0.019	52	0.525
80	Mauritius	0.049	21	0.022	0.012	0.017	27	0.210
81	Montenegro	0.048	13	0.040	0.035	0.018	9	1.100
82	Armenia	0.048	8	0.023	0.054	0.021	10	0.386
83	Paraguay	0.047	21	0.057	0.067	0.006	4	0.054
84	Bolivia (Plurinational State of)	0.047	10	0.032	0.032	0.026	7	0.570
85	United Republic of Tanzania	0.044	5	0.083	0.075	0.032	2	0.667
86	Sri Lanka	0.033	4	0.009	0.008	0.038	18	0.050
87	Myanmar	0.032	8	0.024	0.067	0.010	1	0.251
88	Malta	0.031	3	0.004	0.001	0.041	369	0.058
89	Kuwait	0.030	10	0.004	0.009	0.014	55	1.926
90	Bangladesh	0.030	9	0.070	0.019	0.007	1	0.426
91	Angola	0.028	1	0.005	0.021	0.122	6	0.132

Rank 2017	Country	GDP score	GMVApc	GMVAsh	GEMPsh	GMXsh	GMXpc	CO2VA
92	Pakistan	0.027	2	0.025	0.026	0.029	3	1.411
93	Cameroon	0.027	2	0.011	0.011	0.071	3	0.046
94	Ghana	0.027	4	0.007	0.010	0.029	8	0.304
95	Kyrgyzstan	0.024	2	0.009	0.030	0.019	4	0.691
96	Kenya	0.023	1	0.006	0.038	0.052	3	0.614
97	Albania	0.022	6	0.024	0.018	0.006	2	1.401
98	Senegal	0.021	1	0.017	0.034	0.014	2	0.477
99	Qatar	0.020	65	0.012	0.031	0.001	1	0.815
100	Ethiopia	0.014	1	0.040	0.074	0.012	0	0.869
101	Mongolia	0.012	0	0.002	0.055	0.009	3	1.637
102	Nepal	0.012	3	0.067	0.037	0.006	0	2.722
103	Syrian Arab Republic	0.007	0	0.000	0.049	0.116	29	2.597
104	Yemen	0.006	0	0.029	0.047	0.125	2	0.452
105	Cambodia	0.003	0	0.000	0.000	0.038	24	0.201
106	Kazakhstan	0.003	28	0.028	0.045	0.012	10	2.999
107	Botswana	0.000	0	0.000	0.018	0.009	5	0.777
108	Cuba	0.000	0	0.000	0.000	0.046	4	0.844
109	Nigeria	0.000	0	0.000	0.000	0.014	0	0.153
110	Niger	0.000	0	0.000	0.000	0.008	0	0.461
111	Eritrea	0.000	0	0.000	0.000	0.030	0	0.071
112	Iraq	0.000	0	0.000	0.000	0.000	0	2.152

Source: UNIDO (2020b).

7. Annex B: Country classifications

Table 19: Economies by industrial development stage

INDUSTRIALIZED ECONOMIES				
Australia	Austria	Belarus	Belgium	Canada
Chile	China, Hong Kong SAR	China, Taiwan Province	Czechia	Denmark
Estonia	Finland	France	Germany	Hungary
Iceland	Ireland	Israel	Italy	Japan
Kuwait	Latvia	Lithuania	Luxembourg	Malaysia
Malta	Netherlands	New Zealand	Norway	Poland
Portugal	Qatar	Republic of Korea	Russian Federation	Singapore
Slovakia	Slovenia	Spain	Sweden	Switzerland
Trinidad and Tobago	United Arab Emirates	United Kingdom	United States of America	
DEVELOPING AND EMERGING INDUSTRIALIZED ECONOMIES				
Emerging industrial economies				
Argentina	Bosnia and Herzegovina	Brazil	Brunei Darussalam	Bulgaria
China	Colombia	Costa Rica	Croatia	Cyprus
Egypt	Greece	India	Indonesia	Iran
Jordan	Kazakhstan	Mauritius	Mexico	Oman
Panama	Peru	Philippines	Romania	Saudi Arabia
Serbia	South Africa	Sri Lanka	Thailand	Tunisia
Turkey	Ukraine	Uruguay	Viet Nam	
Other developing countries				
Albania	Armenia	Azerbaijan	Bolivia	Botswana
Cameroon	Cuba	Ecuador	Georgia	Ghana
Iraq	Kenya	Kyrgyzstan	Lebanon	Mongolia
Montenegro	Morocco	Nigeria	Pakistan	Paraguay
Republic of Moldova	Syrian Arab Republic	Uzbekistan		
Least developed countries				
Angola	Bangladesh	Cambodia	Eritrea	Ethiopia
Myanmar	Nepal	Niger	Senegal	Tanzania
Yemen				

Source: UNIDO (2021).

Table 20: Economies by geographical region

Northern America

Canada	United States of America

Latin America and the Caribbean

Argentina	Bolivia	Brazil	Chile	Colombia
Costa Rica	Cuba	Ecuador	Mexico	Panama
Paraguay	Peru	Trinidad and Tobago		Uruguay

Eastern Asia

China	China, Hong Kong SAR	China, Taiwan Province	Japan	Mongolia
Republic of Korea				

Central and Western Asia

Armenia	Azerbaijan	Cyprus	Georgia	Iraq
Israel	Jordan	Kazakhstan	Kuwait	Kyrgyzstan
Lebanon	Oman	Qatar	Saudi Arabia	Syrian Arab Republic
Turkey	United Arab Emirates		Uzbekistan	Yemen

Southern and South-eastern Asia

Bangladesh	Brunei Darussalam	Cambodia	India	Indonesia
Iran	Malaysia	Myanmar	Nepal	Pakistan
Philippines	Singapore	Sri Lanka	Thailand	Viet Nam

Europe

Albania	Austria	Belarus	Belgium	Bosnia and Herzegovina
Bulgaria	Croatia	Czechia	Denmark	Estonia
Finland	France	Germany	Greece	Hungary
Iceland	Ireland	Italy	Latvia	Lithuania
Luxembourg	Malta	Montenegro	Netherlands	Norway
Poland	Portugal	Republic of Moldova	Romania	Russian Federation
Serbia	Slovakia	Slovenia	Spain	Sweden
Switzerland	Ukraine	United Kingdom		

Pacific				
Australia	New Zealand			
Africa				
Angola	Botswana	Cameroon	Egypt	Eritrea
Ethiopia	Ghana	Kenya	Mauritius	Morocco
Niger	Nigeria	Senegal	South Africa	Tunisia
Tanzania				

Source: UNIDO (2021).

8. Annex C: UNIDO green product list

Table 21: The UNIDO green product list

	HS CODE	Product	Source	EA	ISIC3	ISIC4
1	220110	Mineral waters and aerated waters, unsweetened	OECD	RC	1554	1104
2	220190	Other unsweetened waters; ice and snow	OECD	RC	1554	1104
3	220710	Undenatured ethyl alcohol, of alcoholic strengt	DC-ESA-2	RE	1551	2011
4	251710	Pebbles, gravel, shingle and flint	DC-ESA-1	EC	1410	0810
5	252100	Limestone flux; limestone and other calcareous	OECD	PC	1410	0810
6	252220	Slaked lime	OECD	PC	2694	2394
7	253010	Vermiculite, perlite and chlorites (unexpanded)	DC-ESA-2	EC	1429	0899
8	261800	Granulated slag (slag sand) from the manufactur	DC-ESA-2	RC	2710	2410
9	261900	Slag, dross, etc, from the manufacture of iron	DC-ESA-2	RC	2710	2410
10	262011	Hard zinc spelter	DC-ESA-2	RC	2720	2420
11	262019	Ash and residues containing mainly zinc (excl.	DC-ESA-2	RC	2720	2420
12	262020	Ash and residues containing mainly lead	DC-ESA-2	RC	2720	2420
13	262021	Leaded gasoline sludges and leaded antiknock compound sludges	DC-ESA-2	RC	2720	2420
14	262029	Other	DC-ESA-2	RC	2720	2420
15	262030	Ash and residues containing mainly copper	DC-ESA-2	RC	2720	2420
16	262040	Ash and residues containing mainly aluminium	DC-ESA-2	RC	2720	2420
17	262050	Ash and residues containing mainly vanadium	DC-ESA-2	RC	2720	2420
18	262060	Containing arsenic, mercury, thallium or their mixtures, of a kind used for the extraction of arsenic or those metals or for the manufacture of their chemical	DC-ESA-2	RC	2720	2420
19	262090	Ash and residues containing other metals or met	DC-ESA-2	RC	2720	2420
20	262091	Containing antimony, beryllium, cadmium, chromium or their mixtures	DC-ESA-2	RC	2720	2420
21	262099	Other	DC-ESA-2	RC	2720	2420
22	262100	Other slag and ash, including seaweed ash (kelp	DC-ESA-2	RC	9000	382
23	262110	Ash and residues from the incineration of municipal waste	DC-ESA-2	RC	9000	382
24	262190	Other	DC-ESA-2	RC	9000	382
25	280110	Chlorine	DC-ESA-1	PC	2411	2011
26	281410	Anhydrous ammonia	OECD	PC	2412	2012
27	281511	Sodium hydroxide (caustic soda), solid	DC-ESA-2	PC	2411	2011
28	281512	Sodium hydroxide in aqueous solution (soda lye	DC-ESA-2	PC	2411	2011
29	281610	Hydroxide and peroxide of magnesium	DC-ESA-2	PC	2411	2011
30	281830	Aluminium hydroxide	OECD	PC	2411	2011
31	282010	Manganese dioxide	OECD	PC	2411	2011
32	282090	Manganese oxides (excl. manganese dioxide)	OECD	PC	2411	2011
33	282410	Lead monoxide (litharge, massicot)	OECD	PC	2411	2011
34	283210	Sodium sulphites	OECD	PC	2411	2011
35	283220	Sulphites (excl. sodium)	OECD	PC	2411	2011
36	283510	Phosphinates and phosphonates	OECD	PC	2411	2011
37	283521	Phosphates of triammonium	OECD	PC	2412	2012
38	283522	Phosphates of mono or disodium	DC-ESA-2	PC	2411	2011
39	283523	Phosphates of trisodium	OECD	PC	2411	2011
40	283524	Phosphates of potassium	OECD	PC	2411	2011

	HS CODE	Product	Source	EA	ISIC3	ISIC4
41	283525	Calcium hydrogenorthophosphate (dicalcium phosp	OECD	PC	2411	2011
42	283526	Phosphates of calcium, nes	OECD	PC	2411	2011
43	283529	Phosphates (excl. polyphosphates)	OECD	PC	2411	2011
44	284700	Hydrogen peroxide	OECD	RC	2411	2011
45	285100	Other inorganic compounds; liquid air; compress	OECD	RC	2411	2011
46	290511	Methanol (methyl alcohol)	OECD	RE	2411	2011
47	320910	Paints... based on acrylic or vinyl polymers, i	OECD	RC	2422	2022
48	320990	Paints and varnishes, in an aqueous medium, nes	OECD	RC	2422	2022
49	340119	Soap and organic surface-active products in bar	DC-ESA-2	PC	2424	2023
50	340211	Anionic surface-active agents, (excl. soap)	DC-ESA-2	PC	2424	2023
51	340212	Cationic surface-active agents, (excl. soap)	DC-ESA-2	PC	2424	2023
52	340213	Non-ionic surface-active agents, (excl. soap)	DC-ESA-2	PC	2424	2023
53	340219	Organic surface-active agents, (excl. soap), ne	DC-ESA-2	PC	2424	2023
54	340220	Washing and cleaning preparations, put up for r	DC-ESA-2	PC	2424	2023
55	340290	Washing and cleaning preparations, not put up f	DC-ESA-2	PC	2424	2023
56	380210	Activated carbon	DC-ESA-2	PC	2429	2029
57	381511	Supported catalysts with nickel or its compound	OECD	RC	2429	2029
58	381512	Supported catalysts with precious metal or its	OECD	RC	2429	2029
59	381519	Supported catalysts, nes	OECD	RC	2429	2029
60	381590	Reaction initiators, accelerators and catalytic	OECD	RC	2429	2029
61	382600	Biodiesel and mixtures thereof, not containing or containing less than 70 % by weight of petroleum oils or oils obtained from bituminous minerals.	DC-ESA-1	RE	2429	2029
62	391400	Ion-exchangers based on polymers of 39.01 to 39	OECD	RC	2413	2013
63	392010	Plates..., of polymers of ethylene, not reinfor	WB	PC	2520	2220
64	392020	Plates..., of polymers of propylene, not reinfo	OECD	PC	2520	2220
65	392490	Household and toilet articles of plastics, nes	OECD	PC	2520	2220
66	392690	Other articles of plastics, nes	OECD	PC	2520	2220
67	400300	Reclaimed rubber in primary forms or in plates,	DC-ESA-1	RC	3720	3830
68	400700	Vulcanized rubber thread and cord	DC-ESA-2	RC	2519	2219
69	401150	New pneumatic tyres, of rubber of a kind used o	DC-ESA-1	EC	2511	2211
70	401210	Retreaded tyres of rubber	DC-ESA-2	RC	2511	2211
71	401211	Of a kind used on motor cars (including station wagons and racing cars)	DC-ESA-2	RC	2511	2211
72	401212	Of a kind used on buses or lorries	DC-ESA-2	RC	2511	2211
73	401213	Of a kind used on aircraft	DC-ESA-2	RC	2511	2211
74	401219	Other	DC-ESA-2	RC	2511	2211
75	401320	Inner tubes, of rubber of a kind used on bicycl	DC-ESA-1	EC	2511	2211
76	440610	Railway or tramway sleepers (cross-ties) of woo	DC-ESA-1	EC	2010	1610
77	440690	Railway or tramway sleepers (cross-ties) of woo	DC-ESA-1	EC	2010	1610
78	441010	Particle board and similar board of wood, unwor	DC-ESA-1	RC	2021	1621
79	441011	Of wood :-- Waferboard, including oriented strand board	DC-ESA-1	RC	2021	1621
80	441012	Oriented strand board (OSB) of wood, whether/not agglomerated with resins/other organic binding substances	DC-ESA-1	RC	2021	1621
81	441019	Of wood :-- Other	DC-ESA-1	RC	2021	1621
82	441090	Particle board and similar board of ligneous ma	DC-ESA-1	RC	2021	1621
83	441111	Fibreboard of a density >0.8g/cm3, not worked o	DC-ESA-2	RC	2021	1621
84	441112	Medium density of fibreboard of wood/other ligneous materials, whether/not bonded with resins/other organic	DC-ESA-2	RC	2021	1621
85	441113	Medium density of fibreboard of wood/other ligneous materials, whether/not bonded with resins/other organic	DC-ESA-2	RC	2021	1621

	HS CODE	Product	Source	EA	ISIC3	ISIC4
86	441114	Medium density of fibreboard of wood/other ligneous materials, whether/not bonded with resins/other organic	DC-ESA-2	RC	2021	1621
87	441119	Fibreboard of a density >0.8g/cm3, nes	DC-ESA-2	RC	2021	1621
88	441121	Fibreboard of a density >0.5g/cm3 but =<0.8g/cm	DC-ESA-2	RC	2021	1621
89	441129	Fibreboard of a density >0.5g/cm3 but =<0.8g/cm	DC-ESA-2	RC	2021	1621
90	441291	Plywood... containing at least one layer of pa	DC-ESA-1	RC	2021	1621
91	441292	Other :-- With at least one ply of tropical wood specified in Subheading Note 1 to this Chapter	DC-ESA-1	RC	2021	1621
92	441293	Other, containing at least one layer of particle board	DC-ESA-1	RC	2021	1621
93	441872	Assembled flooring panels, multilayer	APEC	RC	2022	1622
94	470710	Waste and scrap of unbleached kraft paper, pape	DC-ESA-1	RC	2100 old	1700 old
95	480524	Weighing 150 g/m² or less	DC-ESA-1	RC	2101	1701
96	480525	Weighing more than 150 g/m²	DC-ESA-1	RC	2101	1701
97	560314	Of man-made filaments :-- Weighing more than 150 g/m2	WB	PC	1729	1399
98	580190	Woven pile and chenille fabrics of other textil	DC-ESA-1	PC	1711	1312
99	591190	Textile articles for technical uses, nes, speci	DC-ESA-1	PC	1729	1399
100	680610	Slag wool, rock wool & similar mineral wools in	DC-ESA-2	EC	2699	2399
101	680620	Exfoliated vermiculite,expanded clays,foamed sl	DC-ESA-2	EC	2699	2399
102	680690	Art. of heat/sound insulating,etc,nes,mineral m	DC-ESA-2	PC	2699	2399
103	681099	Articles of cement, of concrete or of artificia	DC-ESA-2	PC	2695	2395
104	700800	Multiple-walled insulating units of glass	OECD	RC	2610	2310
105	701931	Mats of glass fibres	WB	PC	2610	2310
106	701990	Glass fibres (including glass wool) and article	OECD	RC	2610	2310
107	730210	Rails, iron or steel	DC-ESA-1	EC	2710	2410
108	730220	Sleepers (cross-ties), iron or steel	DC-ESA-1	EC	2710	2410
109	730230	Switch blades, crossing frogs, point rods & oth	DC-ESA-1	EC	2710	2410
110	730240	Fish plates and sole plates, iron or steel	DC-ESA-1	EC	2710	2410
111	730290	Rail or tramway construction material of iron o	DC-ESA-1	EC	2710	2410
112	730820	Towers and lattice masts, iron or steel	WB	RE	2811	2511
113	730900	Reservoirs, tanks, vats & sim ctnr, cap >300L,	WB	PC	2812	2512
114	731010	Tanks, casks, drums, cans, boxes&sim contr, i o	DC-ESA-1	PC	2899	2599
115	731021	Cans,iron or steel,cap<50 litres,to be closed b	DC-ESA-1	PC	2899	2599
116	731029	Cans, iron or steel, capacity <50 litres nes	DC-ESA-1	PC	2899	2599
117	732111	Cooking appliances&plate warmers for gas fuel o	WB	RC	2930	2750
118	732190	Appliance parts clearly identifiable as for hou	WB	RC	2930	2750
119	732490	Sanitary ware&parts thereof,i or s,nes,for exam	WB	RC	2899	2599
120	732510	Cast articles of non-malleable cast iron nes	OECD	PC	2899	2599
121	732690	Articles, iron or steel, nes	DC-ESA-2	RE	2899	2599
122	761100	Reservoirs,vats&similar cont of aluminium,cap >	WB	PC	2812	2512
123	761290	Containers, alum, cap <300L, lined or heated, n	WB	PC	2899	2599
124	780600	Articles of lead nes	OECD	PC	2899	2599
125	840219	Vapour generating boilers nes, including hybrid	WB	PC	2813	2513
126	840290	Parts of steam or vapour generating boilers nes	WB	PC	2813	2513
127	840410	Auxiliary plant for use with steam or vapour ge	WB	PC	2813	2513
128	840420	Condensers for steam or vapour power units	APEC	PC	2813	2513
129	840490	Parts for auxiliary plant & condenser for steam	WB	PC	2813	2513
130	840510	Producer gas or water gas generators acetylene	WB	PC	2919	2819

	HS CODE	Product	Source	EA	ISIC3	ISIC4
131	840681	Other turbines :-- Of an output exceeding 40 MW	WB	PC	2911	2811
132	840690	Parts of steam and vapour turbines	APEC	PC	2911	2811
133	840991	Parts for spark-ignition type engines nes	OECD	PC	3430	2930
134	840999	Parts for diesel and semi-diesel engines	OECD	PC	3430	2930
135	841011	Hydraulic turbines & water wheels of a power no	WB	PC	2911	2811
136	841012	Hyd turbines & water wheels of a power exc 1000	DC-ESA-1	PC	2911	2811
137	841013	Hydraulic turbines and water wheels of a power	DC-ESA-1	PC	2911	2811
138	841090	Parts of hydraulic turbines & water wheels incl	WB	PC	2911	2811
139	841181	Gas turbines nes of a power not exceeding 5000	WB	RE	2911	2811
140	841182	Gas turbines nes of a power exceeding 5000 KW	WB	RE	2911	2811
141	841199	Parts of gas turbines nes	APEC	RE	2911	2811
142	841290	Parts of hydraulic & pneumatic & other power en	APEC	RE	2912	2812
143	841320	Hand pumps nes, o/t those of subheading No 8413	OECD	PC	2912	2813
144	841350	Reciprocating positive displacement pumps nes	OECD	PC	2912	2813
145	841360	Rotary positive displacement pumps nes	OECD	PC	2912	2813
146	841370	Centrifugal pumps nes	OECD	PC	2912	2813
147	841381	Pumps nes	OECD	PC	2912	2813
148	841410	Vacuum pumps	OECD	PC	2912	2813
149	841430	Compressors of a kind used in refrigerating equ	OECD	PC	2912	2813
150	841440	Air compressors mounted on a wheeled chassis fo	OECD	PC	2912	2813
151	841480	Air or gas compressors, hoods	OECD	PC	2912	2813
152	841490	Parts of vacuum pumps, compressors, fans, blowe	OECD	PC	2912	2813
153	841581	Air cond mach nes inc a ref unit and a valve fo	WB	PC	2919	2819
154	841780	Industrial or lab furnaces & ovens, inc inciner	DC-ESA-1	PC	2914	2815
155	841790	Parts of industrial or lab furnaces & ovens inc	OECD	PC	2914	2815
156	841861	Compression type refrigrting or freez equip who	WB	PC	2919	2819
157	841869	Refrigerating or freezing equipment nes	WB	PC	2919	2819
158	841911	Instantaneous gas water heaters	DC-ESA-1	PC	2930	2750
159	841919	Instantaneous or storage water heaters, non-ele	WB	RE	2930	2750
160	841939	Non-domestic, non-electric dryers nes	APEC	PC	2929	2829
161	841940	Distilling or rectifying plant	WB	PC	2919	2819
162	841950	Heat exchange units, non-domestic, non-electric	WB	EC	2919	2819
163	841960	Machinery for liquefying air or other gases	OECD	PC	2919	2819
164	841989	Machinery, plant or laboratory equip for treat	WB	PC	2919	2819
165	841990	Parts of machinery, plant and equipment of head	WB	EC	2919	2819
166	842119	Centrifuges nes	OECD	PC	2919	2819
167	842121	Filtering or purifying machinery and apparatus	DC-ESA-2	PC	2919	2819
168	842129	Filtering or purifying machinery and apparatus	OECD	PC	2919	2819
169	842139	Filtering or purifying machinery and apparatus	DC-ESA-1	PC	2919	2819
170	842191	Parts of centrifuges, including centrifugal dry	OECD	PC	2919	2819
171	842199	Parts for filtering or purifying mchy & apparat	DC-ESA-1	PC	2919	2819
172	842220	Machinery for cleaning or drying bottles or con	OECD	PC	2919	2819
173	842381	Weighing machinery having a maximum weighing ca	DC-ESA-1	PC	2919	2819
174	842382	Weighing machinery having a maximum weighing ca	DC-ESA-1	PC	2919	2819
175	842389	Weighing machinery, nes	DC-ESA-1	PC	2919	2819

	HS CODE	Product	Source	EA	ISIC3	ISIC4
176	842490	Pts of mech app (hand-op or not) for proj/disp	DC-ESA-1	PC	2919	2819
177	842833	Cont-action elevators/conveyors for goods/mat,	DC-ESA-1	PC	2915	2816
178	847420	Crushing/grinding machines for earth/ stone/ore	APEC	PC	2924	2824
179	847439	Mixing or kneading machines nes for earth or ot	OECD	PC	2924	2824
180	847982	Mach for mixing/kneading/crushing/grinding etc	DC-ESA-1	PC	2929	2829
181	847989	Machines & mechanical appliances nes having ind	DC-ESA-1	PC	2929	2829
182	847990	Parts of machines & mechanical appliances nes h	DC-ESA-1	PC	2929	2829
183	848110	Valves, pressure reducing	DC-ESA-2	RE	2912	2813
184	848120	Valves for oleohydraulic or pneumatic transmiss	DC-ESA-2	RE	2912	2813
185	848130	Valves, check	DC-ESA-2	RE	2912	2813
186	848140	Valves, safety or relief	DC-ESA-2	RE	2912	2813
187	848180	Taps, cocks, valves and similar appliances, nes	DC-ESA-2	RE	2912	2813
188	848190	Parts of taps, cocks, valves or similar applian	DC-ESA-2	RE	2912	2813
189	848340	Gears and gearing,ball screws,gear boxes,speed	WB	RE	2913	2814
190	848360	Clutches and shaft couplings (including univers	WB	RE	2913	2814
191	850161	AC generators (alternators), of an output not e	WB	RE	3110	2710
192	850162	AC generators, of an output exceeding 75 KVA bu	WB	RE	3110	2710
193	850163	AC generators, of an output exceeding 375 KVA b	WB	RE	3110	2710
194	850164	AC generators, of an output exceeding 750 KVA	WB	RE	3110	2710
195	850231	Other generating sets :-- Wind-powered	WB	RE	3110	2710
196	850239	Other generating sets :-- Other	APEC	RE	3110	2710
197	850300	Parts of electric motors,generators,generating	APEC	RE	3110	2710
198	850490	Parts of electrical transformers, static conver	APEC	RE	3110	2710
199	850680	Other	WB	RE	3140	2720
200	850720	Lead-acid electric accumulators nes	WB	RE	3140	2720
201	851210	Lighting or signalling equipment of a kind used	DC-ESA-1	EC	3190	2740
202	851220	Lighting or visual signalling equipment nes	DC-ESA-1	EC	3190	2740
203	851230	Sound signalling equipment	DC-ESA-1	EC	3190	2930
204	851410	Industrial & laboratory electric resistance hea	DC-ESA-1	PC	2914	2815
205	851420	Industrial&laboratory electric induction or die	DC-ESA-1	PC	2914	2815
206	851430	Industrial & laboratory electric furnaces & ove	DC-ESA-1	PC	2914	2815
207	851490	Parts of industrial or laboratory electric furn	DC-ESA-1	PC	2914	2815
208	851629	Electric space heating apparatus and electric s	OECD	PC	2930	2750
209	853010	Electrical signalling,safety or traffic control	DC-ESA-1	EC	3190	2790
210	853080	Electrical signalling, safety or traffic contro	DC-ESA-1	EC	3190	2790
211	853090	Parts of electrical signalling, safety or traff	DC-ESA-1	EC	3190	2790
212	853710	Boards, panels, including numerical control pan	WB	RE	3120	2710
213	853931	Fluorescent lamps, hot cathode	OECD	RC	3150	2740
214	854140	Photosensitive semiconductor devices,photovolta	WB	RE	3210	2610
215	854389	Other machines and apparatus :-- Other	OECD	PC	3190	2790
216	854390	Parts of electrical machines & apparatus having	APEC	PC	3190	2790
217	860110	Rail locomotives powered from an external sourc	DC-ESA-1	EC	3520	3020
218	860120	Rail locomotives powered by electric batteries	DC-ESA-1	EC	3520	3020
219	860210	Rail locomotives, diesel-electric	DC-ESA-1	EC	3520	3020
220	860290	Rail locomotives nes and locomotive tenders	DC-ESA-1	EC	3520	3020

	HS CODE	Product	Source	EA	ISIC3	ISIC4
221	860310	Self-propelled railway cars powered from an ext	DC-ESA-1	RC	3520	3020
222	860390	Self-propelled railway cars nes	DC-ESA-1	RC	3520	3020
223	860400	Railway maintenance-of-way service vehicles	DC-ESA-1	EC	3520	3020
224	860500	Railway passenger and special purpose coaches,	DC-ESA-1	RC	3520	3020
225	860610	Railway tank cars, not self-propelled	DC-ESA-1	RC	3520	3020
226	860620	Railway cars, insulated or refrigerated, other	DC-ESA-1	RC	3520	3020
227	860630	Railway cars, self-discharging, other than tank	DC-ESA-1	RC	3520	3020
228	860691	Railway cars, closed and covered	DC-ESA-1	RC	3520	3020
229	860692	Railway cars, open, with non-removable sides of	DC-ESA-1	RC	3520	3020
230	860699	Railway cars nes	DC-ESA-1	RC	3520	3020
231	860711	Driving bogies and bissel-bogies	DC-ESA-1	EC	3520	3020
232	860712	Bogies and bissel-bogies nes	DC-ESA-1	EC	3520	3020
233	860719	Axles and wheels and parts	DC-ESA-1	EC	3520	3020
234	860721	Air brakes and parts for railway rolling stock	DC-ESA-1	EC	3520	3020
235	860729	Brakes nes and parts thereof for railway rollin	DC-ESA-1	EC	3520	3020
236	860730	Coupling devices and parts for railway rolling	DC-ESA-1	EC	3520	3020
237	860791	Locomotive parts nes	DC-ESA-1	EC	3520	3020
238	860799	Railway rolling stock parts nes	DC-ESA-1	EC	3520	3020
239	860800	Signalling devices for railways, waterways and	DC-ESA-1	EC	3520	3020
240	870210	Diesel powered buses with a seating capacity of	DC-ESA-1	EC	3410	2910
241	870290	Buses with a seating capacity of more than nine	DC-ESA-1	EC	3410	2910
242	870892	Mufflers and exhaust pipes for motor vehicles	OECD	PC	3430	2930
243	871200	Bicycles and other cycles (including delivery t	DC-ESA-1	EC	3592	3092
244	900190	Prisms, mirrors & other optical elements of any	WB	RE	3320	2731
245	900290	Lenses, prisms, mirrors and other optical eleme	WB	RE	3320	2731
246	901320	Lasers, other than laser diodes	OECD	PC	3320	2610
247	901380	Optical devices, appliances and instruments, ne	APEC	RE	3320	2670
248	901390	Parts and accessories of optical appliances and	APEC	RE	3320	2670
249	901580	Surveying,hydrographic,oceanographic,meteorolog	APEC	EC	3312	2651
250	902511	Thermometers&pyrometers,not combined with other	OECD	EC	3312	2651
251	902519	Thermometers&pyrometers,not combined with other	OECD	EC	3312	2651
252	902580	Hydrometers, pyrometers, hygrometers and psychr	OECD	EC	3312	2651
253	902610	Instruments and apparatus for measure/checking	OECD	EC	3312	2651
254	902620	Instruments and apparatus for measuring or chec	OECD	EC	3312	2651
255	902680	Instruments & apparatus for measure/checking va	OECD	EC	3312	2651
256	902690	Parts of inst and app for measure/checking vari	OECD	EC	3312	2651
257	902710	Gas or smoke analysis apparatus	OECD	EC	3312	2651
258	902720	Chromatographs and electrophoresis instruments	OECD	EC	3312	2651
259	902730	Spectrometers,spectrophotometers and spectrogra	OECD	EC	3312	2651
260	902740	Exposure meters	OECD	EC	3312	2651
261	902750	Instruments and apparatus using optical radiati	OECD	EC	3312	2651
262	902780	Instruments and apparatus for physical or chemi	OECD	EC	3312	2651
263	902790	Microtomes; parts & access of inst and app for	OECD	EC	3312	2651
264	902810	Gas supply, production and calibrating meters	OECD	EC	3312	2651
265	902820	Liquid supply, production and calibrating meter	OECD	EC	3312	2651

	HS CODE	Product	Source	EA	ISIC3	ISIC4
266	903010	Instruments and apparatus for measuring or dete	DC-ESA-1	PC	3312	2651
267	903090	Parts & access for inst & app for meas or check	DC-ESA-1	PC	3312	2651
268	903149	Other optical instruments and appliances :-- Other	OECD	EC	3312	2651
269	903180	Measuring or checking instruments, appliances a	OECD	EC	3312	2651
270	903190	Parts and accessories for measuring or checking	APEC	EC	3313	2651
271	903210	Thermostats	WB	EC	3312	2651
272	903220	Manostats	WB	EC	3312	2651
273	903281	Hydraulic or pneumatic automatic regulating or	DC-ESA-2	EC	3312	2651
274	903289	Automatic regulating or controlling instruments	DC-ESA-2	EC	3310	2651
275	903290	Parts & access for automatic regulating or cont	DC-ESA-2	EC	3313	2651
276	903300	Parts & access nes for machines, appliances, in	APEC	EC	3312	2651
277	950310	Electric trains, incl tracks, signals and other	DC-ESA-1	EC	3694	3240
278	960310	Brooms/brushes of twigs or oth veg mat bound to	OECD	PC	3699	3290
279	960350	Brushes nes, constituting parts of machines, ap	OECD	PC	3699	3290
280	960390	Hand-operated mechanical floor sweepers; prepar	OECD	PC	3699	3290

Source

- OECD: Steenblik (2005)
- WB: World Bank (2007)
- DC-ESA-1: U.S. DC-ESA (2010)
- DC-ESA-2: U.S. DC-ESA (2010)
- APEC: Reinvang (2014), Steenblik (2005)

EA

- RC: Resource Conservation
- EC: Environmental control
- RE: Renewable/alternative energy
- PC: Pollution control

ISIC3: United Nations (2002)

ISIC4: United Nations (2008)

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