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Product complexity and economic development

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ABSTRACT

Development is a process of transforming a country's economic structure towards the production and export of more complex products. We use Hidalgo and Hausmann's (2009) method of reflections to compute measures of product and country complexity, and rank 5107 products and 124 countries. We find that: (i) the most complex products are in machinery, chemicals, and metals, while the least complex products are raw materials and commodities, wood, textiles, and agricultural products; (ii) the most complex economies in the world are Japan, Germany, and Sweden, and the least complex, Cambodia, Papua New Guinea, and Nigeria; (iii) the major exporters of the more complex products are the high-income countries, while the major exporters of the less complex products are the low-income countries; and (iv) export shares of the more complex products increase with income, while export shares of the less complex products decrease with income.

1. Introduction

The literature pioneered by Lewis (1955), Rostow (1959), Kuznets (1966), Kaldor (1967), Chenery and Taylor (1968), among others, during the 1950s and 1960s viewed development and growth as a process of structural transformation of the productive structure, whereby resources were transferred from activities of lower productivity into activities of higher productivity. As a consequence, this literature also acknowledged that different activities played different roles in the economy because they were subject to different degrees of returns to scale, their outputs had different income elasticities of demand, and because their market structures were different. For a long time, however, this body of work was dormant.

In a series of recent papers, Hidalgo et al. (2007) and Hidalgo and Hausmann (2009) revive these ideas and explain economic development as a process of learning how to produce (and export) more complex products. Using network theory methods, they show that the development path of a country is determined by its capacity to accumulate the capabilities that are required to produce varied and, in particular, more sophisticated goods. Therefore, the overall complexity of a country's productive structure is the key variable in order to explain growth and development: countries' different abilities to accumulate capabilities explain differences in their performance. There is now a well established literature that highlights the importance of capabilities in various contexts. For example, Acemogly and Zillibotti (1999) advance a theoretical explanation for the wide variation in knowledge stock across countries. They argue that societies accumulate knowledge by repeating certain tasks, and that scarcity of capital restricts the repetition of various activities. Kremer (1993) refers to the crucial role of capabilities in the context of growth and development. Lall (1992) and Bell and Pavitt (1995) refer to the importance of capabilities

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from an innovation and development point of view;[1] and Sutton (2001, 2005) from a firm perspective.

In Hidalgo and Hausmann (2009) theory of capabilities, economic development is not only a process of continuously improving upon the production of the same set of goods, but more importantly, a process that requires acquiring more complex sets of capabilities to move towards new activities associated with higher levels of productivity. Specifically, capabilities refer to: (i) the set of human and physical capital, the legal system, institutions, etc. that are needed to produce a product (hence, they are product-specific, not just a set of amorphous factor inputs); (ii) at the firm level, they are the "know-how" or working practices held collectively by the group of individuals comprising the firm; and (iii) the organizational abilities that provide the capacity to form, manage, and operate activities that involve large numbers of people. According to Sutton (2001, 2005), capabilities manifest themselves as a quality-productivity combination. A given capability is embodied in the tacit knowledge of the individuals who comprise the firm's workforce. The quality-productivity combinations are not a continuum from zero; rather, there is a window with a "minimum threshold" below which the firm would be excluded from the market. Therefore, capabilities are largely non-tradable inputs.

The complexity of a product is a function of the capabilities it requires, while the complexity of a country is given by the number of locally available capabilities. These capabilities are not defined *a priori* and we do not attempt to infer specifically what they are. However, what we can say is that countries that have revealed comparative advantage in the same products share those capabilities. The method of reflections explained below uses an iterative procedure to tease out which products require a greater variety and more complex capabilities as well as which countries have a greater array as well as more complex capabilities. As discussed above, these capabilities can range from organizational abilities to legal systems. Hausmann and Hidalgo (2010) note that depending on the disaggregation level of the data used the total number of capabilities worldwide vary from 23 to 80. For a product to be exported with comparative advantage, more than one of those capabilities has to be present. Akin to the O-ring theory of development (Kremer, 1993), lack of one capability may result in the product not being exported with comparative advantage.

This literature in effect implies that development is slow for countries with productive structures geared towards low-productivity and low-wage activities, producing mostly low-valued commodities or agricultural products. Development is fast, on the other hand, for countries with productive structures geared towards high-productivity and high-wage activities.

The newly developed product space of Hidalgo et al. (2007) encapsulates these ideas. The product space is a representation of all products exported in the world, where products are linked based on the similarity of their required capabilities—for example, the link between shirts and pants is stronger than that between shirts and iPods. One implication of the product space is that the lack of connectedness between the products in the periphery (low-productivity products) and in the core (high-productivity products) explains the difficulties poor countries face converging to the income level of the rich countries.

Hausmann et al. (2007) suggested two simple empirical measures of product and economic complexity (or sophistication). The complexity of a product, PRODY, is represented by the income level associated with that product, and it is calculated as a weighted average of the income per capita of the countries that export the said product. The weight is the index of revealed comparative advantage.[2] Economic (or country) complexity, EXPY, represents the productivity level associated with a country's export basket, and it is calculated as a weighted average (where the weight is the share of the product in the country's export basket) of the complexity of the products exported by the country.[3] Hausmann et al. (2007) showed that not all products have the same consequences for economic development: there are products whose capabilities can be easily redeployed into the production and export of other products (which facilitates development), while there are other products that embody capabilities that can hardly be used for the production of other goods. They also showed that rich countries export rich-country products, and that the measure of economic complexity (EXPY) is a good predictor of future growth.[4]

PRODY and EXPY include information on income (income per capita of the countries that export the product), as well as information about the network structure

[1] Lall (1992) and Bell and Pavitt (1995) provide a framework to analyze the industrial "technological capabilities" required for innovation. Among the capabilities at the advanced level are those necessary to: (i) develop new production systems and components; (ii) process basic design and related R&D; (iii) process innovation and related R&D; (iv) do radical innovation in organization; (v) do product innovation and related R&D; (vi) do collaboration in technology development; and (vii) do R&D for specifications and designs of new plant and machinery. These capabilities are distributed across different functions: (i) and (ii) are related to investment activities; (iii)–(v) are related to production activities; and (vi) and (vii) are related to the development of linkages to the economy and capital goods supply.

[2] The weight is the ratio of the share of the product in a country's export basket to the sum of all shares across all countries exporting that product. Algebraically:

$$\mathrm{PRODY}_i = \sum_c \left[\frac{xval_{ci}/\sum_i xval_{ci}}{\sum_c xval_{ci}/xval_{ci}} \right] \times GDPpc_c$$

where $xval_{ci}$ is the value of country c's export of commodity i and $GDPpc_c$ is country c's per capita GDP. PRODY is measured in 2005 PPP$. PRODY provides a measure of the income content of a product and is not therefore an engineering notion.

[3] Algebraically:

$$\mathrm{EXPY}_c = \sum_i \left(\frac{xval_{ci}}{\sum_i xval_{ci}} \times \mathrm{PRODY}_i \right)$$

EXPY is measured in 2005 PPP$.

[4] A very similar measure of product sophistication was developed by Lall et al. (2006). Their sophistication index differs from PRODY in that it uses the export share of a country in total world exports of the product as weights, instead of the ratio of the share of the product in a country's export basket to the sum of all shares across all countries exporting the product.

of countries and the products they export (the weights). Hidalgo and Hausmann (2009) have improved them by separating the information on income from the information on the network structure of countries and the products they export. In doing so, they addressed the criticism that using income information in the computation of the measures makes the conclusion "rich countries export rich-country products" circular (Hidalgo, 2009). To provide an intuition of how complexity is measured in the new method, Hidalgo and Hausmann (2009) used the Lego models as an analogy. Suppose we have a Lego bucket (representing a country) with various kinds of Lego pieces (representing the capabilities available in the country). The different Lego models that we can build (i.e., different products) depend on the kind, diversity, and exclusiveness of the Lego pieces that we have in a bucket. We can build more complex Lego models if we have the necessary Lego pieces, i.e., the Lego model we can build is limited by the Lego pieces we have. A Lego bucket that contains pieces that can only build a bicycle, most likely does not contain the pieces to create an airplane model. However, a Lego bucket that contains pieces that can build an airplane model may also have the necessary pieces needed to build a bicycle model. Moreover, two Lego buckets may be capable of building the same number of models, but the models that the first bucket can build may be entirely different from those that the second bucket can build. Hence, determining the complexity of an economy by looking at the products it produces amounts to determining the "diversity and exclusivity" of the pieces in a Lego bucket by simply looking at the Lego models it can build.

The rest of the paper expands Hidalgo and Hausmann's (2009) empirical analysis and is organized as follows. Section 2 explains Hidalgo and Hausmann's (2009) methods of reflections, their measures of complexity, and ranks 5107 products and 124 countries. Section 3 presents summary statistics of the measures of product complexity and our findings on how the export shares of products of different complexity change with income per capita. While Hidalgo and Hausmann (2009) thoroughly discussed the relationship between economic complexity and income, they did not elaborate on the relationship between product complexity and income. In Section 4, we compare the measures of complexity used in this paper with several other indexes of technological capability, such as those of Archibugi and Coco (2004), Desai et al. (2002), Lall and Albaladejo (2002), and Wagner et al. (2001); and revisit the concept of complex products and systems (CoPS) developed by Hobday (1998) and Hobday et al. (2000). Section 5 concludes the paper and offers some policy implications.

2. Measuring complexity

In this paper, we use the *method of reflections* developed by Hidalgo and Hausmann (2009) to construct measures of product and economic complexity. This method looks at trade data as a network connecting two mutually exclusive sets—the set of countries and the set of products that they export with revealed comparative advantage (RCA). To make their method operational, Hidalgo and Hausmann (2009) define diversification as the number of products that a country exports with RCA (in the Lego analogy, this is represented by the number of models a Lego bucket can create), and ubiquity as the number of countries that export the product with RCA (and this is represented by the exclusivity of the Lego pieces in the bucket). Diversification and ubiquity are the simplest measures of complexity of a country and a product, respectively. A country that exports more goods with RCA (i.e., is more diversified) is more complex than a country that exports fewer goods with RCA (i.e., is less diversified); a product that is exported by fewer countries with RCA (i.e., is less ubiquitous) is more complex than a product that is exported with RCA by more countries (i.e., is more ubiquitous). The intuition behind this is that a country can export a particular product with RCA if it possesses the necessary and specific capabilities (labor skills, institutions, machinery, public inputs, tradable inputs, etc.). Thus, a more diversified country has more capabilities. Similarly, a product that is less ubiquitous requires more exclusive capabilities. Complexity, therefore, is associated with the set of capabilities required by a product (product complexity) or with the set of capabilities that are available to an economy (economic complexity).

Diversification and ubiquity are computed as follows:

$$k_{c,0} = \sum_{p=1}^{N_p} M_{cp} \quad \text{(Diversification)} \tag{1}$$

$$k_{p,0} = \sum_{c=1}^{N_c} M_{cp} \quad \text{(Ubiquity)} \tag{2}$$

where c denotes the country, p the product, and $M_{cp} = 1$ if country c exports product p with revealed comparative advantage[5] and $M_{cp} = 0$, otherwise. As can be seen, these measures only include information about the network structure of countries and products.

The method of reflections consists in calculating jointly and iteratively the average value of the measure computed in the preceding iteration, starting with a measure of a country's *diversification* (Eq. (1)) and a product's *ubiquity* (Eq. (2)). The succeeding iterations of the method of reflections refine the measures of complexity by taking into account the information from the previous iterations. These are given by:

$$k_{c,n} = \frac{1}{k_{c,0}} \sum_{p=1}^{N_p} M_{cp} k_{p,n-1} \tag{3}$$

$$k_{p,n} = \frac{1}{k_{p,0}} \sum_{c=1}^{N_c} M_{cp} k_{c,n-1} \tag{4}$$

where n corresponds to the number of iterations. Eqs. (3) and (4) are iterated until no additional information can be derived from the previous iteration, and this happens

[5] The index of revealed comparative advantage (RCA) is the ratio of the export share of a given product in the country's export basket to the same share at worldwide level (Balassa, 1965). Algebraically:

$$\text{RCA}_{ci} = \frac{xval_{ci} / \sum xval_{ci}}{\sum_c xval_{ci} / \sum_i \sum_c xval_{ci}}.$$

at n when the relative rankings of the values estimated using (3) and (4) in the $n+1$ iteration do not vary. For each country, the even-numbered iterations ($k_{c,0}$, $k_{c,2}$, $k_{c,4}$,...) yield generalized measures of diversification, and the odd-numbered iterations ($k_{c,1}$, $k_{c,3}$, $k_{c,5}$,...) yield generalized measures of the ubiquity of exports. On the other hand, for each product, the even-numbered iterations ($k_{p,0}$, $k_{p,2}$, $k_{p,4}$,...) are related to the product's ubiquity and the ubiquity of related products, and the odd-numbered iterations ($k_{p,1}$, $k_{p,3}$, $k_{p,5}$,...) are related to the diversification of the countries that export the product.

As the number of iterations of Eqs. (3) and (4) increases, the resulting indicators converge to their means. Hence, we only need to look at the *relative* values of these indicators for a sufficient number of iterations, after which the ranking of these variables remain relatively unchanged, i.e., at the point where the method has already extracted all information it could. In this paper, we use $k_{c,16}$ as our measure of economic (or country) complexity and $k_{p,17}$ as our measure of product complexity (see Hidalgo and Hausmann (2009) and Hidalgo (2009) for more details).

We calculate the complexity measures using trade data from the Harmonized System (HS) 6-digit level classification, comprising 5132 products for 176 countries.[6] Export values were calculated using the records of the importing countries under the assumption that data from importers is more accurate. We also deflated the prices of selected products that have shown significant price changes during the period of analysis.[7] The indicators we use are averages for the period 2001–2007.[8]

To illustrate how the method works, let us look at how it determines the complexity of the productive structure of two countries, Canada and Vietnam, by looking at the results of the first two iterations, starting with diversification ($k_{c,0}$) and ubiquity ($k_{p,0}$). Table 1 provides a summary. Vietnam is more diversified than Canada, as it exports a total of 902 products ($k_{\mathrm{VNM},0}=902$) with RCA, while Canada exports 893 products ($k_{\mathrm{CAN},0}=893$) with RCA. Diversification, however, does not tell us how complex the products being exported are. Do the 902 products exported by Vietnam require more capabilities than the 893 products exported by Canada? In terms of the Lego analogy, Vietnam's Lego pieces are capable of building more models than Canada's, but do Vietnam's Lego models require more exclusive Lego pieces? To answer this question we use the ubiquity ($k_{p,0}$) of each product to calculate the first iteration $k_{c,1}$, which gives the average ubiquity of all the products the country exports with RCA. This yields $k_{\mathrm{VNM},1}=25$ and $k_{\mathrm{CAN},1}=20$, which means that Vietnam's exports are exported by 25 countries (this is the average of the number of countries that export each product also exported by Vietnam), and Canada's by 20. This implies that Canada's exports are less standard than Vietnam's, i.e., Canada's Lego bucket has more exclusive pieces than Vietnam's. However, the measure of ubiquity ($k_{p,0}$) is not perfect since it does not provide information about the complexity of the countries that export the products with RCA—two products can be exported by the same number of countries, but the exporters of one of the products may be more diversified than the exporters of the other. This leads us to $k_{p,1}$, which is the average diversification of the countries that export the product. This information is used in the second iteration, $k_{c,2}$, which is the average diversification of the countries that export the same products with RCA as those exported by Canada or Vietnam with RCA. This yields $k_{\mathrm{VNM},2}=885$ and $k_{\mathrm{CAN},2}=975$, which implies that Canadian exports are exported by more diversified countries than Vietnam's exports. Thus, if one had drawn conclusions using only diversification, one would have concluded that Vietnam is a more complex economy than Canada. Instead, by jointly using diversification and ubiquity information in succeeding iterations one can see that indeed the productive structure of Canada is more complex than that of Vietnam because its exports, while less diversified, require more capabilities and are exported by more diversified countries. But we may still ask whether these other countries that export products similar to those exported by Canada or Vietnam export more or less ubiquitous products, which again leads us to the next iteration $k_{c,3}$ using $k_{p,2}$. Thus, one can improve on the previous results by increasing the number of iterations up to the point where there is no new information that could be extracted from the network of countries and products.

The result of iterating the method of reflections is a pair of indexes, $k_{c,n}$ and $k_{p,n}$, that indirectly measure the capabilities locally available in a country (economic complexity) and the capabilities required by a product (product sophistication), respectively. Countries with high values of $k_{c,n}$ are those with productive structures that have many capabilities, while countries with low values of $k_{c,n}$ have productive structures with few capabilities. Likewise, products with high values of $k_{p,n}$ are those that require many or exclusive capabilities, and vice versa.

A discussion of our main findings is provided in Section 3. This is complemented with the information in Appendices A–E. Appendix A lists the 100 most complex products and Appendix B the 100 least complex products.[9] Appendix C ranks the 124 countries according to economic complexity and Appendices D and E show the ten most complex and ten least complex economies and their major exports.[10]

3. Product complexity and economic development

In this section we summarize the major findings that result from the application of the method of reflections

[6] Hidalgo and Hausmann (2009) worked with the SITC rev. 4 (772 products, 129 countries), the HS at the 4-digit level (1241 products, 103 countries), and the NAICS at the 6-digit level (318 products, 150 countries). The trade data is from the UN Commodity Trade Statistics.

[7] These products are: aluminum, gold, petroleum, and copper. The prices used to deflate the export values were obtained from the IMF Commodity Price Index.

[8] Country ($k_{c,16}$) and product ($k_{p,17}$) complexity are calculated for each year for the period 2001–2007 and then averaged.

[9] For purposes of ranking products according to complexity, we exclude 25 commodities. These are products that were not consistently reported during the period 2001–2007 (24 such products) and the HS 2-digit code 99 (there is only one HS-6 digit commodity within HS 2-digit code 99).

[10] We excluded countries with a population of less than 2 million (leaving out 52 countries) for the complexity country ranking.

Table 1
Method of reflections: information from the first three pairs of variables derived from Eqs. (1)–(4).

n	Country	Product
0	$k_{c,0}$, *Diversification:* Number of products exported with RCA by country C (How many products are exported with RCA by country C?)	$k_{p,0}$, *Ubiquity:* Number of countries exporting product P with RCA (How many countries export product P with RCA?)
1	$k_{c,1}$: Average ubiquity of the products exported with RCA by country C (How common are the products exported with RCA by country C?)	$k_{p,1}$: Average diversification of the countries exporting product P with RCA (How diversified are the countries exporting product P with RCA?)
2	$k_{c,2}$: Average diversification of countries with similar export basket as country C (How diversified are the countries exporting similar products with RCA as those exported by country C with RCA?)	$k_{p,2}$: Average ubiquity of the products exported with RCA by countries exporting product P with RCA (How ubiquitous are the products exported by product P's exporters?)

Hidalgo and Hausmann (2009), Supplementary Material, p. 8.

to our product and country database. We infer some observations on the characteristics of the ten most complex and ten least complex products and then generalize our observations (Section 3.1). We also look at the distribution of export shares across the product complexity scale for each country and analyze how export shares of products of different complexity vary with income per capita (Section 3.2). The discussion in this section also serves to show the kind of products that are exported by countries at various levels of development, and in this sense it helps understand the type of capabilities that might be needed by countries on lower rungs of the development ladder as they strive to move up.

3.1. The most and the least complex products, and their major exporters

Tables 2 and 3 show the ten most and the ten least complex products. For each product, the table also shows the top five exporters, the corresponding RCA index, and the share in total world exports. Two observations can be made regarding the complexity across product categories and the income level of the major exporters of products of different complexity.

First, regarding the product categories and their complexity, the ten most complex products belong to machinery, chemicals, and metal products; whereas the least complex products are mostly raw materials and commodities, wood, textile, and agricultural products. To determine whether the same pattern of complexity remains across the 5107 products, we aggregated all commodities into fifteen groups, corresponding to sectors in the HS classification system. We calculated the average complexity of each group and ranked all fifteen groups. Fig. 1 shows the ranking of the fifteen HS groups, from the most complex (chemicals) to the least complex (footwear/headgear). The figure also shows the distribution of products within each HS group by complexity.

Fig. 1 is consistent with the product space literature (Hidalgo et al., 2007). In the product space, the more sophisticated products such as metals, machinery, and chemicals are located in the densely connected core, whereas the less sophisticated products, such as agricultural and forest products, raw materials, and petroleum, can be found in the less connected periphery. In Fig. 1, chemicals and allied industries, machinery/electrical, plastics/rubbers, metal products, and transportation are the most complex products. Their distributions show that the complexity of the majority of the products in these groups is above the average (i.e., to the right of the vertical bar). On the other hand, the least complex product groups are footwear/headgear, textiles, vegetable products, raw hides, skins, leathers and furs, foodstuffs, and animal and animal products. These are the same product groups found in the periphery of the product space. The complexity level of the majority of the products in these groups is below the average complexity (i.e., to the left of the vertical bar).[11]

Second, Tables 2 and 3 show the income levels of the major exporters of products of different complexity. The major exporters of the ten most complex products are high-income countries, while the major exporters of the ten least complex products are low- to middle-income countries. For instance, the top five exporters of "cumene"—the most complex product, used as a raw material for other chemicals and used in the manufacture of rubber, iron and steel, and pulp and paper[12]—are the Netherlands, the United States, Japan, Germany, and the UK, with an average income per capita of about $34,000 (in 2005 PPP$). In contrast, the average per capita income of the top five exporters of "sawlogs and veneer logs"—the least complex product—is about $10,000 (in 2005 PPP$). Fig. 2 provides a generalization of this observation, i.e., the positive relationship between income level (weighted average income of countries exporting each commodity) and product complexity.[13] This implies that richer countries are the major exporters of the more complex products while the poorer countries are the major exporters of the less complex products.

3.2. How do export shares vary with income for different levels of product complexity?

Fig. 3 shows the histograms of the export shares of the 5107 products against the product complexity scale for the ten most and the ten least complex countries. The figure shows that the export baskets of the ten most complex countries are characterized by high shares of complex products (i.e., exports are concentrated to the right of the vertical line, the mean); while the export baskets of the ten least complex countries are characterized by high shares of

[11] The percentage of commodities in the bottom tercile of the least complex groups are as follows: footwear/headgear, 91%; raw hides, skins, leather, and furs, 78%; textile, 76%; and vegetable products, 72%.

[12] Australian Government, Department of the Environment, Water, Heritage, and the Arts, National Pollutant Inventory. Available at: http://www.npi.gov.au/substances/cumene/index.html.

[13] Income per capita is weighted using the export share of a country in total world exports of the product.

Table 2
Ten most complex products and their top five exporters.

Ten most complex products				
Commodity description (HS2 group)	Top five exporters	GDP per capita	RCA	Export share*
(1) Other cyclic hydrocarbons: Cumene (organic chemicals)	Netherlands	34,768	14.3	48.4
	USA	40,977	2.3	23.2
	Japan	29,849	2.5	16.3
	Germany	31,524	0.7	6.2
	United Kingdom	31,664	0.5	2.2
(2) Metalworking machine-tools/ultrasonic machine-tools: for dry-etching patterns on semiconductor materials (nuclear reactors, boilers, machinery, etc.)	USA	40,977	5.8	57.1
	Japan	29,849	4.4	29.8
	Netherlands	34,768	0.9	3.1
	Malaysia	11,350	1.6	2.9
	United Kingdom	31,664	0.6	2.2
(3) Particle accelerators and parts thereof, nes: ion implanters for doping semiconductor materials (electrical, electronic equipment)	USA	40,977	6.3	61.6
	United Kingdom	31,664	5.8	21.8
	Japan	29,849	1.5	10.1
	France	30,411	0.5	2
	Netherlands	34,768	0.2	0.8
(4) Methacrylic acid, salts (organic chemicals)	Germany	31,524	3.4	31.6
	USA	40,977	2.1	20.5
	Japan	29,849	2.8	18.9
	Belgium	31,695	3.4	8
	United Kingdom	31,664	2	7.3
(5) Carbide tool tips, etc.: tool plates/tips/etc., sintered metal carbide and cermets (tools, implements, cutlery, etc. of base metal)	Sweden	31,506	11.9	15.4
	Germany	31,524	1.6	14.7
	Israel	22,915	26.9	12.4
	Japan	29,849	1.6	10.9
	USA	40,977	0.8	7.8
(6) Photo, cine laboratories equipment, nes; screens for projectors: direct write-on-wafer apparatus (optical, photo, technical, medical, etc. apparatus)	Japan	29,849	5.3	35
	Germany	31,524	1.8	16
	Netherlands	34,768	4.2	14.5
	United Kingdom	31,664	2.4	9.3
	USA	40,977	0.8	8.7
(7) Other inorganic esters: hexamethylenediamine, its salts (organic chemicals)	France	30,411	8.6	39.2
	USA	40,977	2.6	25.3
	Belgium	31,695	6.4	15.3
	United Kingdom	31,664	4.4	15.2
	Germany	31,524	0.3	2.9
(8) Other electronic measuring, controlling, etc. apparatus: instruments nes using optical radiations (UV, visible, IR) (optical, photo, technical, medical, etc. apparatus)	USA	40,977	2.7	26.6
	Germany	31,524	1.9	17.4
	Japan	29,849	2.5	16.5
	United Kingdom	31,664	1.4	5.2
	Ireland	37,299	3.4	4.7
(9) Other machinery, mechanical appliances having individual functions: laser, light, and photon beam process machine tools (nuclear reactors, boilers, machinery, etc.)	Switzerland	35,648	17.4	24.2
	Japan	29,849	3.5	23.1
	Germany	31,524	1.8	17
	USA	40,977	1.5	15.2
	Italy	28,277	1.2	4.5
(10) Sheet, plates, rolled of thickness 4.75 mm plus, of iron or steel or other alloy steel: cold rolled alloy-steel nes, not further worked (cold-reduced), <600 mm wide (iron and steel)	Germany	31,524	2.9	26.8
	Japan	29,849	3.3	22
	France	30,411	3.3	14.9
	Belgium	31,695	2.4	5.9
	USA	40,977	0.6	5.8

Notes: 'nes'—not elsewhere specified. *Share of exports in total world exports. GDP per capita, RCA, and export shares reported are averages for 2001–2007. GDP per capita (in 2005 PPP$) from World Development Indicators is used at all places in this paper. Export shares are based on data for all HS 6-digit products and all countries. *Source*: Authors' estimates.

products of low complexity (i.e., exports are concentrated to the left of the vertical line, the mean).

This finding can be generalized by testing for all 124 countries whether a country's exports are skewed towards the more complex or the less complex goods. We first calculate the degree of skewness and then test whether the distributions of the export shares (along the product complexity scale) are normal. The hypothesis of normality is rejected for most countries. Table 4 shows the countries whose distribution are negatively skewed (i.e., towards more complex products) and those whose distributions are positively skewed (i.e., towards less complex products). With the exception of a few cases, the export shares of more complex products are higher for the higher income

Table 3
Ten least complex products and their top five exporters.

Ten least complex products				
Commodity description (HS2 group)	Top 5 exporters	GDP per capita	RCA	Export share*
(5107) Sawlogs and veneer logs, of nonconiferous species, in the rough: logs, tropical woods nes (wood and articles of wood, wood charcoal)	Gabon	13,061	688.7	25.5
	Malaysia	11,350	13.4	23.2
	Congo	3401	333.3	10.0
	Cameroon	1944	236.2	7.8
	Equatorial Guinea	21,079	178.1	5.6
(5106) Cashew nuts, in shell dried (edible fruit, nuts, peel of citrus fruit, melons)	Côte d'Ivoire	1587	270.7	19.3
	United Republic of Tanzania	998	852.6	14.6
	Guinea-Bissau	529	14,280.7	13.8
	Indonesia	3100	11.4	12
	Benin	1315	1383.9	7.8
(5105) Manioc (cassava), fresh or dried (edible vegetables and certain roots and tubers)	Thailand	6164	56.5	69.1
	Vietnam	2034	38.5	12.7
	Costa Rica	8873	60.3	7.5
	Indonesia	3100	3.3	3.5
	Germany	31,524	0.2	1.8
(5104) Technically specified natural rubber (TSNR) (rubber and articles thereof)	Indonesia	3100	39.7	42.3
	Thailand	6164	17.8	21.7
	Malaysia	11,350	11.1	19.1
	Vietnam	2034	15.1	4.8
	Côte d'Ivoire	1587	38.9	2.8
(5103) Cocoa beans, whole or broken, raw or roasted (cocoa and cocoa preparations)	Côte d'Ivoire	1587	562	40.5
	Ghana	1163	601.3	18.6
	Indonesia	3100	12.6	13.5
	Nigeria	1650	23.9	7.4
	Cameroon	1944	125.6	4.1
(5102) Wood of non-coniferous, sawn lengthwise, sliced, or peeled: lumber, tropical wood nes (wood and articles of wood, wood charcoal)	Cameroon	1944	468.7	15.3
	Indonesia	3100	14.2	15.2
	Brazil	8379	11.9	14
	Malaysia	11,350	7.9	13.7
	Côte d'Ivoire	1587	114	8.2
(5101) Natural rubber in other forms (rubber and articles thereof)	Indonesia	3100	24.9	26.5
	Thailand	6164	19.7	24.2
	Malaysia	11,350	12.3	21.3
	Vietnam	2034	14	4.5
	Côte d'Ivoire	1587	56.5	4.1
(5100) Copra (oil seed, oleagic fruits, grain, seed, fruit, etc., nes)	Vietnam	2034	54.5	18.7
	Sri Lanka	3433	252.7	18
	Indonesia	3100	16.3	17.3
	Papua New Guinea	1890	446.3	15.7
	Vanuatu	3230	5009.8	7.7
(5099) Jute and other textile bast fibers, raw or retted (vegetable textile fibers nes, paper yarn, woven fabric)	Bangladesh	1035	790.6	88
	India	2122	5.3	5.1
	Belgium	31,695	0.5	1.2
	China	3823	0.1	0.7
	Kenya	1338	17	0.6
(5098) Wood of non-coniferous, sawn lengthwise, sliced, or peeled: lumber, virola, mahogany (wood and articles of wood, wood charcoal)	Peru	6165	173.8	23.4
	Brazil	8379	10.6	11.7
	Ecuador	6388	99.7	9.8
	Cameroon	1944	238.3	8.1
	Côte d'Ivoire	1587	92.6	6.8

Notes: 'nes'—not elsewhere specified. *Share of exports in total world exports. GDP per capita, RCA, and export shares reported are averages for 2001–2007. GDP per capita is in 2005 PPP$. Export shares are based on data for all HS 6-digit products and all countries. *Source*: Authors' estimates.

countries; likewise, the export shares of less complex products are higher for the lower income countries. Fig. 4 shows the negative relationship between the measure of skewness and the log of GDP per capita: countries whose distribution is skewed to the right have lower income per capita and vice versa.

Next, we estimate the export share elasticity of income per capita for each product and see how these share elasticities vary across the product complexity scale. A central tenet of the literature on economic development is that structural transformation is the key to growth. This involves a shift into higher productivity and higher wage activities. As we have shown above, countries with higher per capita income are characterized by higher shares of more complex products. In other words, in a cross-country setting as per capita income increases, one should expect

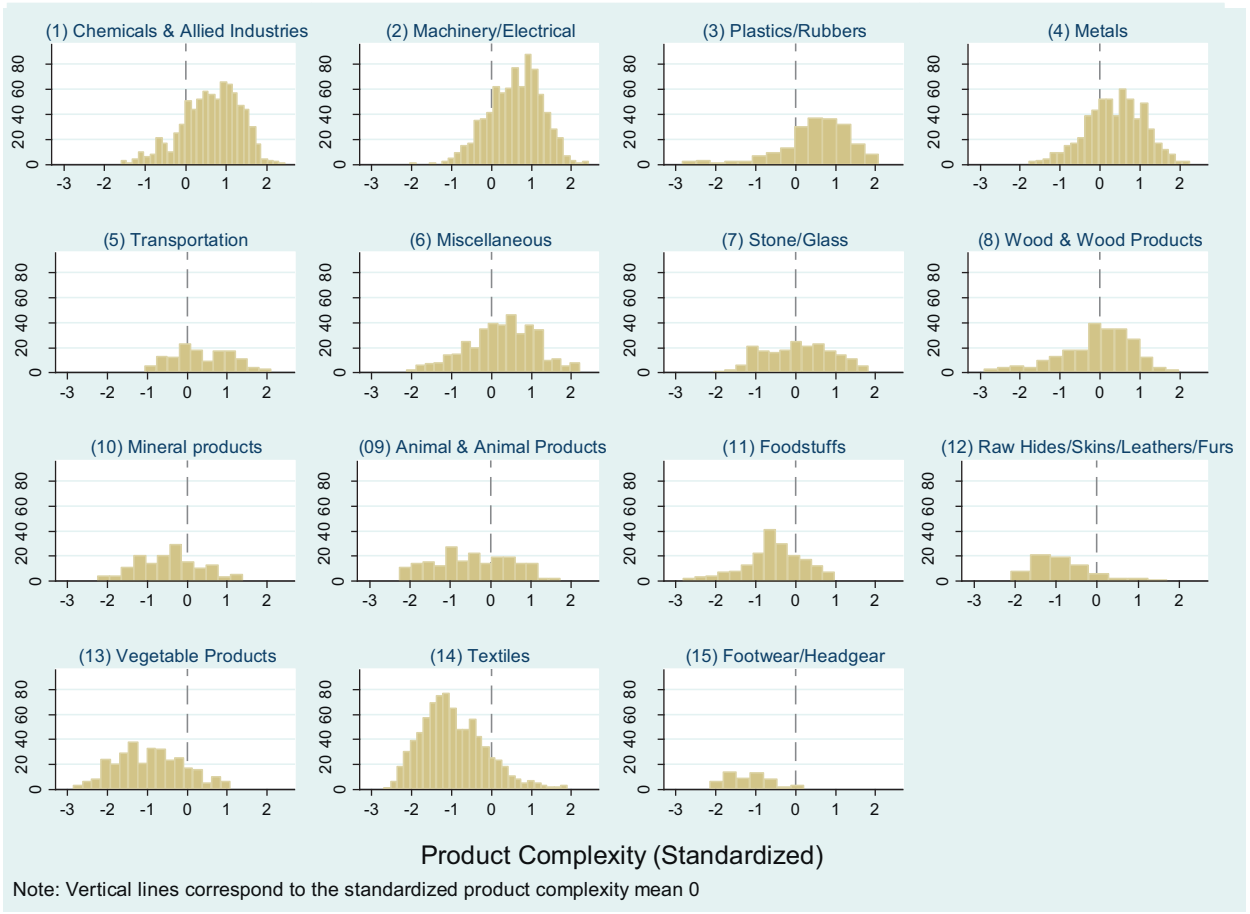

Fig. 1. Distribution of product complexity by HS groups. *Note*: Standardized product complexity (over all 5107 products) with mean zero and standard deviation one. *Source*: Authors' estimates.

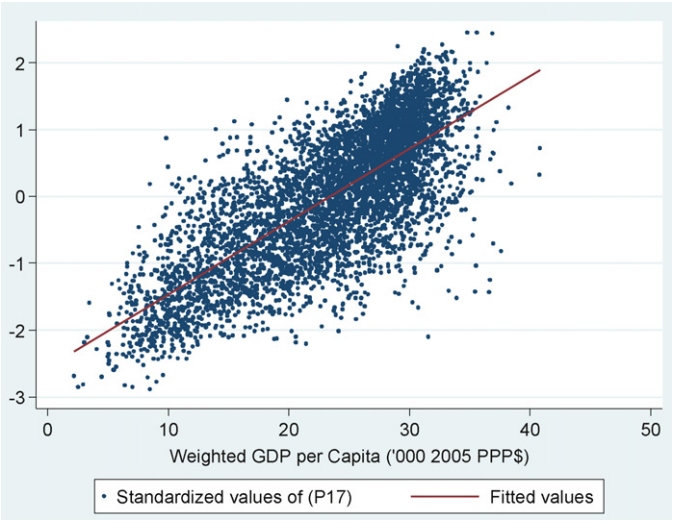

Fig. 2. Product complexity and the weighted mean GDP per capita of exporters. Weighted GDP per capita is the weighted average income of countries exporting each commodity with the weights being the share of each country in the total exports of that commodity. Weighted GDP per capita is measured in 2005 PPP$ and is average for 2001–2007. Data for 5107 products and 124 countries is used. *Source*: Authors' estimates.

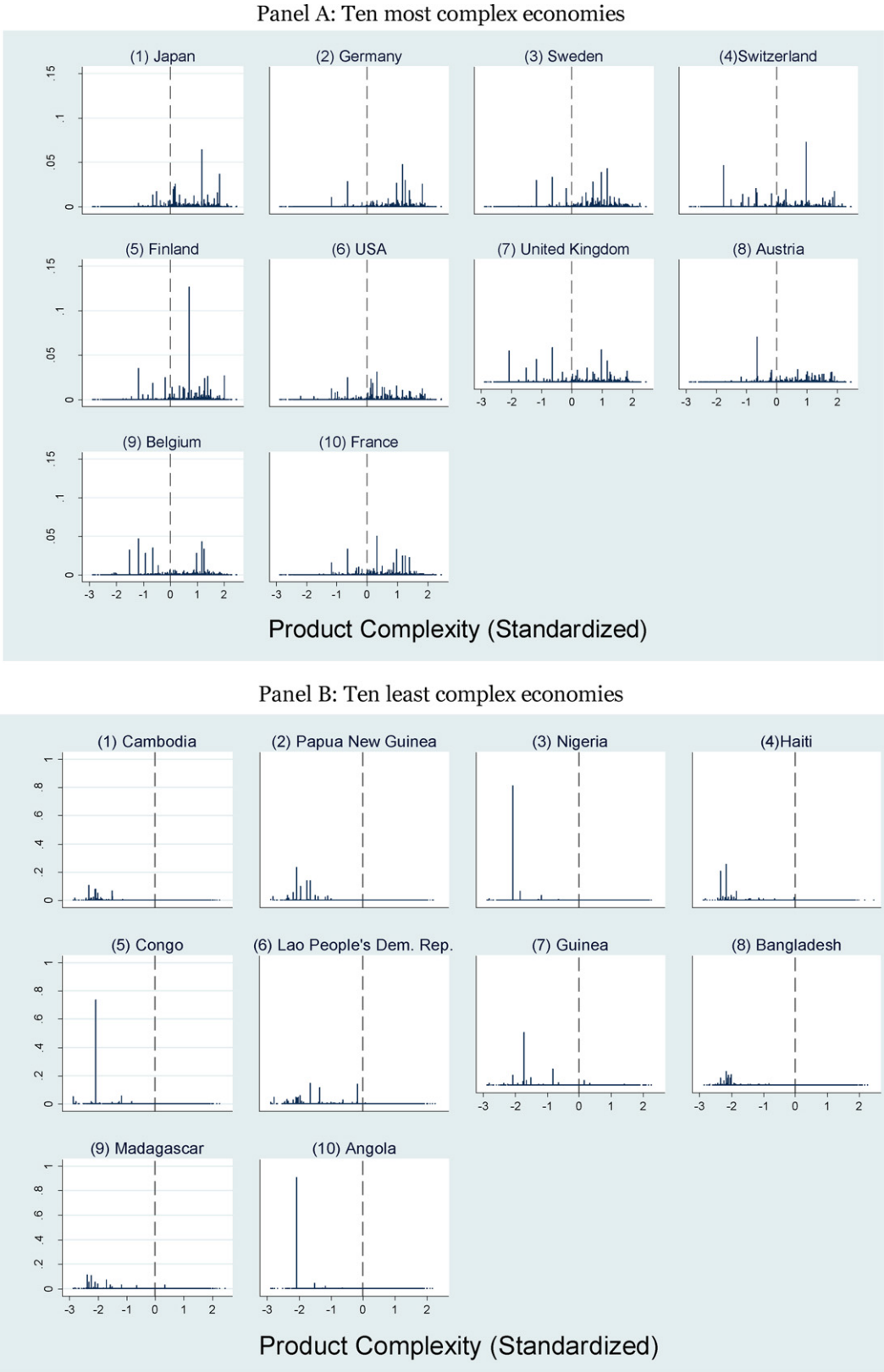

Fig. 3. Export shares in country's total exports across product complexity. Panel A: Ten most complex economies. Panel B: Ten least complex economies. *Notes*: Export shares used for each product are averages for the period 2001–2007. *Source*: Authors' estimates.

Table 4
Distribution (skewness) of exports across product complexity (sorted by country complexity).

Negatively skewed			Positively skewed					
Rank	Country and GDP per capita		Rank	Country and GDP per capita		Rank	Country and GDP per capita	
1	Japan	29,849	16	Norway	46,434	83	Dominican Rep.	6226
2	Germany	31,524	18	Russian Federation	11,221	84	Uganda	889
3	Sweden	31,506	20	Israel	22,915	85	El Salvador	5618
4	Switzerland	35,648	31	Georgia	3299	86	Zambia	1103
5	Finland	30,229	32	Saudi Arabia	20,469	87	Rwanda	771
6	USA	40,977	34	Armenia	3748	88	Burkina Faso	997
7	United Kingdom	31,664	35	Argentina	10,361	89	Nepal	949
8	Austria	33,457	39	Sierra Leone	607	90	Mali	984
9	Belgium	31,695	40	Australia	31,022	92	Tajikistan	1380
10	France	30,411	41	Latvia	12,245	94	Ecuador	6388
11	Ireland	37,299	42	Kazakhstan	8105	96	Chad	1244
12	Netherlands	34,768	43	Venezuela	9656	97	Syria	3914
13	Czech Rep.	19,651	44	Lithuania	13,264	98	Viet Nam	2034
14	Canada	34,446	46	Chile	11,737	99	Nicaragua	2254
15	Denmark	32,974	48	Romania	8943	100	Morocco	3514
16	Slovenia	22,848	48	India	2122	101	Pakistan	2105
19	Singapore	41,406	52	Uruguay	9245	102	Honduras	3203
21	Rep. of Korea	22,093	54	Azerbaijan	4350	103	Côte d'Ivoire	1587
22	Slovakia	15,669	55	Lebanon	9277	104	Tanzania	998
23	Italy	28,277	58	Colombia	7088	106	Benin	1315
24	Hungary	16,191	61	Kyrgyzstan	1701	107	Yemen	2149
26	Poland	13,440	63	Algeria	6832	108	Sri Lanka	3433
27	Spain	26,991	65	Iran	9035	110	Ethiopia	610
28	Mexico	12,424	66	Senegal	1558	111	Cameroon	1944
29	Belarus	7929	67	Libya	12,472	112	Ghana	1163
30	Brazil	8379	68	Central African Rep.	670	113	Sudan	1579
33	New Zealand	24,138	70	Niger	586	114	Malawi	656
38	Malaysia	11,350	71	Uzbekistan	1927	115	Angola	3432
50	China	3823	72	Burundi	347	116	Madagascar	880
52	Portugal	20,711	72	Egypt	4297	117	Bangladesh	1035
56	Hong Kong, China	33,996	75	Panama	8976	118	Guinea	1040
59	Thailand	6164	76	Indonesia	3100	119	Lao People's Dem. Rep.	1611
62	Costa Rica	8873	77	Tunisia	6262	120	Congo	3401
74	Philippines	2846	78	Jamaica	6939	121	Haiti	1103
91	Bolivia	3588	79	Kenya	1338	122	Nigeria	1650
105	Mozambique	648	80	Guatemala	4084	123	Papua New Guinea	1890
109	Turkmenistan	4174	81	Peru	6165	124	Cambodia	1343
			82	Albania	5894			

Notes: GDP per capita, measured in 2005 PPP$, is the average of 2001–2007. For Bosnia and Herzegovina, Bulgaria, Croatia, Greece, Jordan, Paraguay, Republic of Moldova, South Africa, TFYR of Macedonia, Togo, Turkey, and Ukraine the null hypothesis of a normal distribution could not be rejected (p-value > 0.10).
Source: Authors' estimates.

that the share of the more complex products in a country's total exports increases i.e., share elasticity to be positive. And likewise, a negative share elasticity for the less complex products.

We estimate cross-country regressions of each country's export share of product i (in logs) on the level of income per capita (in logs) of country c. We do this for the 5107 products. The equation estimated is:

$$\log(share_{i,c}) = a_i + b_i \times \log(gdppc_c) + e_i \quad (5)$$

where $share_{i,c}$ is the export share of product i in country c's total exports (average for 2001–2007); $gdppc_c$ is the GDP per capita income (measured in 2005 PPP$ and is the average for 2001–2007) of country c; and a_i and e_i are the constant and error terms, respectively. Our main object of interest in Eq. (5) is the coefficients b_i—the elasticity of the export share of product i in a country's export basket with respect to income per capita. Estimation results show that, out of the 5107 products, 2554 have statistically significant positive elasticities; 680 have statistically significant negative elasticities; and there are 1873 products with statistically insignificant (not different from zero at the p-value > 0.10) elasticities. For example, for HS-6 digit product 860310 (self-propelled railway cars, external electric power) the estimated share elasticity is 1.55, which means that as income per capita increases by 10%, the *share* of this product in total exports increases by 15%. Similarly, for HS-6 digit code 030343 (skipjack, stripe-bellied, bonito, frozen, whole), the share elasticity is −1.8, i.e., the share of this product decreases by 18% with an increase in income per capita by 10%.

Table 5 provides a summary of how the estimated share elasticities are distributed across the 15 HS groups. Positive share elasticities are distributed across all the HS groups, although the proportion is higher for the most complex groups (chemicals to wood products). Negative (but statistically significant) and statistically insignificant share elasticities are also distributed across all HS groups, but the proportion is higher for the less complex groups (except foodstuff and footwear/headgear).

In the next step, we determine *where* these products lie in the product complexity scale. Fig. 5 plots the

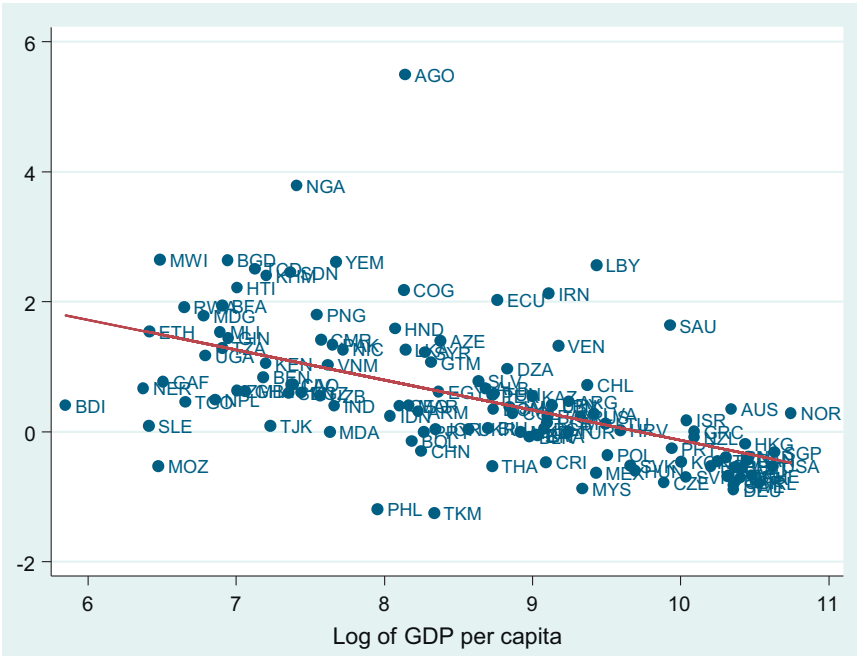

Fig. 4. Skewness of the distribution of export shares and GDP per capita. *Notes*: Skewness is based on the distribution of average export shares for 2001–2007. GDP per capita (GDPPC), measured in 2005 PPP$, is average for 2001–2007. *Source*: Authors' estimates.

estimated share elasticities b_i obtained in Eq. (5) against the standardized product complexity index. Three observations can be made:

(i) Products with positive export share elasticities ($b_i > 0$), represented by '+' in Fig. 5, are mostly located in the top-right quadrant (1903 out of the 2554), with complexity above average (to the right of the vertical line); and the rest (651 out of 2554) are located in the second quadrant. For the more complex (i.e., above average complexity) products, the export share increases with income per capita;

(ii) Products with negative export share elasticities ($b_i < 0$), represented by 'Δ' in Fig. 5, are mostly located in the bottom-left quadrant (638 out of the 680), with complexity below average (to the left of the vertical line). For the less complex (i.e., below average complexity) products, the export share decreases with income per capita; and

(iii) Products with export share elasticities statistically equal to zero (represented by 'o' in Fig. 5) lay across a wide range of the product complexity.

In Fig. 6, we divide the 5107 products into terciles according to their complexity and study the relationship

Table 5
Export share elasticity of income by HS groups.

HS Groups	Proportion of statistically significant elasticities (%)			Proportion of statistically insignificant elasticities	Total number of products
	All	Negative	Positive		
1. Chemicals	51.4	5.9	45.5	48.6	784
2. Machinery/Electrical	85.3	0.7	84.6	14.7	804
3. Plastics/Rubbers	81.8	4.5	77.3	18.2	198
4. Transportation	63.6	4.5	59.1	36.4	132
5. Metals	67.4	3.2	64.3	32.6	571
6. Miscellaneous	76.0	1.5	74.5	24.0	392
7. Stone/Glass	63.5	7.6	55.8	36.5	197
8. Wood and Wood Products	72.1	11.4	60.7	27.9	229
9. Mineral Products	42.6	23.0	19.6	57.4	148
10. Animal and Animal Products	50.2	26.9	23.4	49.8	201
11. Foodstuffs	60.8	17.7	43.0	39.2	186
12. Vegetable Products	58.9	48.4	10.4	41.1	316
13. Textiles	47.4	29.0	18.5	52.6	822
14. Raw Hides/Skins/etc.	61.1	33.3	27.8	38.9	72
15. Footwear/Headgear	52.7	21.8	30.9	47.3	55
Total no. of products	3234	680	2554	1873	5107

Note: Proportions of statistically (in)significant elasticities correspond to the share of (in)significant coefficients obtained from estimating Eq. (5) in the total number of products in each HS group (last column). *Source*: Authors' estimates.

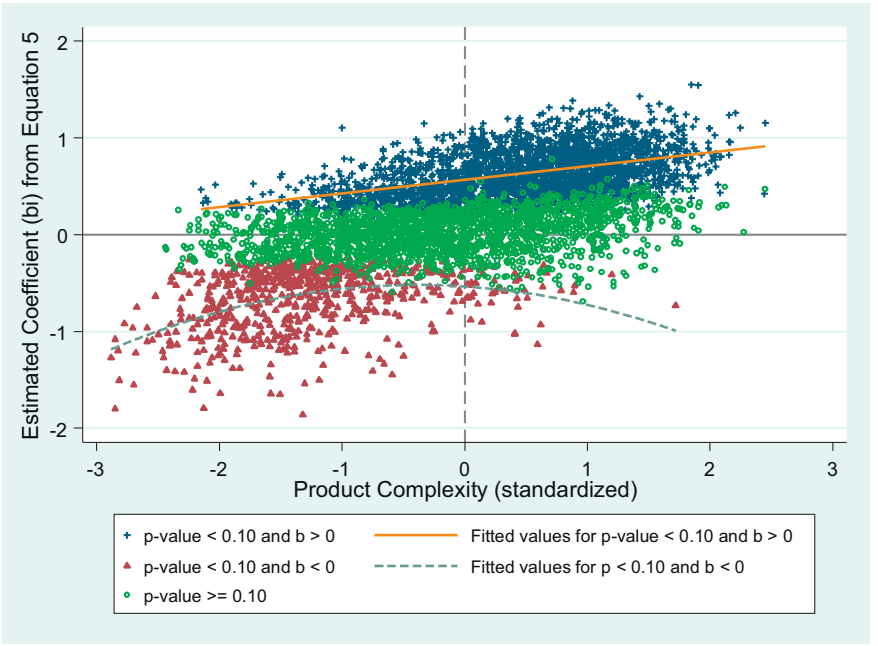

Fig. 5. Elasticity of the export share with respect to income and product complexity. *Notes*: The share elasticities are estimated from Eq. (5). Horizontal and vertical lines correspond to a share elasticity = 0 and mean of the product complexity, respectively. *Source*: Authors' estimates.

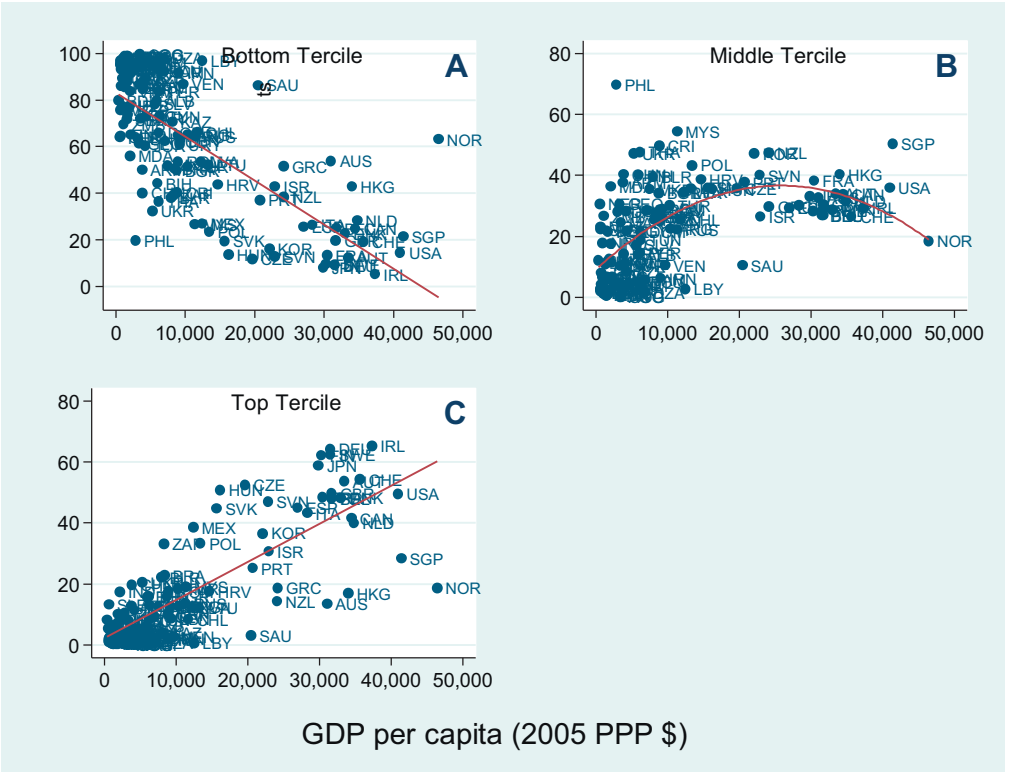

Fig. 6. Export shares and income per capita. *Notes*: In all the panels, GDP per capita, measured in 2005 PPP$, averaged for 2001–2007, is shown on the horizontal axis. The vertical axis is the share of the products in total exports. Panel A shows the share of products in the bottom tercile of the product complexity ranking. Panel B shows the share of middle tercile. Panel C shows the share of top tercile. Data for 124 countries and 5107 products. *Source*: Authors' estimates.

Table 6
Share in country's total exports, by product complexity.

Country	Rank	Product complexity level (1 – highest; 6 – lowest)						
		1	Top 100	2	3	4	5	6
Japan	1	39.7	10.0	19.0	21.9	11.4	6.6	1.5
Germany	2	39.6	7.9	24.5	16.0	10.9	5.6	3.4
USA	6	28.1	7.2	21.5	22.8	12.9	9.4	5.2
France	10	26.2	3.2	22.3	22.0	16.1	7.5	5.9
Singapore	19	14.3	1.5	14.0	39.2	11.1	4.2	17.2
Rep. of Korea	21	17.7	2.2	18.9	32.5	14.6	8.3	8.0
Malaysia	38	4.7	0.5	14.3	38.6	15.6	7.4	19.4
India	49	8.1	0.7	9.2	8.3	9.4	30.4	34.7
China	50	5.7	0.5	13.9	20.7	19.5	15.6	24.5
Thailand	59	6.8	0.5	9.1	31.3	16.2	11.5	25.1
Philippines	74	3.3	0.3	7.3	49.2	20.5	6.4	13.4
Indonesia	76	3.1	0.4	5.3	12.9	15.2	14.4	49.1
Viet Nam	98	1.8	0.2	3.0	4.2	7.3	14.2	69.6
Pakistan	101	0.7	0.1	2.2	2.2	3.5	11.9	79.6

Note: 1 is the most complex and 6 the least. Top 100 refers to the top most complex products. Rank is the ranking of the country (in a total of 124 countries) according to the measure of country complexity (as shown in Appendix C). Appendix C shows the distribution across the six categories for all the countries.
Source: Authors' estimates.

with income per capita. Each country's export share of each tercile is plotted against income per capita. The data shows that poorer countries have higher export shares than richer countries of the least complex products (panel A), and that richer countries have higher export shares than poorer countries of the most complex products (panel C). Finally, export shares of the midlevel complex products increase with income per capita up to about $25,671, and then decrease (panel B).[14]

Finally, Table 6 shows the export shares of different complexity levels in each country's total exports for a group of Asian and developed countries. The export structures of the most complex economies—Japan, Germany, the United States, and France—contain high shares of highly complex products (levels 1 and 2), reaching almost two-thirds of total exports in the case of Germany. Singapore and Korea also produce highly complex products, but the shares of levels 1 and 2 are lower (28% for Singapore and 37% for Korea). Although more than one-fourth of Singapore's and Korea's exports are already complex products, the bulk of their exports are still of mid-level complexity (levels 3 and 4). As the classification gets thinner, it becomes obvious that the most complex products are exported by the most advanced countries. For example, the top 100 most complex products represent at least 7% of the exports of Japan, Germany, and the United States, but only 1.5% for Singapore and 2.2% for Korea.

This analysis corroborates the findings of Hobday et al. (2004), who using the case-study methodology (interviews) concluded that South Korea is still far from the technological frontier. They argued that, while it is true that some Korean companies have made very important advances in some areas in electronics, they are not manufacturing and exporting the most advanced products. Appendix C shows that Korea ranks number 21 in complexity. This is certainly high for world standards, but it lags behind most of the advanced countries. As Table 5 shows, among the Asian counties (other than Japan), the most complex economy is Singapore, ranked 19th, followed by Korea, 21st. Malaysia is ranked 38th, India, 49th, and China, 50th. Fig. 3 showed that the export baskets of the most complex countries have high shares of complex products, and this finding was generalized through the results shown in Table 4.

4. The *method of reflections* and other measures of technological capability: a comparison

A number of cross-country indexes of technological capability have been developed in the recent past. Notable among them are the ones provided by Archibugi and Coco, 2004 and Desai et al. (2002), released as UNDP's Technological Achievement Index (TAI), Lall and Albaladejo (2002) for UNIDO, Wagner et al. (2001), and the OECD's high-tech product classification (Hatzichronoglou, 1997). Archibugi and Coco (2005) provide an excellent overview of the various indexes. Table 7 provides a summary of the main differences between the approaches followed in these papers and that in this paper.

Table 8 shows the rank correlations between our economic (country) complexity ranking and those in other studies discussed in Table 7. The rank correlation is computed only for the set of overlapping countries. The results indicate that the rank correlation is very high, 0.83 and above.

Following the convention in the literature, a country is considered to have revealed comparative advantage in a product if the Balassa (1965) index of RCA is greater than or equal to 1. To check if the two measures of complexity (i.e., product and country) are sensitive to this cut-off, we recalculate them by using four different cut-offs to decide

[14] We also divided each HS group into terciles and found that: (i) in the bottom tercile, export shares decrease with GDP per capita for metals and for the less complex HS groups, from stone/glass to footwear/headgear; (ii) in the middle tercile, export shares increase with GDP per capita up to a point and then decline for machinery/electrical, plastics/rubbers, metals, and wood products; and (iii) in the top tercile, export shares increase with GDP per capita for raw hides, etc., wood products, and the most complex HS groups, from chemicals to miscellaneous products.

Table 7
Literature on cross-country technological capabilities: a summary.

Other related work	What do the other papers do?	This paper
- Archibugi and Coco (2004)	1. All these indexes are constructed as a combination of various components, e.g., some measure of patents granted, research and development spending, scientific publications, and physical and social infrastructure, etc.	1. The measure of complexity developed by Hidalgo and Hausmann (2009) used in this paper relies on the bipartite network of products and countries to rank countries and products in terms of their capabilities. The measure of complexity relies on whether a country displays RCA $\geq$ 1 in a particular product or not.
- Desai et al. (2002)	2. The various components are aggregated on the basis of some weighting scheme. This differs across the various papers.	2. The measure of complexity used in our paper does not entail any aggregation through weights.
- Lall and Albaladejo (2002)	3. These studies differ in the use of manufacturing value-added and/or trade data. For example, Desai et al. (2002) and Lall and Albaladejo (2002) use the share of medium and high technology exports in total exports as one of the components. Lall and Albaladejo (2002) also use manufactured value added per capita, medium and high technology share in manufactured value added, and manufactured exports per capita. Archibugi and Coco (2004) and Wagner et al. (2001) do not use any of these indicators.	3. Archibugi and Coco (2005) acknowledge that trade data is highly accurate. We go a step further and argue that trade data: (i) is comparable across countries (as opposed to, for example, human resources, where even though data on tertiary enrolment is available, issues related to quality of education remain); (ii) is available for a large number of countries at a fairly disaggregated level (we use data at the HS-6 level for over 5000 products); and (iii) is readily available (though with some lag). Trade data is easily available and readily comparable which makes it a very good candidate in constructing indicators of product and country complexity.
- Wagner et al. (2001).	Archibugi and Coco (2005) argue that Archibugi and Coco (2004) do not include trade-based indicators because all the other components of their index take into account the size of the economy (measured by population).	Moreover, the construction of the measures of complexity uses only two values: (i) the number of products exported with RCA $\geq$ 1, and not the actual export values; and (ii) the number of countries exporting a particular product with RCA $\geq$ 1. The use of the actual export value is restricted to the calculation of RCA. Hidalgo and Hausmann (2009) show that the higher order measures of diversification that the method of reflection generates are independent of a country's population. Although diversification (i.e., the number of products a country exports with RCA $\geq$ 1) depends on a country's population, the relationship between both variables is not linear.[17]

Source: Authors.

whether a product is exported with RCA by country. We use 0.75, 0.9, 1.1, and 1.25 as the alternative cut-offs for RCA. Table 9 shows the rank correlations of product and country complexity of the four alternative cut-offs of RCA with the baseline measures of product and country complexity calculated using RCA cut-off of 1. All correlations are very high. The rank correlation of country complexity based on different cut-off values for RCA is positive and very high, in general above 0.998. The rank correlation of product complexity based on the different cut-off values for RCA is a bit lower than the one for countries, but it is still positive and above 0.87.

We have also recalculated product and economic complexity without deflating the prices of aluminum, copper, gold, and petroleum. We find that the rank correlations between country and product complexity based on the unadjusted prices and that of our baseline measure (which uses adjusted prices) are very high, 0.999 and 0.895, respectively. The baseline measures of product and country complexity used in this paper are the average the complexities for 2001–2007. To be sure that our country and product rankings are not sensitive to the time period chosen for averaging, we average product and country complexity for

Table 8
Rank correlation between ranking obtained in this paper (economic complexity) and in other studies.

	Rank correlation	Number of common countries
Technology achievement index—Desai et al. (2002)	0.9141	69
Technology effort index—Lall and Albaladejo (2002)	0.9222	82
Industrial performance index—Lall and Albaladejo (2002)	0.9064	82
Combined index (above two rows)—Lall and Albaladejo (2002)	0.9087	82
Indicator of technological capabilities—Archibugi and Coco (2004)	0.8578	122
Index of science and technology capacity—Wagner et al. (2001)	0.8360	124

Note: In each case, the rank correlation is computed only for the countries common to both this paper and the study indicated in column 1. The number of countries is shown in column 3. *Source*: Authors' estimates.

Table 9
Rank correlation of the baseline measures of product and country complexity with alternative rankings based on different cut-off values.

Rank correlation	Country complexity	Product complexity
RCA cut-off = 0.75	0.9984	0.8768
RCA cut-off = 0.9	0.9993	0.8831
RCA cut-off = 1.1	0.9996	0.8884
RCA cut-off = 1.25	0.9992	0.8897

Source: Authors' estimates.

Table 10A
Rank correlations of product complexity for different periods.

	2001–2007	2001–2003	2001–2005	2003–2005	2003–2007
2001–2007	1.0000				
2001–2003	0.9882	1.0000			
2001–2005	0.9972	0.9931	1.0000		
2003–2005	0.9915	0.9753	0.9925	1.0000	
2003–2007	0.9954	0.9721	0.9889	0.9943	1.0000

Source: Authors' estimates.

Table 10B
Rank correlations of country complexity for different periods.

	2001–2007	2001–2003	2001–2005	2003–2005	2003–2007
2001–2007	1.0000				
2001–2003	0.9942	1.0000			
2001–2005	0.9983	0.9975	1.0000		
2003–2005	0.9979	0.9902	0.9966	1.0000	
2003–2007	0.9977	0.9867	0.9938	0.9981	1.0000

Source: Authors' estimates.

different time periods and calculate the rank correlation. Tables 10A and 10B show that the rank correlations for both country and product complexity are very high (0.975 and above). We can therefore be confident that the country and product rankings are not sensitive to the period chosen for the baseline measures of complexity.

Finally, in another strand of the complexity literature, Hobday (1998) and Hobday et al. (2000) developed the concept of complex products and systems (CoPS). CoPS are defined as "high cost, technology-intensive customized, capital goods, systems, networks, control units, software packages, constructs and services" (Hobday et al., 2000: 793–794). Examples of CoPS include aircraft engines, air-traffic control systems, chemical plants, helicopters, and rail transit systems (Hobday [1998: Table 1] provides a list of almost 100 products). Complexity here reflects "the number of customized components, the breadth of knowledge and skills required, and the degree of new knowledge involved in production" (Hobday, 1998: 690). CoPS are "a subset of capital goods: the high technology capital goods which underpin the provision of services and manufacturing—the 'technological backbone' of the modern economy" (Hobday et al., 2000: 794). They are often produced under imperfectly competitive market structures.

This notion of complexity, while not the same as that of Hidalgo and Hausmann (2009), is not entirely unrelated. Obviously, "the number of customized components, the breadth of knowledge and skills required, and the degree of new knowledge involved in production" are part of the capability set required to produce/export a product. However, while Hobday's definition of complexity is intuitive and the candidate examples of CoPS are certainly informative and *make sense*, it poses some empirical problems. First, while Hobday defines *a priori* the products that are complex based on how they seem to fit his definition, Hidalgo and Hausmann (2009) determine empirically whether a product is complex or not. Moreover, many of the products that Hobday defines as complex are not traded in standard markets and hence, they are not shown in the statistics, especially the trade statistics (e.g., space stations). Also, take a product like a dam. A dam is the result of assembling millions of products and components that result in such a gigantic structure. But many of these products and components are certainly *not* complex, e.g., bricks and mortar. What makes a dam a complex structure is that it needs some very special materials, its cost, and the very specialized knowledge to put it all together so that it retains millions of gallons of water and releases it whenever required (see the definition of capabilities in the Introduction). An additional problem is that it is very difficult to come up with empirical measures of the pieces (e.g., breadth of knowledge) that identify what a complex product is.[15]

Despite these potential problems, Acha et al. (2004) developed a method to classify CoPS based on the UK Standard Industrial Classification (SIC) data and on the UK Annual Business Inquiry. The first set of criteria used to determine whether a product qualifies as CoPS is its three main features: high unit costs, low volume, and high degree of customization of components. The second set of criteria to further refine the selection is the number of components, variety of design options, diversity of scientific and technical skills and knowledge, and intensive role of user in design. Out of the 504 UK manufacturing, construction, and service industries, Acha et al. (2004) identified 29 industries that are consistent with the concept of CoPS. These industries, with their corresponding groups in the Harmonized System (HS), are listed in Table 11.[16]

To what extent does the method of reflections capture the concept of CoPS as conceptualized by Hobday (1998)

[15] Also, Hobday (1998: 692) indicates that some high-cost, mature products, such as roadworks and simple building constructs, are not considered complex because they involve a narrow range of knowledge and skills and utilize mostly standard components and materials. This might not be the case under the definition of Hidalgo and Hausmann (2009).

[16] We use the concordance between NACE Rev. 1 (on which UK SIC is based) and ISIC Rev. 3 (http://www.macalester.edu/research/economics/page/haveman/trade.resources/tradeconcordances.html), and the concordance between ISIC Rev. 3 and HS 1996 (World Integrated Trade Solution, http://wits.worldbank.org/witsweb/). The last three industries in Table 7 (4521, 4523, and 4524) do not have corresponding codes in the HS system.

[17] Available at: http://www.chidalgo.com/Papers/HidalgoHausmann_PNAS_2009_PaperAndSM.pdf.

Table 11
CoPS industries.

SIC	Description	HS Group
2821	Manufacture of tanks reservoirs of metal	Metals
2830	Manufacture of steam generators	Machinery/Electrical
2911	Manufacture of engines and turbines	Machinery/Electrical
2912	Manufacture of pumps and compressors	Machinery/Electrical
2921	Manufacture of furnaces and furnace burners	Machinery/Electrical
2922	Manufacture of lifting and handling equip	Machinery/Electrical; Transportation
2923	Manufacture of commercial cooling and vent	Machinery/Electrical
2924	Manufacture of general purpose machinery	Machinery/Electrical
2932	Manufacture of other agricultural and forestry	Machinery/Electrical; Transportation
2940	Manufacture of machine tools	Machinery/Electrical
2951	Manufacture of machinery for metallurgy	Machinery/Electrical
2952	Manufacture of machinery for mining	Machinery/Electrical; Transportation
2953	Manufacture of machinery for food drink	Machinery/Electrical
2954	Manufacture of machinery for textiles	Machinery/Electrical
2955	Manufacture of machinery for paper	Machinery/Electrical
2956	Manufacture of special purpose machinery	Machinery/Electrical
2960	Manufacture of weapons and ammunition	Miscellaneous; Transportation
3162	Manufacture of other electrical equipment	Machinery/Electrical
3220	Manufacture of radio television communications	Machinery/Electrical
3310	Manufacture of medical and surgical equip.	Machinery/Electrical; Miscellaneous
3320	Manufacture of electronic instruments	Machinery/Electrical; Miscellaneous
3330	Manufacture of industrial process control equip.	Miscellaneous
3340	Manufacture of optical and photographic equipment	Miscellaneous
3511	Building and repairing of ships	Transportation
3520	Manufacture of locomotive and rolling stock	Transportation
3530	Manufacture of aircraft and spacecraft	Machinery/Electrical; Transportation
4521	General construction and building	–
4523	Construction highways airfield	–
4524	Construction of water project	–

Source: Acha et al. (2004) and authors' estimates.

and Hobday et al. (2000) and the classification by Acha et al. (2004)? To answer this question, we identified the products in the HS 6-digit level list that correspond to CoPS industries. This resulted in 742 out of the 5107 (15%) products that matched the definition of CoPS. By HS group, these products are distributed as follows: 509 in machinery/electrical; 170 in miscellaneous; 57 in transportation; and 6 in metals (Table 12). Note that these HS groups, along with chemicals and plastics/rubbers, are those that have the highest average complexity (Fig. 1). In terms of complexity (divided into terciles), 490 are in the most complex product group; 222 in the middle one; and only 30 belong to the least complex group. These observations show conformity, albeit not perfect, between the concept of CoPS and the methods of reflections.

Moreover, the method of reflections can distinguish between more and less complex products within each CoPS industry. We show two examples in Tables 13 and 14. First, within "manufacture of weapons and ammunition" (SIC

Table 12
Distribution of CoPS by complexity and HS group.

	Complexity group			
	Bottom	Middle	Top	Total
Machinery/Electrical	16	145	348	509
Transportation	7	30	20	57
Metals	1	3	2	6
Miscellaneous	6	44	120	170
Total	30	222	490	742

Note: The figures correspond to the number of products at the HS 6-digit level. *Source*: Authors' estimates.

Table 13
Complexity levels of different types of weapons and ammunitions (SIC 2960).

HS code	Description	Complexity tercile
871000	Tanks and other armored fighting vehicles	Top
930330	Rifles, sporting, hunting or target-shooting, nes	Top
930400	Arms nes, (spring/air/gas guns, truncheons, etc.)	Top
930510	Parts and accessories of revolvers or pistols	Top
930521	Shotgun barrels	Top
930529	Parts and accessories of shotguns or rifles, nes	Top
930590	Parts and accessories nes of weapons, nes	Top
930690	Munitions of war, ammunition/projectiles and parts	Top
930100	Military weapons, other than hand guns, swords, etc.	Middle
930200	Revolvers and pistols	Middle
930310	Muzzle-loading firearms	Middle
930320	Shotguns, shotgun-rifles for sport, hunting, or target	Middle
930390	Signal pistols, etc., humane killers, etc.	Middle
930610	Cartridges for rivet etc. tools, humane killers, etc.	Middle
930621	Cartridges, shotgun	Middle
930629	Air gun pellets, parts of shotgun cartridges	Middle
930630	Cartridges nes, parts thereof	Middle

Source: Authors' estimates. *Note*: 'nes' – not elsewhere specified.

Table 14
Complexity levels of different types of building and repairing of ships (SIC 3511).

HS code	Description	Complexity tercile
890110	Cruise ships, excursion boats, ferry boats	Middle
890120	Tankers	Middle
890130	Refrigerated vessels other than tankers	Middle
890520	Floating, submersible drilling or production platforms	Middle
890600	Warships, lifeboats, hospital ships, vessels nes	Middle
890790	Buoys, beacons, coffer-dams, pontoons, floats nes	Middle
890190	Cargo vessels other than tanker or refrigerated	Bottom
890200	Fishing vessels and factory ships	Bottom
890400	Tugs and pusher craft	Bottom
890510	Dredgers	Bottom
890590	Floating docks, special function vessels nes	Bottom
890710	Inflatable rafts	Bottom

Source: Authors' estimates. *Note*: 'nes' – not elsewhere specified.

2960), the method of reflections places "tanks and other armored fighting vehicles" in the top tercile, and "air gun pellets, parts of shotgun cartridges" in the middle tercile. Second, within "building and repairing of ships" (SIC 3511), tankers, cruise ships, and warships are placed among the most complex products, while inflatable rafts and tugs and pusher crafts are placed among the least complex. This illustrates the ability of the method of reflections to discriminate between products that require more complex capabilities and those that require simpler capabilities.

Finally, Hatzichronoglou (1997) provides a list of 252 high-tech products using the HS-6 product categories. This classification uses the concept of technology intensity, measured by the technology specific to the sector (measured by the ratio of research and development expenditure to value added) and the technology embodied in the intermediate and capital goods used in the sector. We find that out of the 252 high-tech products, 131 belong to the top tercile of complexity, 112 to the middle, and 9 to the bottom tercile. This means that out of the 1700 products in the top tercile of the complexity distribution, there are as many as 1569 products considered as "non high-tech" according to the classification used by Hatzichronoglou (1997). This could be due to the criterion used to classify a product as high-tech, namely research intensity.

5. Conclusions and policy implications

The classical literature on development argues that what differentiates countries, and what determines their fortunes, is their productive structure and the specific characteristics of the products that they export. These, in turn, depend on the capabilities that the firms possess. Development is a process of generating new activities and letting others disappear. The primary driver of growth is the gradual build-up in firms' capabilities.

Using Hidalgo and Hausmann's (2009) method of reflections and definitions of complexity, we have ranked 5107 products and 124 countries. Product complexity refers to the ubiquity of a product, that is, the number of countries that export the product with RCA, while country complexity is the degree of diversification of the export basket, that is, the number of products that a country exports with RCA. The most complex products are in machinery, chemicals, and metals, while the least complex products are raw materials and commodities, wood, textiles, and agricultural products. The most complex economies in the world are Japan, Germany, and Sweden, and the least complex Cambodia, Papua New Guinea, and Nigeria

We find that export shares of products of different complexity (in the country's total exports) vary with income per capita: export shares of the most complex products increase with income, while the export share of the less complex products decrease with income. Also, the sensitivity of export shares to income per capita increases the farther the complexity level of the product is from the average level of complexity.

We also find a high degree of concordance between the products considered as CoPS by Hobday (1998), Hobday et al. (2000), and Acha et al. (2004) and the measure of product complexity used in this paper. We have also shown that the method of reflections can distinguish between products that require more complex capabilities and products that require simpler capabilities within the same CoPS industry. And there is also a high degree of correlations between our ranking of country complexity and that provided by the so-called indexes of technological capability

The significance of the complexity of the productive structure of an economy for development suggests the need to implement policies that foster the accumulation of capabilities and promote the development of new more complex products, i.e., diversify. A more complex productive structure enables countries to engage in high-productivity activities that lead to faster development. Policymakers need to understand that not all products carry the same consequences for development, and that the efforts to produce and export more complex products pay off. Once a country is able to establish a foothold in a product, Hwang (2006) shows that there is rapid unconditional convergence in unit values (a proxy for quality) across countries. The problem that poor countries face is that the range of products that they produce is very limited and the goods that they produce see limited convergence.

The accumulation of capabilities, especially in developing (or the less complex economies) countries, is often hindered by information and coordination externalities that may lead to market failures and inadequate action by the private sector. This problem has no easy solution. Countries with high shares of simple capabilities need to implement policies that range from competitiveness and soft parsimonious industrial policy to aggressive policies that lead to the rapid accumulation of relevant capabilities; as well as strategic bets with significant government intervention. Historically, it has been impossible to become a rich country without creating an industrial and an advanced service sector. And likewise, historically, no country has become rich without explicit government interventions that amount to industrial policy in different shapes and forms.

Appendix A. List of 100 most complex products

Rank	HS 6-digit level description	HS 2-digit level description
1	Other cyclic hydrocarbons: cumene	Organic chemicals
2	Metalworking machine-tools/ultrasonic machine-tools: for dry-etching patterns on semiconductor materials	Nuclear reactors, boilers, machinery, etc.
3	Particle accelerators, and parts thereof, nes: ion implanters for doping semiconductor materials	Electrical, electronic equipment
4	Methacrylic acid, salts	Organic chemicals
5	Carbide tool tips, etc.: tool plates/tips/etc., sintered metal carbide and cermets	Tools, implements, cutlery, etc. of base metal
6	Photo, cine laboratories equipment, nes; screens for projectors: direct write-on-wafer apparatus	Optical, photo, technical, medical, etc. apparatus
7	Other inorganic esters: hexamethylenediamine, its salts	Organic chemicals
8	Other electronic measuring, controlling, etc., apparatus: instruments nes using optical radiations (UV, visible, IR)	Optical, photo, technical, medical, etc. apparatus
9	Other machinery, mechanical appliances having individual functions: laser, light, and photon beam process machine tools	Nuclear reactors, boilers, machinery, etc.
10	Sheet, plates, rolled of thickness 4.75 mm plus, of iron or steel or other alloy steel: cold rolled alloy-steel nes nfw, <600 mm wide	Iron and steel
11	Apparatus for the projection or drawing of circuit patterns on sensitized semiconductor materials: step and repeat aligners	Optical, photo, technical, medical, etc. apparatus
12	Acetic acid and its salts; acetic anhydride: isobutyl acetate	Organic chemicals
13	Acyclic polyamines and their derivatives; salts thereof: ethylenediamine, its salts	Organic chemicals
14	Motorcycles, spark ignition engine of >800 cc	Vehicles other than railway, tramway
15	Cellulose ethers nes, in primary forms	Plastics and articles thereof
16	Apparatus based on the use of X-rays, including radiography or radiotherapy apparatus: computed tomography apparatus	Optical, photo, technical, medical, etc. apparatus
17	Phenols; polyphenols: resorcinol, salts	Organic chemicals
18	Flat-rolled products of other alloy steel, of a width of 600 mm or more: electrolytically plated or coated with zinc	Iron and steel
19	Other metal cutting or surfacing machine-tools: numerically controlled grinding machines nes, in which the positioning in any one axis can be set up to an accuracy of at least 0.01 mm	Nuclear reactors, boilers, machinery, etc.
20	Metalworking machine-tools/ultrasonic machine-tools: others	Nuclear reactors, boilers, machinery, etc.
21	Nickel plates, sheets, strip and foil: of nickel alloys	Nickel and articles thereof
22	Instruments and appliances used in medical, surgical, dental or veterinary sciences: electro-diagnostic apparatus–magnetic resonance imaging apparatus	Optical, photo, technical, medical, etc. apparatus
23	Microscopes other than optical microscopes; diffraction apparatus	Optical, photo, technical, medical, etc. apparatus
24	Apparatus based on the use of X-rays for medical, surgical or veterinary uses	Optical, photo, technical, medical, etc. apparatus
25	Reaction initiators, reaction accelerators and catalytic preparations, except nickel or precious metal	Miscellaneous chemical products
26	Paper and paperboard of which more than 10% by weight of the total fiber content consists of fibers obtained by a mechanical process: light weight coated paper	Paper and paperboard, articles of pulp, paper and board
27	Other hormones and their derivatives; other steroids used primarily as hormones: insulin, salts, in bulk	Organic chemicals
28	Other optical instruments and appliances for inspecting semiconductor wafers or devices/photomasks or reticles used in manufacturing semiconductor devices	Optical, photo, technical, medical, etc. apparatus
29	Silicones in primary forms	Plastics and articles thereof
30	Machines for manufacturing or hot working glass or glassware	Nuclear reactors, boilers, machinery, etc.
31	Self-adhesive plates, sheets, film, foil, tape, strip, and other flat shapes, of plastics in rolls exceeding 20 cm	Plastics and articles thereof

Rank	HS 6-digit level description	HS 2-digit level description
32	Apparatus based on the use of X-rays for dental uses	Optical, photo, technical, medical, etc. apparatus
33	Furnace burners for liquid fuel	Nuclear reactors, boilers, machinery, etc.
34	Parts and accessories for nonoptical microscopes, etc.	Optical, photo, technical, medical, etc. apparatus
35	Polymers of vinyl chloride or of other halogenated olefins: fluoro-polymers nes in primary forms	Plastics and articles thereof
36	Polyvinyl alcohol, whether or not containing unhydrolyzed acetate groups	Plastics and articles thereof
37	Artif staple fibers, except rayon, not carded or combed	Manmade staple fibers
38	Acetic acid and its salts: acetic anhydride	Organic chemicals
39	Antisera and other blood fractions and modified immunological products, whether or not obtained by means of biotechnological processes	Pharmaceutical products
40	Industrial robots, not elsewhere specified or included	Nuclear reactors, boilers, machinery, etc.
41	Taps, cocks, valves, and similar appliances for pipes, boiler shells, tanks, vats, or the like: valves for oleohydraulic or pneumatic transmissions	Nuclear reactors, boilers, machinery, etc.
42	Synthetic rubber and factice derived from oils: ethylene–propylene–non-conj diene rubber (EPDM)	Rubber and articles thereof
43	Tubes and pipes of nickel alloy	Nickel and articles thereof
44	Acyclic alcohols: other polyhydric alcohols – trimethylolpropane	Organic chemicals
45	Parts of pumps for liquids	Nuclear reactors, boilers, machinery, etc.
46	Butyl rubber (IIR): halo-isobutene–isoprene rubber (CIIR/BIIR)	Rubber and articles thereof
47	Composite diagnostic or laboratory reagents, nes	Miscellaneous chemical products
48	Pacemakers for stimulating heart muscles	Optical, photo, technical, medical, etc. apparatus
49	Flat-rolled products of other alloy steel, of a width of 600 mm or more: otherwise plated or coated with zinc	Iron and steel
50	Lubricating preparations, zero petroleum content, nes	Soaps, lubricants, waxes, candles, modeling pastes
51	Acyclic polyamines nes, their derivatives and salts	Organic chemicals
52	Self-propelled railway cars powered from an external electric power	Railway, tramway locomotives, rolling stock, equipment
53	Phenols; phenol–alcohols: monophenols nes	Organic chemicals
54	Clutches and shaft couplings including universal joints	Nuclear reactors, boilers, machinery, etc.
55	Fuel elements nonirradiated, for nuclear reactors	Nuclear reactors, boilers, machinery, etc.
56	Apparatus for the projection or drawing of circuit patterns on sensitized semiconductor materials: others	Optical, photo, technical, medical, etc. apparatus
57	Ceramic wares for laboratory, chemical, or other technical uses except for porcelain	Ceramic products

Rank	HS 6-digit level description	HS 2-digit level description
58	Epoxides, epoxyalcohols, epoxyphenols, and epoxyethers, with a three-membered ring: 1-chloro-2,3-epoxypropane (epichlorohy-drin)	Organic chemicals
59	Automobiles, spark ignition engine of cylinder capacity exceeding 3000 cm^3	Vehicles other than railway, tramway
60	Acrylic polymers nes, in primary forms	Plastics and articles thereof
61	Ultra-violet or infrared lamps; arc-lamps	Electrical, electronic equipment
62	Photo plates and film in the flat, nes, any side >255 mm	Photographic or cinematographic goods
63	Bars, rods, and profiles of nickel alloy	Nickel and articles thereof
64	Machinery parts, nonelectrical, nes: mechanical seals	Nuclear reactors, boilers, machinery, etc.
65	Parts and accessories for radiation apparatus	Optical, photo, technical, medical, etc. apparatus
66	Parts of machines and mechanical appliances nes	Nuclear reactors, boilers, machinery, etc.
67	Gearing, ball screws, speed changers, torque converter	Nuclear reactors, boilers, machinery, etc.
68	Chemical preparations for photographic uses, nes	Photographic or cinematographic goods
69	Printing ink, other than black	Tanning, dyeing extracts, tannins, derives, pigments, etc.
70	Parts of nuclear reactors	Nuclear reactors, boilers, machinery, etc.
71	Textile fabric used in papermaking etc., >650 g/m^2	Impregnated, coated, or laminated textile fabric
72	Polyhydric acyclic alcohols nes	Organic chemicals
73	Engines, spark-ignition reciprocating, over 1000 cc	Nuclear reactors, boilers, machinery, etc.
74	Chemical preparations for photographic uses: sensitizing emulsions	Photographic or cinematographic goods
75	Flat-rolled products of other alloy steel, not further worked, of a width of less than 600 mm	Iron and steel
76	Wire of nickel, not alloyed	Nickel and articles thereof
77	Pneumatic power engines/motors, linear acting	Nuclear reactors, boilers, machinery, etc.
78	Mineral heat or sound insulating materials and articles	Stone, plaster, cement, asbestos, mica, etc. articles
79	Glass tubes, unworked	Glass and glassware
80	Textile flock, dust, or mill neps	Wadding, felt, nonwovens, yarns, twine, cordage, etc.
81	Molybdenum profile/sheet/strip etc. not simply sintered	Other base metals, cermets, articles thereof
82	Heterocyclic compounds containing a benzothiazole ring	Organic chemicals
83	Lubricating oil etc. containing <70% petroleum oil nes	Soaps, lubricants, waxes, candles, modeling pastes
84	Swine hams, shoulders and cuts bone in, fresh or chilled	Meat and edible meat offal
85	Reciprocating positive displacement pumps nes	Nuclear reactors, boilers, machinery, etc.
86	Wire, copper–nickel, or copper–nickel–zinc base alloy	Copper and articles thereof
87	Paper >150 g/m^2, bleached, plastic coated/impregnated	Paper and paperboard, articles of pulp, paper, and board
88	Machines and mechanical appliances nes	Nuclear reactors, boilers, machinery, etc.
89	Hot rolled alloy–steel, coils width >600 mm, nes	Iron and steel
90	Hydantoin, derivatives	Organic chemicals
91	Spectrometers, spectrophotometers, etc. using light	Optical, photo, technical, medical, etc. apparatus
92	Spacecraft (including satellites) and suborbital and spacecraft launch vehicles	Aircraft, spacecraft, and parts thereof
93	Grinding/polishing machines for stone, ceramics, glass	Nuclear reactors, boilers, machinery, etc.
94	Nonionic surface active agents	Soaps, lubricants, waxes, candles, modeling pastes
95	Parts for filter/purifying machines for liquid/gas	Nuclear reactors, boilers, machinery, etc.
96	Formic acid, its salts, and esters: esters of formic acid	Organic chemicals
97	Vegetable alkaloids: nicotine, salts, in bulk	Organic chemicals
98	Television camera tubes and other photocathode tubes	Electrical, electronic equipment
99	Acyclic alcohols: diols except ethylene and propylene glycol	Organic chemicals
100	Unsaturated monohydric alcohols: acyclic terpene alcohols	Organic chemicals

Note: Ties between products are broken arbitrarily. For example, two products that are tied for rank 1 are ranked 1 and 2. Rank is the ranking of the product (in a total of 5107 products) according to its complexity. 1 is the most complex and 5107 is the least complex. 'nes' – not elsewhere specified. *Source*: Authors' estimates.

Appendix B. List of 100 least complex products

Rank	HS 6-digit level description	HS 2-digit level description
5107	Sawlogs and veneer logs, of non-coniferous species, in the rough: logs, tropical woods nes	Wood and articles of wood, wood charcoal
5106	Cashew nuts, in shell dried	Edible fruit, nuts, peel of citrus fruit, melons
5105	Manioc (cassava), fresh or dried	Edible vegetables and certain roots and tubers
5104	Technically specified natural rubber (TSNR)	Rubber and articles thereof
5103	Cocoa beans, whole or broken, raw or roasted	Cocoa and cocoa preparations
5102	Wood of nonconiferous, sawn lengthwise, sliced or peeled: lumber, tropical wood nes	Wood and articles of wood, wood charcoal
5101	Natural rubber in other forms	Rubber and articles thereof
5100	Copra	Oil seed, oleagic fruits, grain, seed, fruit, etc., nes
5099	Jute and other textile bast fibers, raw or retted	Vegetable textile fibers nes, paper yarn, woven fabric
5098	Wood of nonconiferous, sawn lengthwise, sliced or peeled: lumber, Virola, Mahogany	Wood and articles of wood, wood charcoal
5097	Cashew nuts, shelled	Edible fruit, nuts, peel of citrus fruit, melons
5096	Turmeric (curcuma)	Coffee, tea, mate, and spices
5095	Coconut or copra oil-cake and other solid residues	Residues, wastes of food industry, animal fodder
5094	Statuettes and other ornaments of wood	Wood and articles of wood, wood charcoal
5093	Woven fabric of jute/bast fibers, unbleached/bleached	Vegetable textile fibers nes, paper yarn, woven fabric
5092	Natural rubber in smoked sheets	Rubber and articles thereof
5091	Abaca fiber, raw	Vegetable textile fibers nes, paper yarn, woven fabric
5090	Men's, boy's shirts, of cotton, knit	Articles of apparel, accessories, knit or crochet
5089	Castor oil seeds	Oil seed, oleagic fruits, grain, seed, fruit, etc., nes
5088	Garments nes, of cotton, knit	Articles of apparel, accessories, knit or crochet
5087	Palm nut or kernel oil cake and other solid residues	Residues, wastes of food industry, animal fodder
5086	Palm nuts and kernels	Oil seed, oleagic fruits, grain, seed, fruit, etc., nes
5085	Cocoa shells, husks, skins and waste	Cocoa and cocoa preparations
5084	Coconut (copra) oil crude	Animal, vegetable fats and oils, cleavage products, etc.
5083	Cotton yarn >85% single combed >714d tex, not retail	Cotton
5082	Women's, girl's nightdress, pajamas, of cotton, not knit	Articles of apparel, accessories, not knit or crochet
5081	Vanilla beans	Coffee, tea, mate, and spices
5080	Coffee, not roasted, not decaffeinated	Coffee, tea, mate, and spices
5079	Basketwork, wickerwork products of vegetable material	Manufactures of plaiting material, basketwork, etc.
5078	Sacks and bags, packing, of jute or other bast fibers	Other made textile articles, sets, worn clothing etc.
5077	Sisal and agave, raw	Vegetable textile fibers nes, paper yarn, woven fabric
5076	Men's, boy's shirts, of manmade fibers, knit	Articles of apparel, accessories, knit or crochet
5075	Pullovers, cardigans, etc. of cotton, knit	Articles of apparel, accessories, knit or crochet
5074	Tuna, skipjack, bonito, prepared/preserved, not minced	Meat, fish and seafood food preparations nes
5073	Women's/girl's nightdress, pajama, manmade fiber, not knit	Articles of apparel, accessories, not knit or crochet
5072	Arrowroot, salep, etc. fresh or dried and sago pith	Edible vegetables and certain roots and tubers
5071	Logs, Meranti red	Wood and articles of wood, wood charcoal
5070	Women's, girl's overcoats, etc., of cotton, knit	Articles of apparel, accessories, knit or crochet
5069	Natural rubber latex, including prevulcanised	Rubber and articles thereof
5068	Babies garments, accessories of synthetic fibers, knit	Articles of apparel, accessories, knit or crochet
5067	Sesamum seeds	Oil seed, oleagic fruits, grain, seed, fruit, etc., nes
5066	Men's, boy's trousers, shorts, of synthetic fibers, knit	Articles of apparel, accessories, knit or crochet
5065	Babies garments, accessories of cotton, not knit	Articles of apparel, accessories, not knit or crochet
5064	Women's, girl's trousers and shorts, of cotton, knit	Articles of apparel, accessories, knit or crochet
5063	Shrimps and prawns, frozen	Fish, crustaceans, mollusks, aquatic invertebrates nes
5062	Manioc (cassava) starch	Milling products, malt, starches, inulin, wheat gluten
5061	Cobalt ores and concentrates	Ores, slag, and ash
5060	Plywood, outer ply	Wood and articles of wood, wood charcoal

Rank	HS 6-digit level description	HS 2-digit level description
5059	Babies garments, accessories of cotton, knit	Articles of apparel, accessories, knit or crochet
5058	Men's, boy's overcoats, etc., of cotton, knit	Articles of apparel, accessories, knit or crochet
5057	Women's, girl's blouses and shirts, of cotton, knit	Articles of apparel, accessories, knit or crochet
5056	Tea, black (fermented or partly) in packages >3 kg	Coffee, tea, mate and spices
5055	Men's, boy's swimwear, not knit	Articles of apparel, accessories, not knit or crochet
5054	Ginger	Coffee, tea, mate, and spices
5053	Tin ores and concentrates	Ores, slag, and ash
5052	Tea, green (unfermented) in packages >3 kg	Coffee, tea, mate, and spices
5051	Women's, girls skirt's, of cotton, knit	Articles of apparel, accessories, knit or crochet
5050	Men's, boy's trousers and shorts, of cotton, knit	Articles of apparel, accessories, knit or crochet
5049	Cotton, not carded or combed	Cotton
5048	Men's, boy's underpants or briefs, of cotton, not knit	Articles of apparel, accessories, not knit or crochet
5047	Mats, matting, and screens, vegetable plaiting material	Manufactures of plaiting material, basketwork, etc.
5046	Ornamental fish, live	Fish, crustaceans, mollusks, aquatic invertebrates nes
5045	Octopus, frozen, dried, salted, or in brine	Fish, crustaceans, mollusks, aquatic invertebrates nes
5044	Palm oil, crude	Animal, vegetable fats and oils, cleavage products, etc.
5043	Yarn of jute, textile bast fiber nes, multiple, cabled	Vegetable textile fibers nes, paper yarn, woven fabric
5042	Coconut (coir) fiber, raw	Vegetable textile fibers nes, paper yarn, woven fabric
5041	Pullovers, cardigans, etc. of material nes knit	Articles of apparel, accessories, knit or crochet
5040	T-shirts, singlets, and other vests, of cotton, knit	Articles of apparel, accessories, knit or crochet
5039	Gloves, mittens, and mitts, textile material, not knit	Articles of apparel, accessories, not knit or crochet
5038	Raw vegetable materials for dyeing or tanning	Vegetable plaiting materials, vegetable products nes
5037	Plastic apparel and clothing accessories	Plastics and articles thereof
5036	Gloves, mittens, or mitts, nes, of cotton, knit	Articles of apparel, accessories, knit or crochet
5035	Men's/boy's nightshirts, pajama, manmade fiber, not knit	Articles of apparel, accessories, not knit or crochet
5034	Men's, boy's underpants, briefs, material nes, not knit	Articles of apparel, accessories, not knit or crochet
5033	Men's, boy's shirts, of wool or hair, not knit	Articles of apparel, accessories, not knit or crochet
5032	Hats and other headgear, knit or crochet, nes	Headgear and parts thereof
5031	Skipjack, stripe-bellied bonito, frozen, whole	Fish, crustaceans, mollusks, aquatic invertebrates nes
5030	Raw sugar, cane	Sugars and sugar confectionery
5029	Dried fish, other than cod, not smoked	Fish, crustaceans, mollusks, aquatic invertebrates nes
5028	Men's, boy's shirts, of manmade fibers, not knit	Articles of apparel, accessories, not knit or crochet
5027	Women's, girl's trousers and shorts, of cotton, not knit	Articles of apparel, accessories, not knit or crochet
5026	Men's, boy's anoraks etc., of manmade fibers, not knit	Articles of apparel, accessories, not knit or crochet
5025	Festive, carnival, other entertainment articles, nes	Toys, games, sports requisites
5024	Rock lobster and other sea crawfish, frozen	Fish, crustaceans, mollusks, aquatic invertebrates nes
5023	Goat or kid skin leather, otherwise pretanned	Raw hides and skins (other than furskins) and leather
5022	Yarn of jute or textile bast fibers nes, single	Vegetable textile fibers nes, paper yarn, woven fabric
5021	Women's, girl's nightdress, pajamas, material nes, knit	Articles of apparel, accessories, knit or crochet
5020	Women's, girl's blouses and shirts, of cotton, not knit	Articles of apparel, accessories, not knit or crochet
5019	Lobsters (Homarus) frozen	Fish, crustaceans, mollusks, aquatic invertebrates nes
5018	Salmonidae, nes, frozen, whole	Fish, crustaceans, mollusks, aquatic invertebrates nes
5017	Pullovers, cardigans, etc. of manmade fibers, knit	Articles of apparel, accessories, knit or crochet
5016	Men's, boy's dressing gowns, etc. cotton, not knit	Articles of apparel, accessories, not knit or crochet
5015	Men's, boy's nightshirts or pajamas, cotton, not knit	Articles of apparel, accessories, not knit or crochet
5014	Pineapples, fresh or dried	Edible fruit, nuts, peel of citrus fruit, melons
5013	Ground-nuts shelled, not roasted or cooked	Oil seed, oleagic fruits, grain, seed, fruit, etc., nes
5012	Petroleum oils, oils from bituminous minerals, crude	Mineral fuels, oils, distillation products, etc.
5011	Footwear, rubber, plastic, straps fix to sole by plugs	Footwear, gaiters, and the like, parts thereof
5010	Tunas (yellowfin) frozen, whole	Fish, crustaceans, mollusks, aquatic invertebrates nes
5009	Plants and parts, pharmacy, perfume, insecticide use nes	Oil seed, oleagic fruits, grain, seed, fruit, etc., nes
5008	Palm kernel or babassu oil, crude	Animal, vegetable fats and oils, cleavage products, etc.

Note: Ties between products are broken arbitrarily. For example, two products that are tied for rank 1 are ranked 1 and 2. Rank is the ranking of the product (in a total of 5107 products) according to its complexity. 1 is the most complex and 5107 is the least complex. 'nes' – not elsewhere specified. *Source*: Authors' estimates.

Appendix C. Complexity ranking of the 124 countries and distribution of exports across six complexity categories

Country name (ISO code)	Rank	Product complexity level (1 – highest; 6 – lowest)						
		1	Top 100	2	3	4	5	6
Japan (JPN)	1	39.7	10.0	19.0	21.9	11.4	6.6	1.5
Germany (DEU)	2	39.6	7.9	24.5	16.0	10.9	5.6	3.4
Sweden (SWE)	3	34.6	4.9	27.7	16.2	12.0	4.6	4.8
Switzerland (CHE)	4	28.6	6.8	25.8	13.9	12.4	10.1	9.2
Finland (FIN)	5	30.1	6.1	32.0	15.2	13.1	4.5	5.1
USA (USA)	6	28.1	7.2	21.5	22.8	12.9	9.4	5.2
United Kingdom (GBR)	7	27.7	5.2	22.1	17.2	13.1	6.5	13.4
Austria (AUT)	8	30.4	6.2	23.3	19.0	15.0	8.8	3.5
Belgium (BEL)	9	27.8	3.8	20.3	15.5	11.3	12.1	13.0
France (FRA)	10	26.2	3.2	22.3	22.0	16.1	7.5	5.9
Ireland (IRL)	11	39.1	2.3	26.3	15.6	13.8	4.0	1.3
Netherlands (NLD)	12	20.2	4.8	19.7	19.6	12.1	13.1	15.3
Czech Rep. (CZE)	13	27.3	1.9	25.1	21.4	14.1	8.0	3.9
Canada (CAN)	14	27.8	12.3	13.8	18.7	15.0	12.8	12.0
Denmark (DNK)	15	26.1	4.6	22.1	15.7	13.0	11.1	11.9
Norway (SVN)	16	6.2	1.0	12.4	7.6	10.8	17.9	45.2
Slovenia (NOR)	17	19.5	1.1	27.4	22.1	18.0	8.7	4.3
Russian Federation (RUS)	18	6.5	0.9	7.0	9.9	12.3	22.7	41.6
Singapore (SGP)	19	14.3	1.5	14.0	39.2	11.1	4.2	17.2
Israel (ISR)	20	13.1	4.0	17.4	18.0	8.5	30.3	12.7
Rep. of Korea (KOR)	21	17.7	2.2	18.9	32.5	14.6	8.3	8.0
Slovakia (SVK)	22	23.3	4.8	21.4	20.0	15.9	8.4	11.1
Italy (ITA)	23	23.2	3.5	20.1	16.2	14.1	14.5	12.0
Hungary (HUN)	24	27.1	6.0	23.7	20.8	14.7	7.7	6.0
Ukraine (UKR)	25	7.7	1.2	12.8	19.9	27.2	22.9	9.4
Poland (POL)	26	16.1	1.2	17.3	22.6	20.7	15.4	8.0
Spain (ESP)	27	24.2	1.9	20.8	16.5	12.8	14.5	11.2
Mexico (MEX)	28	22.7	4.3	15.9	23.9	10.7	10.2	16.7
Belarus (BLR)	29	9.1	0.3	13.2	20.5	19.0	13.7	24.5
Brazil (BRA)	30	11.1	1.1	11.7	13.8	12.7	30.6	20.0
Georgia (GEO)	31	4.3	0.5	3.6	5.4	25.1	23.3	38.3
Saudi Arabia (SAU)	32	1.8	0.1	1.4	8.2	2.4	3.5	82.8
New Zealand (NZL)	33	5.6	0.6	8.6	22.8	24.6	28.0	10.5
Armenia (ARM)	34	5.5	0.2	7.2	19.3	18.1	33.7	16.2
Argentina (ARG)	35	7.1	0.5	5.4	9.9	12.5	42.7	22.4
South Africa (ZAF)	36	17.4	1.3	15.8	10.0	17.6	18.7	20.6
Croatia (HRV)	37	6.4	0.5	11.3	15.9	22.7	21.3	22.4
Malaysia (MYS)	38	4.7	0.5	14.3	38.6	15.6	7.4	19.4
Sierra Leone (SLE)	39	4.2	0.2	9.1	15.3	6.9	7.4	57.2
Australia (AUS)	40	6.2	1.8	7.2	8.0	24.7	29.7	24.1
Latvia (LVA)	41	4.7	0.5	7.5	15.5	18.9	17.4	36.1
Kazakhstan (KAZ)	42	1.4	0.1	2.6	7.3	18.0	12.9	57.8
Venezuela (VEN)	43	1.1	0.2	1.5	3.3	7.2	6.9	79.9
Lithuania (LTU)	44	4.8	0.6	7.2	17.7	18.0	18.2	34.0
Bosnia and Herzegovina (BIH)	45	7.2	0.3	8.5	11.4	28.5	27.5	16.9
Chile (CHL)	46	4.6	0.1	3.8	9.7	15.7	23.4	42.8
Bulgaria (BGR)	47	5.3	0.6	10.7	13.4	20.8	19.6	30.1
Romania (ROM)	48	7.2	0.6	10.5	13.6	15.1	20.3	33.3
India (IND)	49	8.1	0.7	9.2	8.3	9.4	30.4	34.7
China (CHN)	50	5.7	0.5	13.9	20.7	19.5	15.6	24.5
Greece (GRC)	51	3.8	0.4	14.8	12.5	17.2	18.6	33.1
Portugal (PRT)	52	15.3	0.4	9.8	22.1	15.6	15.5	21.7
Uruguay (URY)	53	5.1	0.5	7.4	9.6	16.9	38.0	23.1
Azerbaijan (AZE)	54	1.0	0.1	1.2	2.4	5.8	6.8	82.7
Lebanon (LBN)	55	3.0	0.4	5.5	9.1	19.8	38.5	24.0
Hong Kong, China (HKG)	56	6.6	1.3	10.4	23.4	16.8	17.9	24.9
Jordan (JOR)	57	3.7	0.6	7.5	14.8	13.6	24.6	35.8
Colombia (COL)	58	2.8	0.3	6.3	6.7	21.9	14.1	48.2
Thailand (THA)	59	6.8	0.5	9.1	31.3	16.2	11.5	25.1
Turkey (TUR)	60	8.6	0.6	9.8	15.8	14.4	19.5	31.9
Kyrgyzstan (KGZ)	61	2.3	0.2	2.6	8.3	12.9	16.6	57.1
Costa Rica (CRI)	62	1.3	0.2	8.6	41.8	7.8	7.1	33.4
Algeria (DZA)	63	0.1	0.0	0.4	0.6	1.0	17.9	79.9
TFYR of Macedonia (MKD)	64	1.7	0.1	10.8	11.1	24.3	15.9	36.2
Iran (IRN)	65	0.6	0.0	1.5	3.0	3.2	6.2	85.4
Senegal (SEN)	66	2.2	0.2	4.4	3.6	18.1	14.4	57.2
Libya (LBY)	67	0.0	0.0	0.5	1.3	1.3	2.7	94.1
Central African Rep. (CAF)	68	0.5	0.0	1.6	1.2	1.4	3.0	92.2

Country name (ISO code)	Rank	Product complexity level (1 – highest; 6 – lowest)						
		1	Top 100	2	3	4	5	6
Rep. of Moldova (MDA)	69	2.4	0.2	5.3	5.3	31.0	31.3	24.7
Niger (NER)	70	2.8	1.7	2.6	28.2	2.4	12.2	51.7
Uzbekistan (UZB)	71	1.1	0.0	8.9	7.5	5.1	18.1	59.2
Egypt (BDI)	72	1.7	0.1	3.4	6.6	15.3	15.8	57.3
Burundi (EGY)	73	3.2	0.2	5.0	4.0	8.1	5.2	74.6
Philippines (PHL)	74	3.3	0.3	7.3	49.2	20.5	6.4	13.4
Panama (PAN)	75	2.3	0.3	8.1	7.1	17.7	23.9	40.8
Indonesia (IDN)	76	3.1	0.4	5.3	12.9	15.2	14.4	49.1
Tunisia (TUN)	77	2.9	0.2	5.4	8.4	10.4	22.2	50.8
Jamaica (JAM)	78	0.9	0.1	1.3	1.8	3.9	59.4	32.8
Kenya (KEN)	79	1.3	0.2	2.7	3.3	7.4	11.0	74.4
Guatemala (GTM)	80	0.8	0.1	2.9	2.4	8.7	14.6	70.5
Peru (PER)	81	0.5	0.1	1.5	2.1	12.5	22.9	60.5
Albania (ALB)	82	2.5	0.2	3.8	5.1	8.9	31.0	48.8
Dominican Rep. (DOM)	83	1.9	0.1	11.0	7.7	13.6	18.1	47.6
Uganda (UGA)	84	0.9	0.1	3.4	1.9	4.6	10.0	79.1
El Salvador (SLV)	85	1.0	0.1	3.6	6.7	10.5	13.8	64.5
Zambia (ZMB)	86	0.6	0.0	3.4	0.8	25.7	12.4	57.1
Rwanda (RWA)	87	0.9	0.1	1.6	2.0	2.1	2.7	90.8
Burkina Faso (BFA)	88	0.6	0.1	1.0	1.3	2.1	6.5	88.5
Nepal (NPL)	89	1.5	0.7	3.2	7.3	10.5	22.9	54.6
Mali (MLI)	90	0.7	0.1	1.3	2.0	2.7	7.0	86.3
Bolivia (BOL)	91	0.6	0.1	0.8	1.3	2.8	60.4	34.1
Tajikistan (TJK)	92	0.4	0.0	0.6	2.8	3.4	56.3	36.5
Paraguay (PRY)	93	0.2	0.0	1.2	1.0	13.2	69.0	15.4
Ecuador (ECU)	94	1.2	0.1	1.2	2.2	2.9	6.8	85.8
Togo (TGO)	95	1.0	0.1	5.0	3.4	4.6	12.1	74.0
Chad (TCD)	96	0.2	0.0	0.3	2.1	0.5	0.3	96.6
Syria (SYR)	97	0.8	0.1	1.4	2.5	7.6	12.4	75.3
Viet Nam (VNM)	98	1.8	0.2	3.0	4.2	7.3	14.2	69.6
Nicaragua (NIC)	99	0.6	0.1	0.7	3.4	3.2	20.1	72.1
Morocco (MAR)	100	1.1	0.1	2.5	8.4	16.0	21.5	50.4
Pakistan (PAK)	101	0.7	0.1	2.2	2.2	3.5	11.9	79.6
Honduras (HND)	102	0.8	0.0	0.6	1.4	3.0	13.4	80.8
Côte d'Ivoire (CIV)	103	0.4	0.0	3.8	1.3	5.3	11.8	77.3
United Rep. of Tanzania (TZA)	104	0.9	0.1	1.1	1.7	3.1	7.8	85.4
Mozambique (MOZ)	105	0.5	0.0	0.6	5.8	17.3	50.3	25.5
Benin (BEN)	106	0.3	0.0	3.2	0.7	2.0	11.5	82.3
Yemen (YEM)	107	0.7	0.1	0.6	0.5	2.1	3.1	93.0
Sri Lanka (LKA)	108	0.8	0.1	2.3	3.6	6.6	11.8	74.9
Turkmenistan (TKM)	109	0.1	0.0	0.1	1.5	2.3	70.0	26.0
Ethiopia (ETH)	110	0.4	0.0	1.4	0.9	1.8	6.3	89.2
Cameroon (CMR)	111	0.3	0.0	0.5	0.5	1.9	7.4	89.4
Ghana (GHA)	112	0.4	0.1	1.0	0.8	4.7	11.4	81.6
Sudan (SDN)	113	0.2	0.0	0.4	0.3	0.4	2.6	96.2
Malawi (MWI)	114	0.4	0.0	0.7	0.8	1.2	4.8	92.1
Angola (AGO)	115	0.1	0.0	0.1	0.1	0.1	0.6	99.0
Madagascar (MDG)	116	0.4	0.1	0.8	1.7	2.2	4.3	90.6
Bangladesh (BGD)	117	0.3	0.0	0.6	0.6	0.9	4.9	92.7
Guinea (GIN)	118	0.3	0.0	0.3	4.1	0.5	15.3	79.5
Lao People's Dem. Rep. (LAO)	119	0.3	0.0	0.5	1.0	10.6	8.5	79.1
Congo (COG)	120	0.1	0.0	0.1	0.1	0.3	2.9	96.4
Haiti (HTI)	121	0.2	0.0	0.5	0.7	0.6	3.0	95.0
Nigeria (NGA)	122	0.1	0.0	0.2	0.3	0.6	1.6	97.2
Papua New Guinea (PNG)	123	0.2	0.0	0.2	0.4	0.9	2.7	95.5
Cambodia (KHM)	124	0.1	0.0	0.2	0.2	0.5	2.2	96.7

Note: 1 is the most complex and 6 the least. Top 100 refers to the top most complex products. Rank is the ranking of the country (in a total of 124 countries) according to the measure of country complexity. *Source*: Authors' estimates.

Appendix D. The 10 most complex economies

Country	Top 5 exports	Share in country's exports	Rank*	Top 5 most complex exports	Share in world's exports
(1) Japan	Automobiles, spark ignition engine of 1500–3000 cc	6.5	585	Other cyclic hydrocarbons: cumene	16.3
Number of products exported with RCA ≥ 1: 1362					
GDP per capita: 29,849	Automobiles, spark ignition engine of >3000 cc	3.7	59	Metalworking machine-tools/ultrasonic machine-tools: for dry-etching patterns on semiconductor materials	29.8
	Parts and accessories of data processing equipment nes	2.5	2386	Particle accelerators, and parts thereof, nes: ion implanters for doping semiconductor materials	10.1
	Electronic components: metal oxide semiconductors	2.3	2476	Methacrylic acid, salts	18.9
	Electronic components: monolithic integrated circuits	1.9	2526	Carbide tool tips etc.: tool plates/tips/etc., sintered metal carbide and cermets	10.9
(2) Germany	Automobiles, spark ignition engine of 1500–3000 cc	4.8	585	Other cyclic hydrocarbons: cumene	6.2
Number of products exported with RCA ≥ 1: 2113					
GDP per capita: 31,524	Automobiles, diesel engine of 1500–2500 cc	3.0	485	Metalworking machine-tools/ultrasonic machine-tools: for dry-etching patterns on semiconductor materials	0.5
	Medicaments nes, in dosage	2.7	940	Particle accelerators, and parts thereof, nes: ion implanters for doping semiconductor materials	0.4
	Automobiles, spark ignition engine of >3000 cc	2.6	59	Methacrylic acid, salts	31.6
	Motor vehicle parts nes	1.8	327	Carbide tool tips etc.: tool plates/tips/etc., sintered metal carbide and cermets	14.7
(3) Sweden	Automobiles, spark ignition engine of 1500–3000 cc	4.3	585	Other cyclic hydrocarbons: cumene	<0.1
Number of products exported with RCA ≥ 1: 1145					
GDP per capita: 31,506	Medicaments nes, in dosage	3.9	940	Metalworking machine-tools/ultrasonic machine-tools: for dry-etching patterns on semiconductor materials	0.1
	Petroleum oils and oils obtained from bituminous minerals, other than crude	3.0	4362	Particle accelerators, and parts thereof, nes: ion implanters for doping semiconductor materials	<0.1
	Transmit-receive apparatus for radio, TV, etc.	2.8	1435	Methacrylic acid, salts	<0.1

Country	Top 5 exports	Share in country's exports	Rank*	Top 5 most complex exports	Share in world's exports
	Lumber, coniferous (softwood) thickness <6 mm	2.1	3037	Carbide tool tips etc.: tool plates/tips/etc., sintered metal carbide and cermets	15.4
(4) Switzerland	Medicaments nes, in dosage	7.3	940	Other cyclic hydrocarbons: cumene	<0.1
Number of products exported with RCA ≥ 1: 1233	Gold in unwrought forms non-monetary	4.7	4851	Metalworking machine-tools/ultrasonic machine-tools: for dry-etching patterns on semiconductor materials	0.1
GDP per capita: 35,648	Wrist-watch, base–metal case, battery, with hands	2.1	3775	Particle accelerators, and parts thereof, nes: ion implanters for doping semiconductor materials	0.1
	Wrist-watch, base–metal case, automatic wound	2.0	2158	Methacrylic acid, salts	<0.1
	Antisera and other blood fractions	1.8	36	Carbide tool tips etc.: tool plates/tips/etc., sintered metal carbide and cermets	1.9
(5) Finland	Transmit-receive apparatus for radio, TV, etc.	12.6	1435	Other cyclic hydrocarbons: cumene	1.8
Number of products exported with RCA ≥ 1: 766					
GDP per capita: 30,229	Petroleum oils and oils obtained from bituminous minerals, other than crude	3.6	4362	Metalworking machine-tools/ultrasonic machine-tools: for dry-etching patterns on semiconductor materials	<0.1
	Paper, fine, light weight coated	2.7	26	Particle accelerators, and parts thereof, nes: ion implanters for doping semiconductor materials	<0.1
	Paper, fine, wood-containing, uncoated, nes	2.6	327	Methacrylic acid, salts	<0.1
	Lumber, coniferous (softwood) thickness <6 mm	2.5	3037	Carbide tool tips etc.: tool plates/tips/etc., sintered metal carbide and cermets	<0.1
(6) USA	Fixed wing aircraft, unladen weight >15,000 kg	3.1	2117	Other cyclic hydrocarbons: cumene	23.2
Number of products exported with RCA ≥ 1: 1847					
GDP per capita: 40,977	Metal oxide semiconductor	2.3	2476	Metalworking machine-tools/ultrasonic machine-tools: for dry-etching patterns on semiconductor materials	57.1

Country	Top 5 exports	Share in country's exports	Rank*	Top 5 most complex exports	Share in world's exports
	Parts and accessories of data processing equipment nes	1.8	2386	Particle accelerators, and parts thereof, nes: ion implanters for doping semiconductor materials	61.6
	Medicaments nes, in dosage	1.5	940	Methacrylic acid, salts	20.5
	Aircraft parts nes	1.4	1823	Carbide tool tips etc.: tool plates/tips/etc., sintered metal carbide and cermets	7.8
(7) United Kingdom	Medicaments nes, in dosage	4.2	940	Other cyclic hydrocarbons: cumene	2.2
Number of products exported with RCA $\geq$ 1: 1539	Petroleum oils, oils from bituminous minerals, crude	4.1	5012	Metalworking machine-tools/ultrasonic machine-tools: for dry-etching patterns on semiconductor materials	2.2
GDP per capita: 31,664					
	Petroleum oils and oils obtained from bituminous minerals, other than crude	3.0	4362	Particle accelerators, and parts thereof, nes: ion implanters for doping semiconductor materials	21.8
	Automobiles, spark ignition engine of 1500–3000 cc	2.7	585	Methacrylic acid, salts	7.3
	Diamonds (jewelry) unworked or simply sawn, cleaved	1.9	4681	Carbide tool tips etc.: tool plates/tips/etc., sintered metal carbide and cermets	2.0
(8) Austria	Transmit-receive apparatus for radio, TV, etc.	1.6	1435	Other cyclic hydrocarbons: cumene	<0.1
Number of products exported with RCA $\geq$ 1: 1370					
GDP per capita: 33,457	Electrical energy	1.6	3020	Metalworking machine-tools/ultrasonic machine-tools: for dry-etching patterns on semiconductor materials	0.1
	Automobiles, diesel engine of >2500 cc	1.3	870	Particle accelerators, and parts thereof, nes: ion implanters for doping semiconductor materials	0.4
	Automobiles, spark ignition engine of >3000 cc	1.3	59	Methacrylic acid, salts	0.1
	Lumber, coniferous (softwood) thickness <6 mm	1.2	3037	Carbide tool tips etc.: tool plates/tips/etc., sintered metal carbide and cermets	4.7

Country	Top 5 exports	Share in country's exports	Rank*	Top 5 most complex exports	Share in world's exports
(9) Belgium Number of products exported with RCA ≥ 1: 1471 GDP per capita: 31,695	Petroleum oils and oils obtained from bituminous minerals, other than crude	4.7	4362	Other cyclic hydrocarbons: cumene	0.1
	Automobiles, spark ignition engine of 1500–3000 cc	4.3	585	Metalworking machine-tools/ultrasonic machine-tools: for dry-etching patterns on semiconductor materials	0.4
	Automobiles, diesel engine of 1500–2500 cc	3.4	485	Particle accelerators, and parts thereof, nes: ion implanters for doping semiconductor materials	<0.1
	Diamonds (jewelry) unworked or simply sawn, cleaved	3.2	4681	Methacrylic acid, salts	8.0
	Medicaments nes, in dosage	2.8	940	Carbide tool tips etc.: tool plates/tips/etc., sintered metal carbide and cermets	5.8
(10) France Number of products exported with RCA ≥ 1: 1789 GDP per capita: 30,411	Fixed wing aircraft, unladen weight >15,000 kg	5.0	2117	Other cyclic hydrocarbons: cumene	0.5
	Medicaments nes, in dosage	3.3	940	Metalworking machine-tools/ultrasonic machine-tools: for dry-etching patterns on semiconductor materials	0.6
	Automobiles, spark ignition engine of 1500–3000 cc	2.5	585	Particle accelerators, and parts thereof, nes: ion implanters for doping semiconductor materials	2.0
	Automobiles, diesel engine of 1500–2500 cc	2.5	485	Methacrylic acid, salts	3.9
	Motor vehicle parts nes	2.3	327	Carbide tool tips etc.: tool plates/tips/etc., sintered metal carbide and cermets	1.4

Notes: "nes"—not elsewhere specified; *Product complexity ranking. *Notes*: GDP per capita is measured in 2005 PPP$ and is average for 2001–2007. Number of products exported with RCA is the average number of products exported with RCA ≥ 1 during 2001–2007. Share in country's exports and world exports are averages for 2001–2007. Shares are based on data for all HS 6-digit products and all countries. Rank is the ranking of the product (in a total of 5107 products) according to its complexity. 1 is the most complex and 5107 is the least complex. *Source*: Authors' estimates.

Appendix E. The 10 least complex economies

Country	Top 5 exports	Share in country's exports (%)	Rank	Top 5 most complex exports	Share in world's exports (%)	Rank
(124) Cambodia Number of products exported with RCA ≥ 1: 278 GDP per capita: 1343	Jerseys, pullovers, cardigans, waistcoats and similar articles of cotton, knitted or crocheted	10.7	5076	Carbide tool tips etc.: tool plates/tips/etc., sintered metal carbide and cermets	<0.001	5
	Women's/girls' trousers and shorts, of cotton, not knitted	8.0	5026	Other electronic measuring, controlling, etc., apparatus: instruments nes using optical radiations (UV, visible, IR)	<0.001	8
	Jerseys, pullovers, cardigans, waistcoats and similar articles of manmade fibers, knitted or crocheted	7.8	5016	Motorcycles, spark ignition engine of >800 cc	0.001	14
	Unused postage; stamp-impressed papers; stock; check books, etc.: documents of title (bonds, etc.), unused stamps, etc.	6.7	4681	Microscopes except optical, diffraction apparatus	<0.001	23
	Men's/boys' trousers and shorts, of cotton, not knitted	5.3	4985	X-rays apparatus, for medical, surgical or veterinary uses	<0.001	24
(123) Papua New Guinea Number of products exported with RCA ≥ 1: 101 GDP per capita: 1890	Petroleum oils, oils from bituminous minerals, crude	23.4	5012	Photo, cine laboratories equipment, nes, screens for projectors: direct write-on-wafer apparatus	<0.001	6
	Copper ores and concentrates	13.9	4788	Sheet, plates, rolled of thickness 4.75 mm plus, of iron or steel or other alloy steel: cold rolled alloy-steel nes, not further worked (cold-reduced), <600 mm wide	0.019	8
	Gold in unwrought forms non-monetary	13.9	4851	Other electronic measuring, controlling, etc., apparatus: instruments nes using optical radiations (UV, visible, IR)	<0.001	8
	Logs, non-coniferous nes	10.0	4948	Motorcycles, spark ignition engine of >800 cc	<0.001	14
	Palm oil, crude	5.7	5043	Microscopes except optical, diffraction apparatus	<0.001	23
(122) Nigeria Number of products exported with RCA ≥ 1: 77 GDP per capita: 1650	Petroleum oils, oils from bituminous minerals, crude	81.3	5012	Carbide tool tips, etc.: tool plates/tips/etc., sintered metal carbide and cermets	<0.001	5
	Natural gas, liquefied	6.2	4905	Photo, cine laboratories equipment, nes, screens for projectors: direct write-on-wafer apparatus	<0.001	6

Country	Top 5 exports	Share in country's exports (%)	Rank	Top 5 most complex exports	Share in world's exports (%)	Rank
	Petroleum oils and oils obtained from bituminous minerals, other than crude	3.6	4362	Other machinery, mechanical appliances having individual functions: laser, light and photon beam process machine tools	<0.001	8
	Cocoa beans, whole or broken, raw or roasted	1.2	5104	Other electronic measuring, controlling, etc., apparatus: instruments nes using optical radiations (UV, visible, IR)	0.001	8
	Butanes, liquefied	0.9	4475	Photo, cine laboratories equipment, nes; screens for projectors: step and repeat aligners	<0.001	11
(121) Haiti Number of products exported with RCA $\geq$ 1: 152 GDP per capita: 1103	T-shirts, singlets and other vests, of cotton, knit	25.7	5040	Particle accelerators, and parts thereof, nes: ion implanters for doping semiconductor materials	0.003	3
	Jerseys, pullovers, cardigans, waistcoats and similar articles of cotton, knitted or crocheted	20.8	5076	Other electronic measuring, controlling, etc., apparatus: instruments nes using optical radiations (UV, visible, IR)	<0.001	8
	T-shirts, singlets, etc., of material nes, knitted	6.5	4905	Self-adhesive plates, sheets, film, plastic, w >20 cm	<0.001	29
	Men, boy's trousers and shorts, of cotton, not knitted	3.4	4985	Furnace burners for liquid fuel	0.001	33
	Women's/girls' trousers and shorts, of cotton, knit	2.7	5065	Valves for oleohydraulic or pneumatic transmissions	<0.001	40
(120) Congo Number of products exported with RCA $\geq$ 1: 57 GDP per capita: 3401	Petroleum oils, oils from bituminous minerals, crude	73.8	5012	Carbide tool tips, etc.: tool plates/tips/etc., sintered metal carbide and cermets	<0.001	5
	Petroleum oils and oils obtained from bituminous minerals, other than crude	5.7	4362	Other electronic measuring, controlling, etc., apparatus: instruments nes using optical radiations (UV, visible, IR)	<0.001	8
	Logs, tropical woods nes	5.3	5108	Plates, sheet, strip and foil, nickel alloy	0.098	21
	Cobalt ores and concentrates	1.6	5060	X-rays apparatus, for medical, surgical or veterinary uses	<0.001	24
	Propane, liquefied	1.5	4445	Polyurethanes; in primary forms: silicones in primary forms	<0.001	29

Country	Top 5 exports	Share in country's exports (%)	Rank	Top 5 most complex exports	Share in world's exports (%)	Rank
(119) Lao People's Dem. Rep. Number of products exported with RCA ≥ 1: 213 GDP per capita: 1611	Lumber, non-coniferous nes	14.6	4772	Carbide tool tips, etc.: tool plates/tips/etc., sintered metal carbide and cermets	<0.001	5
	Electrical energy	13.8	3020	Other electronic measuring, controlling, etc., apparatus: instruments nes using optical radiations (UV, visible, IR)	<0.001	8
	Copper cathodes and sections of cathodes unwrought	11.4	4515	Ethylenediamine, its salts	0.052	13
	Logs, non-coniferous nes	5.8	4948	Microscopes except optical, diffraction apparatus	<0.001	23
	Men's/boys' trousers and shorts, of cotton, not knit	4.8	4985	Supported catalysts, except nickel or precious metal	<0.001	25
(118) Guinea Number of products exported with RCA ≥ 1: 101 GDP per capita: 1040	Aluminum ores and concentrates	43.1	4829	Carbide tool tips, etc.: tool plates/tips/etc., sintered metal carbide and cermets	<0.001	5
	Aluminum oxide, except artificial corundum	13.2	3954	Other machinery, mechanical appliances having individual functions: laser, light and photon beam process machine tools	0.002	8
	Petroleum oils, oils from bituminous minerals, crude	8.2	5012	Other electronic measuring, controlling, etc., apparatus: instruments nes using optical radiations (UV, visible, IR)	<0.001	8
	Diamonds (jewelry) unworked or simply sawn, cleaved	6.4	4681	Motorcycles, spark ignition engine of >800 cc	<0.001	14
	Aluminum hydroxide	4.1	2443	Other chemical derivatives of cellulose, non-plasticized: cellulose ethers nes, in primary forms	0.001	15
(117) Bangladesh Number of products exported with RCA ≥ 1: 437 GDP per capita: 1035	T-shirts, singlets and other vests, of cotton, knitted	11.2	5040	Tool plates/tips/etc., sintered metal carbide and cermets	0.001	5

Country	Top 5 exports	Share in country's exports (%)	Rank	Top 5 most complex exports	Share in world's exports (%)	Rank
	Men's/boys' trousers and shorts, of cotton, not knitted	8.5	4985	Other electronic measuring, controlling, etc., apparatus: instruments nes using optical radiations (UV, visible, IR)	<0.001	8
	Jerseys, pullovers, cardigans, waistcoats and similar articles of manmade fibers, knitted or crocheted	8.1	5016	Motorcycles, spark ignition engine of >800 cc	<0.001	14
	Women's/girls' trousers and shorts, of cotton, not knit	5.9	5026	Other chemical derivatives of cellulose, non-plasticized: cellulose ethers nes, in primary forms	<0.001	15
	Jerseys, pullovers, cardigans, waistcoats and similar articles of cotton, knitted or crocheted	5.8	5076	Orthopaedic appliances to compensate for a defect or disability: computed tomography apparatus	0.004	15
(116) Madagascar Number of products exported with RCA ≥ 1: 451 GDP per capita: 880	Vanilla beans	11.4	5082	Particle accelerators, and parts thereof, nes: ion implanters for doping semiconductor materials	<0.001	3
	Shrimps and prawns, frozen	10.7	5060	Carbide tool tips, etc.: tool plates/tips/etc., sintered metal carbide and cermets	<0.001	5
	Jerseys, pullovers, cardigans, waistcoats and similar articles of wool or hair, knitted or crocheted	7.1	4829	Other electronic measuring, controlling, etc., apparatus: instruments nes using optical radiations (UV, visible, IR)	0.001	8
	Women's/girls' trousers and shorts, of cotton, not knitted	5.4	5026	Motorcycles, spark ignition engine of >800 cc	0.002	14
	Jerseys, pullovers, cardigans, waistcoats and similar articles of cotton, knitted or crocheted	5.1	5076	Other chemical derivatives of cellulose, non-plasticized: cellulose ethers nes, in primary forms	0.001	15
(115) Angola Number of products exported with RCA ≥ 1: 14 GDP per capita: 3432	Petroleum oils, oils from bituminous minerals, crude	90.8	5012	Hexamethylenediamine, its salts	<0.001	7
	Diamonds (jewelry) unworked or simply sawn, cleaved	4.6	4681	Other electronic measuring, controlling, etc., apparatus: instruments nes using optical radiations (UV, visible, IR)	<0.001	8
	Petroleum oils and oils obtained from bituminous minerals, other than crude	2.1	4362	Motorcycles, spark ignition engine of >800 cc	<0.001	14
	Propane, liquefied	0.6	4445	X-rays apparatus, for medical, surgical or veterinary uses	0.002	24
	Petroleum gases and gaseous hydrocarbons nes, liquefied	0.3	4131	Measuring or checking instruments, appliances and machines: optical instruments for inspecting semiconductor wafers or devices/photomasks/reticles used in manufacturing semiconductor devices	0.004	26

Note: 'nes' – not elsewhere specified; *Product complexity ranking. *Notes*: GDP per capita is measured in 2005 PPP$ and is average for 2001–2007. Number of products exported with RCA is the average number of products exported with RCA ≥ 1 during 2001–2007. Share in country's exports and world exports are averages for 2001–2007. Shares are based on data for all HS 6-digit products and all countries. Rank is the ranking of the product (in a total of 5107 products) according to its complexity. 1 is the most complex and 5107 is the least complex. *Source*: Authors' estimates.

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