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Product Complexity and Economic Development

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ABSTRACT

We rank 5,107 products and 124 countries according to the Hidalgo and Hausmann (2009) measures of complexity. We find that: (1) 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; (2) the most complex economies in the world are Japan, Germany, and Sweden, and the least complex, Cambodia, Papua New Guinea, and Nigeria; (3) 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 (4) export shares of the more complex products increase with income, while export shares of the less complex products decrease with income. Finally, we relate the measure of product complexity with the concept of Complex Products and Systems, and find a high degree of conformity between them.

Keywords: Capabilities; Development; Economic Complexity; Diversification; Method of Reflections; Product Complexity; Ubiquity

JEL Classifications: O10, O14

1. INTRODUCTION

In a series of recent papers, Hidalgo et al. (2007) and Hidalgo and Hausmann (2009) explain economic development as a process of learning how to produce (and export) more complex products.[1] 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.

In this 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. Capabilities are 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); at the firm level, they are the "know-how" or working practices held collectively by the group of individuals comprising the firm.[2] 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*, but are inferred through the network of countries and the products they export.

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.

[1] Their ideas are reminiscent of the literature on structural transformation pioneered by Kaldor (1967), among others, during the 1950s and 1960s. Apart from the revival of the old literature, the most important contribution of this new strand of work is on the empirical side, the application of network theory.

[2] Bell and Pavit (1995) and Lall (1992) provide a framework to analyze the industrial "technological capabilities" required for innovation. Among the capabilities in 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) to (v) are related to production activities; and (vi) and (vii) are related to the development of linkages to the economy and capital goods supply.

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 difficulty of poor countries to converge to the income level of the rich countries.

Hausmann, Hwang, and Rodik (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.[3] 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.[4] Hausmann, Hwang, and Rodik (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

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

$$PRODY_i = \sum_c \left[\frac{xval_{ci} \Big/ \sum_i xval_{ci}}{\sum_c \left(xval_{ci} \Big/ \sum_i xval_{ci} \right)} \right] \times GDPpc_c$$

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.

[4] Algebraically:

$$EXPY_c = \sum_i \left(\frac{xval_{ci}}{\sum_i xval_{ci}} \times PRODY_i \right)$$

EXPY is measured in 2005 PPP$.

export rich-country products, and that the measure of economic complexity (EXPY) is a good predictor of future growth.[5]

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 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 5,107 products and 124 countries. Section 3 presents summary statistics of the measures of product complexity and our findings on how the export

[5] A very similar measure of product sophistication was developed by Lall, Weiss, and Zhang (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.

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 revisit the concept of complex products and systems (CoPS) developed by Hobday (1998) and Hobday, Rush, and Tidd (2000). Section 5 concludes the paper.

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. To make their method operational, Hidalgo and Hausmann (2009) define diversification as the number of products that a country exports with revealed comparative advantage (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 revealed comparative advantage (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 produces more goods (more diversified) is more complex than a country that exports fewer goods (less diversified); a product that is produced by fewer countries (less ubiquitous) is more complex than a product that is exported by more countries (more ubiquitous). The intuition behind this is that a country can produce/export a particular product 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[6] and M_{cp}=0, otherwise.[7] 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* (1) and a product's *ubiquity* (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:

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

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

[6] The index of revealed comparative advantage 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:

$$RCA_{ci} = \frac{xval_{ci} \Big/ \sum_i xval_{ci}}{\sum_c xval_{ci} \Big/ \sum_i \sum_c xval_{ci}}.$$

[7] Hulst, Mulder, and Soete (1987) developed a measure of technical competitiveness called the "revealed technological advantage" (RTA) index. The RTA is computed the same way as the revealed comparative advantage (RCA) index, but uses patent shares instead of export shares. They showed that the two are strongly correlated: a country with a relatively strong technological position also has a relatively strong trade position. The RTA, however, has the disadvantage that it requires patent data that may not be available for many countries. Moreover, analyses using RTA are done at the industry level.

where n corresponds to the number of iterations. Equations (3) and (4) are iterated until no additional information can be derived from the previous iteration, and this happens 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 equations (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 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) six-digit level classification, comprising 5,107 products for 124 countries.[8] 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.[9] The indicators we use are averages for the period 2001–07.

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 ($k_{VNM,0}$=902) with revealed comparative advantage, while Canada exports 893 products ($k_{CAN,0}$=893) with revealed comparative advantage. Diversification, however, does not tell us

[8] Hidalgo and Hausmann (2009) worked with the SITC rev. 4 (772 products, 129 countries), the HS at the four-digit level (1,241 products, 103 countries), and the NAICS at the six-digit level (318 products, 150 countries). The trade data is from the UN Commodity Trade Statistics. We exclude 25 commodities. These are products that were not consistently reported during the period 2001 to 2007 and the HS two-digit code 99.

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

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 revealed comparative advantage. This yields $k_{VNM,1}=25$ and $k_{CAN,1}=20$, 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—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. We use this information in the second iteration, $k_{c,2}$, which is the average diversification of the countries that export the same products exported by Canada or Vietnam. This yields $k_{VNM,2}=885$ and $k_{CAN,2}=975$, which implies that Canadian exports are exported by more diversified countries than Vietnam's exports. We have shown that if we had drawn our conclusions using only diversification, we would have concluded that Vietnam is a more complex economy than Canada. Instead, we jointly used diversification and ubiquity information in our succeeding iterations and showed that 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, we 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.

Table 1. Method of Reflections: Information from the First Three Pairs of Variables Derived from Equations (1)–(4)

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

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

A discussion of our main findings is provided in section 3. This is complemented by the information in appendixes A, B, C, D, and E. Appendix A lists the 100 most complex products and Appendix B the 100 least complex products. Appendix C ranks the 124 countries according to economic complexity and appendixes D and E show the ten most complex and ten least complex economies and their major exports.

3. PRODUCT COMPLEXITY AND ECONOMIC DEVELOPMENT

In this section we summarize the major findings that result from the application of the method of reflections to our product and country data base. 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).

3.1. The Most and 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 revealed comparative advantage (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.

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 4.75mm plus, of iron or steel or other alloy steel: cold rolled alloy-steel nes nfw, <600mm 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.

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	13.2	23
	Congo	3,401	307.9	9.3
	Cameroon	1,944	246.3	8.4
	Equatorial Guinea	21,079	201.8	5.8
(5106) Cashew nuts, in shell dried (edible fruit, nuts, peel of citrus fruit, melons)	Côte d'Ivoire	1,587	270.7	19.3
	United Republic of Tanzania	998	852.6	14.6
	Guinea-Bissau	529	14280.7	13.8
	Indonesia	3,100	11.4	12
	Benin	1,315	1383.9	7.8
(5105) Manioc (cassava), fresh or dried (edible vegetables and certain roots and tubers)	Thailand	6,164	56.5	69.1
	Vietnam	2,034	38.5	12.7
	Costa Rica	8,873	60.3	7.5
	Indonesia	3,100	3.3	3.5
	Germany	31,524	0.2	1.8
(5104) Technically specified natural rubber (TSNR) (rubber and articles thereof)	Indonesia	3,100	39.7	42.3
	Thailand	6,164	17.8	21.7
	Malaysia	11,350	11.1	19.1
	Vietnam	2,034	15.1	4.8
	Côte d'Ivoire	1,587	38.9	2.8
(5103) Cocoa beans, whole or broken, raw or roasted (cocoa and cocoa preparations)	Côte d'Ivoire	1,587	562	40.5
	Ghana	1,163	601.3	18.6
	Indonesia	3,100	12.6	13.5
	Nigeria	1,650	23.9	7.4
	Cameroon	1,944	125.6	4.1
(5102) Wood of nonconiferous, sawn lengthwise, sliced, or peeled: lumber, tropical wood nes (wood and articles of wood, wood charcoal)	Cameroon	1,944	468.7	15.3
	Indonesia	3,100	14.2	15.2
	Brazil	8,379	11.9	14
	Malaysia	11,350	7.9	13.7
	Côte d'Ivoire	1,587	114	8.2
(5101) Natural rubber in other forms (rubber and articles thereof)	Indonesia	3,100	24.9	26.5
	Thailand	6,164	19.7	24.2
	Malaysia	11,350	12.3	21.3
	Vietnam	2,034	14	4.5
	Côte d'Ivoire	1,587	56.5	4.1
(5100) Copra (oil seed, oleagic fruits, grain, seed, fruit, etc., nes)	Vietnam	2,034	54.5	18.7
	Sri Lanka	3,433	252.7	18
	Indonesia	3,100	16.3	17.3
	Papua New Guinea	1,890	446.3	15.7
	Vanuatu	3,230	5009.8	7.7
(5099) Jute and other textile bast fibers, raw or retted (vegetable textile fibers nes, paper yarn, woven fabric)	Bangladesh	1,035	790.6	88
	India	2,122	5.3	5.1
	Belgium	31,695	0.5	1.2
	China	3,823	0.1	0.7
	Kenya	1,338	17	0.6
(5098) Wood of nonconiferous, sawn lengthwise, sliced, or peeled: lumber, virola, mahogany (wood and articles of wood, wood charcoal)	Peru	6,165	173.8	23.4
	Brazil	8,379	10.6	11.7
	Ecuador	6,388	99.7	9.8
	Cameroon	1,944	238.3	8.1
	Côte d'Ivoire	1,587	92.6	6.8

Notes: "nes"—not elsewhere specified.

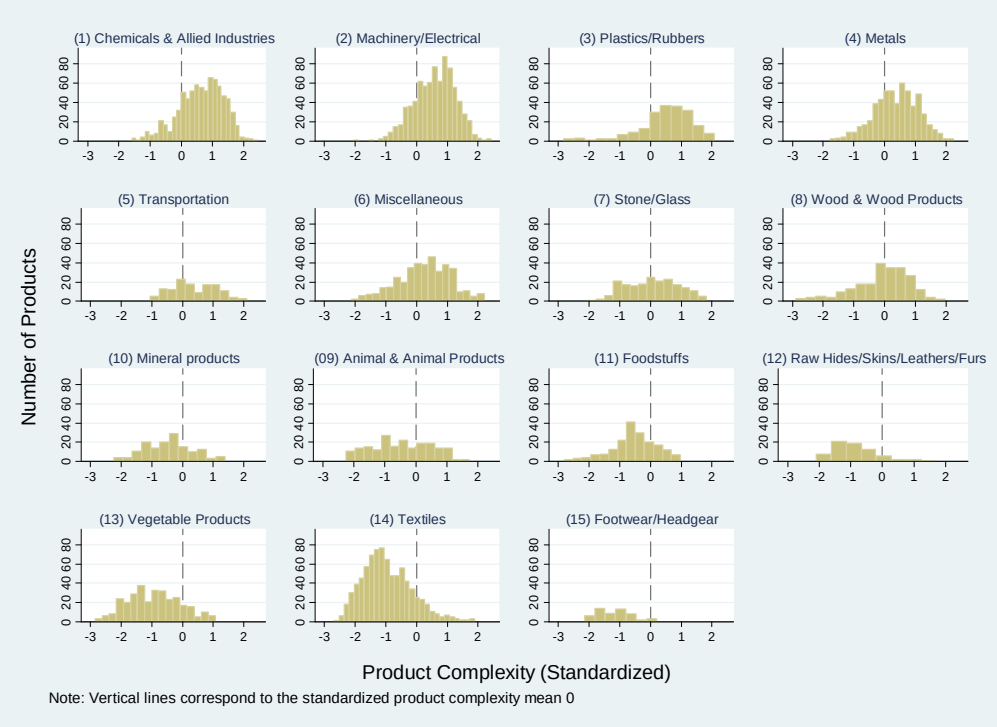
*Share of exports in total world exports.

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 5,107 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. Figure 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 distributions of products in each HS group by complexity.

Figure 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 figure 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). [10]

[10] 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%.

Figure 1. Distribution of Product Complexity by HS Groups



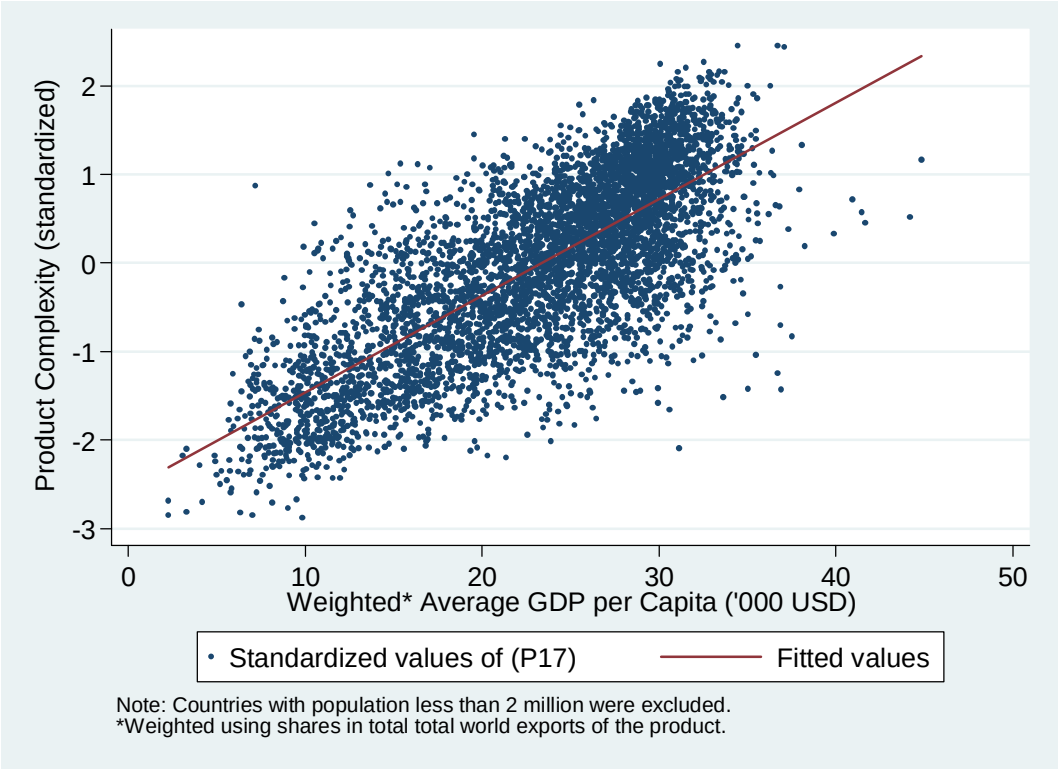
Note: Standardized product complexity (over all 5,107 products) with mean zero and standard deviation one.

Second, tables 2 and 3 show the contrast in 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[11]—are the Netherlands, the United States, Japan, Germany, and the UK, with an average income per capita of about PPP$34,000. In contrast, the average per capita income of the top five exporters of "sawlogs and veneer logs"—the least complex product—is about PPP$10,000. Figure 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.[12] This implies that richer countries are the major exporters

[11] 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.
[12] Income per capita is weighted using the export share of a country in total world exports of the product.

of the more complex products while the poorer countries are the major exporters of the less complex products.

Figure 2. Product Complexity and the Weighted Mean GDP Per Capita of Exporters



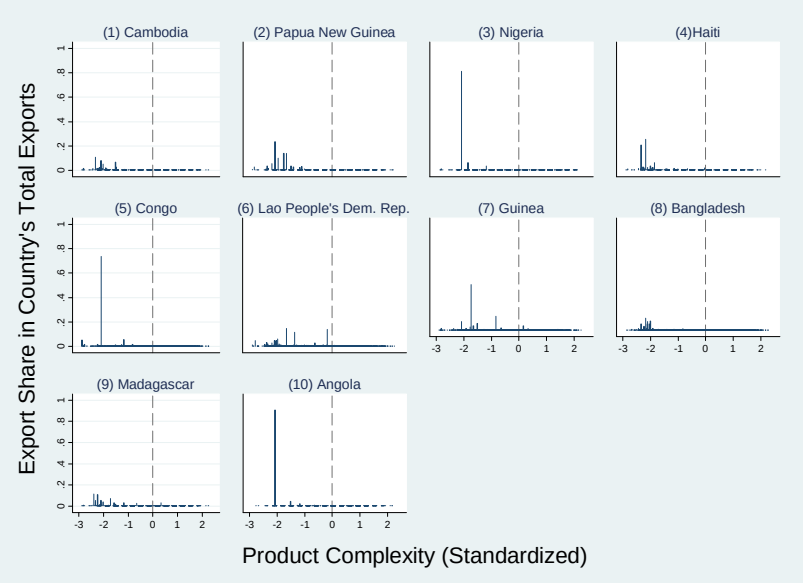
3.2. How Do Export Shares Vary with Income for Different Levels of Product Complexity?

Figure 3 shows the histograms of the export shares of the 5,107 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 products of low complexity (i.e., exports are concentrated to the right of the vertical line, the mean).

Figure 3. Export Shares in Country's Total Exports across Product Complexity

Panel A: Ten Most Complex Economies

Panel B: 10 Least Complex Economies



This finding can be generalized by testing for all 124 countries whether a country's export is biased towards the more complex or the less complex goods. That is, we 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 countries; likewise, the export shares of less complex products are higher for the lower income countries. Figure 4 shows the negative relationship between the measure of skewness and GDP per capita: countries whose distribution is skewed to the right have lower income per capita and vice versa.

Table 4. Distribution (skewness) of Exports across Product Complexity (sorted by country complexity)

Negatively Skewed			Positively Skewed					
Rank	Country Name and GDPPC (PPP$)		Rank	Country Name and GDPPC (PPP$)		Rank	Country Name and GDPPC (PPP$)	
1	Japan	29,849	17	Norway	46,434	113	Peru	6,165
2	Germany	31,524	19	Russian Federation	11,221	114	Albania	5,894
3	Sweden	31,506	21	Israel	22,915	115	Dominican Rep.	6,226
4	Switzerland	35,648	26	Ukraine	5,249*	116	Uganda	889
5	Finland	30,229	33	Georgia	3,299	117	El Salvador	5,618
6	USA	40,977	34	Saudi Arabia	20,469	118	Zambia	1,103
7	United Kingdom	31,664	36	Armenia	3,748	119	Rwanda	771
8	Austria	33,457	37	Argentina	10,361	120	Burkina Faso	997
10	Belgium	31,695	43	Croatia	14,646*	121	Nepal	949
11	France	30,411	45	Sierra Leone	607	122	Mali	984
12	Ireland	37,299	47	Australia	31,022	125	Tajikistan	1,380*
13	Netherlands	34,768	49	Latvia	12,245	128	Paraguay	3,890*
14	Czech Rep.	19,651	50	Kazakhstan	8,105	129	Ecuador	6,388
15	Canada	34,446	51	Venezuela	9,656	129	Togo	777
16	Denmark	32,974	54	Lithuania	13,264	131	Chad	1,244
17	Slovenia	22,848	55	Bosnia Herzegovina	6,000*	133	Syria	3,914
20	Singapore	41,406	56	Chile	11,737	134	Viet Nam	2,034
22	Rep. of Korea	22,093	57	Bulgaria	8,757*	135	Nicaragua	2,254
23	Slovakia	15,669	58	Romania	8,943	137	Morocco	3,514
24	Italy	28,277	58	India	2,122	138	Pakistan	2,105
25	Hungary	16,191	64	Uruguay	9,245	139	Honduras	3,203
27	Poland	13,440	66	Azerbaijan	4,350	140	Côte d'Ivoire	1,587
28	Spain	26,991	69	Lebanon	9,277	141	United Rep. of Tanzania	998
29	Mexico	12,424	73	Jordan	4,198*	145	Benin	1,315
30	Belarus	7,929*	75	Colombia	7,088	147	Yemen	2,149
31	Brazil	8,379	81	Kyrgyzstan	1,701	148	Sri Lanka	3,433
35	New Zealand	24,138	85	Algeria	6,832	154	Ethiopia	610
42	South Africa	8,289	88	Iran	9,035	155	Cameroon	1,944
44	Malaysia	11,350	89	Senegal	1,558	156	Ghana	1,163
61	China	3,823	90	Libya	12,472	159	Sudan	1,579
63	Greece	24,151*	91	Central African Rep.	670	160	Malawi	656
64	Portugal	20,711	92	Rep. of Moldova	2,064*	162	Angola	3,432
71	China, Hong Kong SAR	33,996	93	Niger	586	164	Madagascar	880
76	Thailand	6,164	95	Uzbekistan	1,927	165	Bangladesh	1,035
77	Turkey	10,313*	96	Egypt	4,297	166	Guinea	1,040
83	Costa Rica	8,873	96	Burundi	347*	167	Lao People's Dem. Rep.	1,611
87	TFYR of Macedonia	7474*	102	Panama	8,976	169	Congo	3,401
99	Philippines	2,846	105	Indonesia	3,100	170	Haiti	1,103
123	Bolivia	3,588	108	Tunisia	6,262	173	Nigeria	1,650
142	Mozambique	648	109	Jamaica	6,939	174	Papua New Guinea	1,890
153	Turkmenistan	4,174	110	Kenya	1,338	175	Cambodia	1,343
			112	Guatemala	4,084			

* p-value > 0.10

Note: GDP per capita is the average for 2001–2007.

Figure 4. Skewness of the Distribution of Export Shares and GDP Per Capita

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. We start by estimating 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 all 5,107 products. The equation estimated is:

$$\log(\text{share}_{i,c}) = a_i + b_i * \log(\text{gdppc}_c) + e_i \qquad (5)$$

where $share_{i,c}$ is the export share of product *i* in country *c*'s total exports; $gdppc_c$ is the GDP per capita income of country *c*; and a_i and e_i are the constant and error terms, respectively. Our main object of interest in equation (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 5,107 products, 2,499 have statistically significant positive elasticities; 712 have

statistically negative elasticities; and there are 1,896 products with statistically insignificant elasticities.[13]

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 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).

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	50.8	7.0	43.8	49.2	784
2. Machinery/Electrical	85.0	0.9	84.1	15.0	804
3. Plastics/Rubbers	80.8	4.5	76.3	19.2	198
4. Transportation	63.6	5.3	58.3	36.4	132
5. Metals	66.5	3.2	63.4	33.5	571
6. Miscellaneous	75.8	1.8	74.0	24.2	392
7. Stone/Glass	65.0	10.2	54.8	35.0	197
8. Wood and Wood Products	71.6	11.4	60.3	28.4	229
9. Mineral Products	44.6	25.0	19.6	55.4	148
10. Animal and Animal Products	50.7	28.4	22.4	49.3	201
11. Foodstuffs	59.1	18.3	40.9	40.9	186
12. Vegetable Products	58.5	49.4	9.2	41.5	316
13. Textiles	46.6	29.7	16.9	53.4	822
14. Raw Hides/Skins/etc.	59.7	31.9	27.8	40.3	72
15. Footwear/Headgear	50.9	21.8	29.1	49.1	55
Total no. of products	**3,211**	**712**	**2,499**	**1,896**	**5,107**

Note: Proportions are shares in the total number of products in each HS group (last column)

Next, we determine: (a) *where* these products lie in the product complexity scale; and (b) *how* b_i varies with product complexity, conditional on whether $b_i>0$, $b_i<0$, or $b_i=0$. Figure 5 plots the estimated share elasticities b_i against the standardized product complexity index. Three observations can be made:

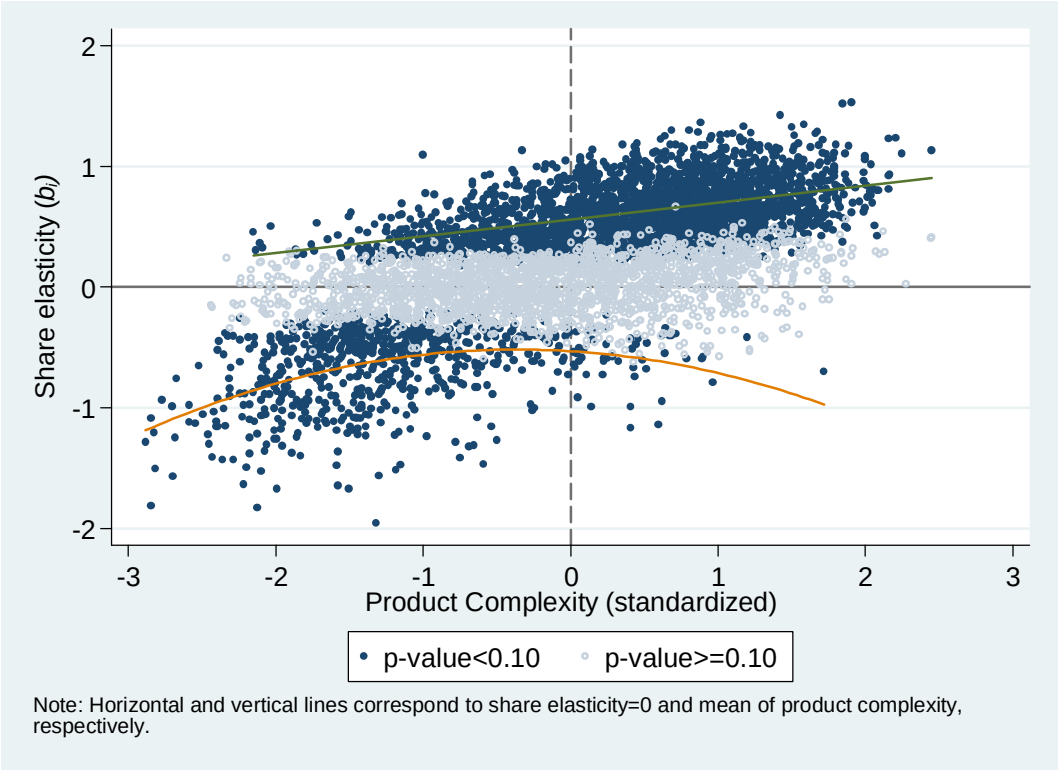
[13] We set the significance level at 10%.

(i) Products with positive export share elasticities (b_i>0) are mostly located in the top-right quadrant (1,879 out of the 2,499), with complexity above average (to the right of the vertical line). For these products, the elasticity increases with complexity at a constant rate (i.e., it is linear);

(ii) Products with negative export share elasticities (b_i<0) are mostly located in the bottom-left quadrant (663 out of the 712), with complexity below average (to the left of the vertical line). For these products, the elasticity also increases with product complexity, but at a decreasing rate; and

(iii) Products with export share elasticities equal to zero (represented as light dots in figure 5) lay across a wide range of the product complexity.

Figure 5. Elasticity of the Export Share with Respect to Income and Product Complexity

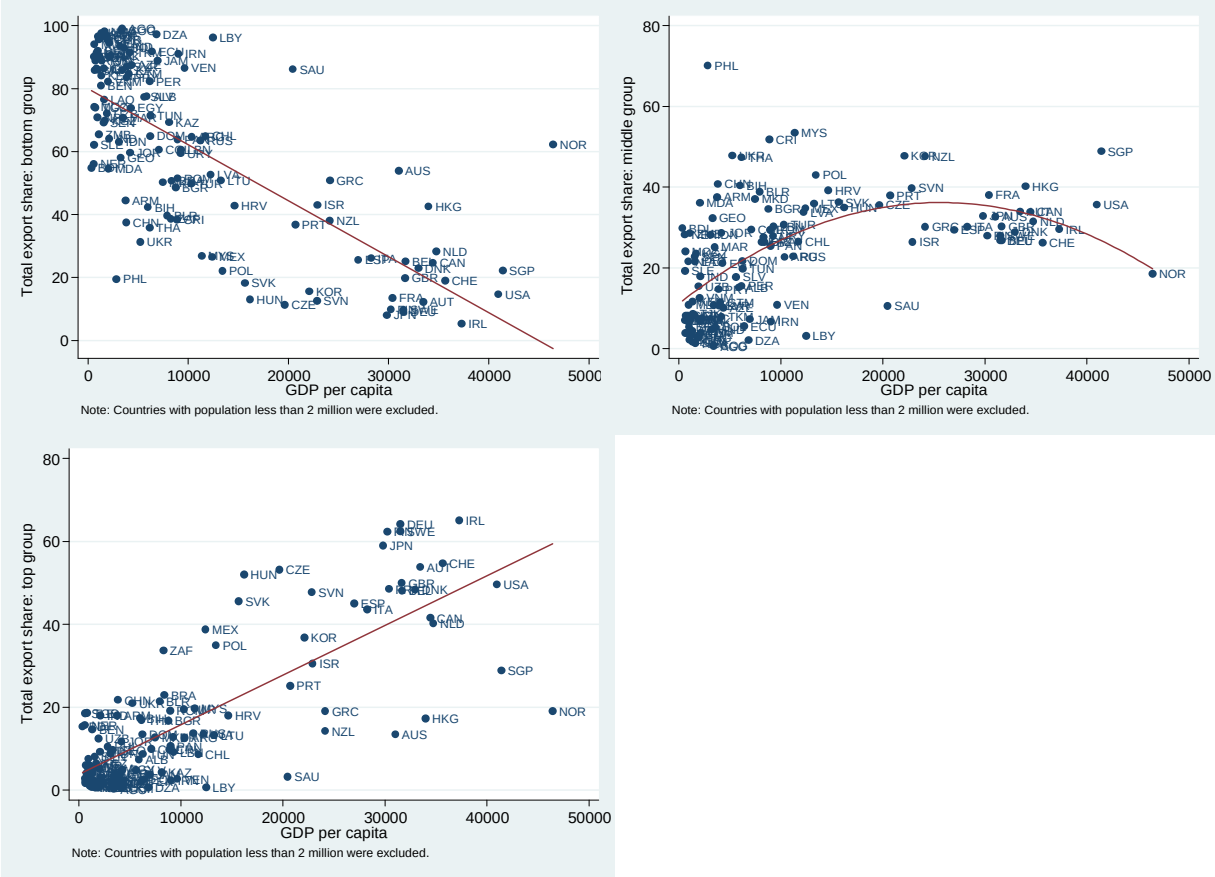


Note: Horizontal and vertical lines correspond to share elasticity=0 and mean of product complexity, respectively.

These results imply that export shares increase with income per capita for the more complex products while export shares decrease with income for the less complex products. In figure 6, we divide the 5,107 products into terciles according to their complexity and study the relationship with income per capita. The figure shows the export shares of the 5,107 products

divided into three complexity levels. 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, and that richer countries have higher export shares than poorer countries of the most complex products. Finally, export shares of the midlevel complex products increase with income per capita up to about $25,671, and then decrease.[14]

Figure 6. Export Shares and Income per Capita



Hobday, Rush, and Bessant (2004), using interviews, concluded that South Korea is still far from the technological frontier. While it is true that some Korean companies have made very important advances in electronics, they are not manufacturing and exporting the most advanced

[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.

products. Appendix C shows that Korea ranks number 21 in complexity. This is certainly high for world standards, but below most advanced countries. Among the Asian counties (other than Japan), the most complex economy is Singapore, ranked 19th, followed by Korea. Malaysia ranks 38th, India, 49th, and China, 50th. Figure 3 showed that the export baskets of the most complex countries have high shares of complex products. This finding was generalized in table 4.

Table 6 shows the export shares in each country's total exports, divided by complexity level, 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 (29% 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 1.47% for Singapore and 2.31% for Korea.

Table 6. Percentage 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	40.0	10.14	19.0	21.7	11.2	6.6	1.5
Germany	2	39.5	7.93	24.7	15.9	10.9	5.6	3.5
USA	6	28.2	7.25	21.5	22.7	13.0	9.4	5.2
France	10	26.2	3.27	22.3	22.0	16.1	7.5	5.9
Singapore	19	14.7	1.47	14.2	38.4	10.5	4.1	18.1
Rep. of Korea	21	18.2	2.31	18.6	33.8	13.9	7.9	7.6
Malaysia	38	4.9	0.49	14.7	38.3	15.2	7.3	19.5
India	49	8.4	0.66	9.6	8.4	9.5	30.1	34.0
China	50	6.3	0.58	15.5	21.6	19.2	14.9	22.6
Thailand	59	7.3	0.53	9.6	31.8	15.5	11.3	24.4
Philippines	74	3.3	0.29	7.2	49.9	20.2	6.5	13.0
Indonesia	76	3.3	0.40	5.4	12.9	15.3	14.6	48.5
Viet Nam	98	2.0	0.21	3.2	4.5	8.0	14.8	67.5
Pakistan	101	0.8	0.09	2.3	2.4	4.3	12.4	77.8

Note: 1 is the most complex and 6 the least. Top 100 refers to the top most complex products.

4. THE *METHOD OF REFLECTIONS* AND COPS

In another strand of the complexity literature, Hobday (1998) and Hobday, Rush, and Tidd (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, Rush, and Tidd 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 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 different. 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 sold in standard markets and hence, they are not 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 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. 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 7. [16]

[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 Hildalgo and Hausmann (2009).

[16] We use the concordance between NACE Rev. 1 (from which UK SIC was 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.

Table 7. 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)

To what extent does the method of reflections capture the concept of CoPS as conceptualized by Hobday (1998 and 2000) and classified by Acha et al. (2004)? To answer this question, we identified the products in the HS six-digit level list that correspond to CoPS industries. This resulted in 742 out of the 5,107 (15%) products that matched the 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 8). Note that these HS groups, with chemicals and plastics/rubbers, are those that have the highest average complexity (figure 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.

Table 8. 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 six-digit level.

Moreover, the method of reflections can distinguish between more and less complex products within each CoPS industry. We show two examples in tables 8 and 9. First, within "manufacture of weapons and ammunition" (SIC 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 simple capabilities within the same CoPS industry.

Table 9. 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

Table 10. 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

5. CONCLUSIONS

Using Hidalgo and Hausmann's (2009) method of reflections and definitions of complexity, we have ranked 5,107 products and 124 countries. Product complexity refers to the ubiquity of a product, that is, the number of countries that export the product with comparative advantage, while country complexity is the degree of diversification of the export basket, that is, the number of products that a country exports with comparative advantage. 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 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.

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.

Finally, we find a high degree of concordance between the products considered as CoPS by Hobday (1998), Hobday, Rush, and Tidd (2000), and Acha et al. (2004) and our measure of product complexity. 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.

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Appendix A. List of 100 Most Complex Products

Rank	HS six-digit level description	HS two-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 & 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 4.75mm plus, of iron or steel or other alloy steel: Cold rolled alloy-steel nes nfw, <600mm 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 0.01mm	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 & 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
32	Apparatus based on the use of X-rays for dental uses	Optical, photo, technical, medical, etc.

Rank	HS six-digit level description	HS two-digit level description
		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
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 & film in the flat, nes, any side >255mm	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

Rank	HS six-digit level description	HS two-digit level description
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, derivs, pigments, etc.
70	Parts of nuclear reactors	Nuclear reactors, boilers, machinery, etc.
71	Textile fabric used in papermaking etc., >650 g/m2	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 & 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 & 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 >150g/m2, 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 >600mm, 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

Appendix B. List of 100 Least Complex Products

Rank	HS six-digit level description	HS two-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 fibres 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 fibres nes, paper yarn, woven fabric
5092	Natural rubber in smoked sheets	Rubber and articles thereof
5091	Abaca fiber, raw	Vegetable textile fibres 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 & bags, packing, of jute or other bast fibers	Other made textile articles, sets, worn clothing etc.
5077	Sisal and agave, raw	Vegetable textile fibres 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 & 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

Rank	HS six-digit level description	HS two-digit level description
		gluten
5061	Cobalt ores and concentrates	Ores, slag, and ash
5060	Plywood, outer ply	Wood and articles of wood, wood charcoal
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 & 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 & 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 fibres nes, paper yarn, woven fabric
5042	Coconut (coir) fiber, raw	Vegetable textile fibres 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 & 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 fibres nes, paper yarn, woven fabric

Rank	HS six-digit level description	HS two-digit level description
5021	Women's, girl's nightdress, pajamas, material nes, knit	Articles of apparel, accessories, knit or crochet
5020	Women's, girl's blouses & 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 & 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 are broken arbitrarily. For example, two products that are tied for rank 1 are ranked 1 and 2.

Appendix C. Complexity Ranking of the 124 Countries

Rank	Country	Rank	Country	Rank	Country
1	Japan	51	Greece	101	Pakistan
2	Germany	52	Portugal	102	Honduras
3	Sweden	53	Uruguay	103	Côte d'Ivoire
4	Switzerland	54	Azerbaijan	104	United Rep. of Tanzania
5	Finland	55	Lebanon	105	Mozambique
6	USA	56	China, Hong Kong SAR	106	Benin
7	United Kingdom	57	Jordan	107	Yemen
8	Austria	58	Colombia	108	Sri Lanka
9	Belgium	59	Thailand	109	Turkmenistan
10	France	60	Turkey	110	Ethiopia
11	Ireland	61	Kyrgyzstan	111	Cameroon
12	Netherlands	62	Costa Rica	112	Ghana
13	Czech Rep.	63	Algeria	113	Sudan
14	Canada	64	TFYR of Macedonia	114	Malawi
15	Denmark	65	Iran	115	Angola
16	Norway	66	Senegal	116	Madagascar
17	Slovenia	67	Libya	117	Bangladesh
18	Russian Federation	68	Central African Rep.	118	Guinea
19	Singapore	69	Rep. of Moldova	119	Lao People's Dem. Rep.
20	Israel	70	Niger	120	Congo
21	Rep. of Korea	71	Uzbekistan	121	Haiti
22	Slovakia	72	Egypt	122	Nigeria
23	Italy	73	Burundi	123	Papua New Guinea
24	Hungary	74	Philippines	124	Cambodia
25	Ukraine	75	Panama		
26	Poland	76	Indonesia		
27	Spain	77	Tunisia		
28	Mexico	78	Jamaica		
29	Belarus	79	Kenya		
30	Brazil	80	Guatemala		
31	Georgia	81	Peru		
32	Saudi Arabia	82	Albania		
33	New Zealand	83	Dominican Rep.		
34	Armenia	84	Uganda		
35	Argentina	85	El Salvador		
36	South Africa	86	Zambia		
37	Croatia	87	Rwanda		
38	Malaysia	88	Burkina Faso		
39	Sierra Leone	89	Nepal		
40	Australia	90	Mali		
41	Latvia	91	Bolivia		
42	Kazakhstan	92	Tajikistan		
43	Venezuela	93	Paraguay		
44	Lithuania	94	Ecuador		
45	Bosnia Herzegovina	95	Togo		
46	Chile	96	Chad		
47	Bulgaria	97	Syria		
48	Romania	98	Viet Nam		
49	India	99	Nicaragua		
50	China	100	Morocco		

Appendix D. The Ten 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 No. of exports with RCA≥1: **1,362** GDP per capita (US$): **29,695**	Automobiles, spark ignition engine of 1500-3000 cc	6.5	585	Other cyclic hydrocarbons: Cumene	15.6
	Automobiles, spark ignition engine of >3000 cc	3.5	59	Metalworking machine-tools/ ultrasonic machine-tools: For dry-etching patterns on semiconductor materials	30.6
	Parts and accessories of data processing equipment nes	2.6	2,386	Particle accelerators, and parts thereof, nes: Ion implanters for doping semiconductor materials	9.7
	Electronic components: Metal oxide semiconductors	2.3	2,476	Methacrylic acid, salts	19.2
	Electronic components: Monolithic integrated circuits	1.9	2,526	Carbide tool tips etc.: Tool plates/tips/etc., sintered metal carbide & cermets	10.9
(2) Germany No. of exports with RCA≥1: **2,113** GDP per capita (US$): **31,410**	Automobiles, spark ignition engine of 1500-3000 cc	4.9	585	Other cyclic hydrocarbons: Cumene	7.5
	Automobiles, diesel engine of 1500-2500 cc	2.9	485	Metalworking machine-tools/ ultrasonic machine-tools: For dry-etching patterns on semiconductor materials	0.5
	Automobiles, spark ignition engine of >3000 cc	2.6	59	Particle accelerators, and parts thereof, nes: Ion implanters for doping semiconductor materials	0.4
	Medicaments nes, in dosage	2.5	940	Methacrylic acid, salts	30.9
	Motor vehicle parts nes	1.8	327	Carbide tool tips etc.: Tool plates/tips/etc., sintered metal carbide & cermets	14.4
(3) Sweden No. of exports with RCA≥1: **1,145** GDP per capita (US$): **31,191**	Automobiles, spark ignition engine of 1500-3000 cc	4.4	585	Other cyclic hydrocarbons: Cumene	0.0
	Medicaments nes, in dosage	3.8	940	Metalworking machine-tools/ ultrasonic machine-tools: For dry-etching patterns on semiconductor materials	0.2
	Transmit-receive apparatus for radio, TV, etc..	3.1	1,435	Particle accelerators, and parts thereof, nes: Ion implanters for doping semiconductor materials	<0.1
	Petroleum oils and oils obtained from bituminous minerals, other than crude	2.9	4,362	Methacrylic acid, salts	<0.1
	Lumber, coniferous (softwood) thickness < 6 mm	2.1	3,037	Carbide tool tips etc.: Tool plates/tips/etc., sintered metal carbide & cermets	16.0
(4) Switzerland No. of exports with RCA≥1: **1,233** GDP per capita (US$): **35,540**	Medicaments nes, in dosage	7.0	940	Cumene	<0.1
	Gold in unwrought forms non-monetary	4.8	4,851	Mach-tls f dry-etching p	<0.1
	Wrist-watch, base-metal case, battery, with hands	2.1	3,775	Ion implanters for dopin	0.1
	Wrist-watch, base-metal case, automatic wound	1.9	2,158	Methacrylic acid, salts	<0.1
	Antisera and other blood fractions	1.6	36	Tool plates/tips/etc., sintered metal carbide & cermets	1.9
(5) Finland No. of exports with RCA≥1: **766** GDP per capita (US$): **29,883**	Transmit-receive apparatus for radio, TV, etc.	12.4	1,435	Other cyclic hydrocarbons: Cumene	1.8
	Petroleum oils and oils obtained from bituminous minerals, other than crude	3.5	4,362	Metalworking machine-tools/ ultrasonic machine-tools: For dry-etching patterns on semiconductor materials	<0.1
	Paper, fine, light weight coated	2.8	26	Particle accelerators, and parts thereof, nes: Ion implanters for doping semiconductor materials	<0.1
	Paper, fine, wood-containing, uncoated, nes	2.6	327	Methacrylic acid, salts	<0.1
	Lumber, coniferous (softwood) thickness < 6 mm	2.6	3,037	Carbide tool tips etc.: Tool plates/tips/etc., sintered metal carbide & cermets	<0.1
(6) USA No. of exports with RCA≥1: **1,847** GDP per capita (US$): **40,744**	Fixed wing aircraft, unladen weight > 15,000 kg	3.1	2,117	Cumene	24.0
	Metal oxide semiconductor	2.3	2,476	Mach-tls f dry-etching p	57.3
	Parts and accessories of data processing equipment nes	1.9	2,386	Ion implanters for dopin	61.5
	Medicaments nes, in dosage	1.4	940	Methacrylic acid, salts	20.8
	Aircraft parts nes	1.4	1,823	Tool plates/tips/etc., sintered metal carbide & cermets	8.0
(7) United Kingdom No. of exports with RCA≥1: **1,539** GDP per capita (US$): **31,352**	Petroleum oils, oils from bituminous minerals, crude	4.3	5,012	Other cyclic hydrocarbons: Cumene	3.5
	Medicaments nes, in dosage	4.0	940	Metalworking machine-tools/ ultrasonic machine-tools: For dry-etching patterns on semiconductor materials	2.2
	Petroleum oils and oils obtained from bituminous minerals, other than crude	2.8	4,362	Particle accelerators, and parts thereof, nes: Ion implanters for doping semiconductor materials	22.0
	Automobiles, spark ignition engine of 1500-3000 cc	2.6	585	Methacrylic acid, salts	7.5
	Diamonds (jewelry) unworked or simply sawn, cleaved	1.9	4,681	Carbide tool tips etc.: Tool plates/tips/etc., sintered metal carbide & cermets	2.3
(8) Austria	Transmit-receive apparatus for	1.5	1,435	Other cyclic hydrocarbons: Cumene	0.0

Country	Top 5 exports	Share in country's exports	Rank*	Top 5 most complex exports	Share in world's exports
	radio, TV, etc.				
No. of exports with RCA≥1: **1,370**	Electrical energy	1.4	3,020	Metalworking machine-tools/ ultrasonic machine-tools: For dry-etching patterns on semiconductor materials	0.1
GDP per capita (US$): **33,294**	Engines, spark-ignition reciprocating, over 1000 cc	1.4	72	Particle accelerators, and parts thereof, nes: Ion implanters for doping semiconductor materials	0.4
	Automobiles, spark ignition engine of >3000 cc	1.3	59	Methacrylic acid, salts	0.1
	Automobiles, diesel engine of >2500 cc	1.3	870	Carbide tool tips etc.: Tool plates/tips/etc., sintered metal carbide & cermets	4.6
(9) Belgium	Petroleum oils and oils obtained from bituminous minerals, other than crude	4.6	4,362	Other cyclic hydrocarbons: Cumene	0.3
No. of exports with RCA≥1: **1,471**	Automobiles, spark ignition engine of 1500-3000 cc	4.5	585	Metalworking machine-tools/ ultrasonic machine-tools: For dry-etching patterns on semiconductor materials	0.1
GDP per capita (US$): **31,517**	Diamonds (jewelry) unworked or simply sawn, cleaved	3.4	4,681	Particle accelerators, and parts thereof, nes: Ion implanters for doping semiconductor materials	<0.1
	Automobiles, diesel engine of 1500-2500 cc	3.3	485	Methacrylic acid, salts	8.0
	Diamonds (jewelry) worked but not mounted or set	2.8	4,074	Carbide tool tips etc.: Tool plates/tips/etc., sintered metal carbide & cermets	5.6
(10) France	Fixed wing aircraft, unladen weight > 15,000 kg	5.0	2,117	Other cyclic hydrocarbons: Cumene	0.5
No. of exports with RCA≥1: **1,789**	Medicaments nes, in dosage	3.1	940	Metalworking machine-tools/ ultrasonic machine-tools: For dry-etching patterns on semiconductor materials	0.6
GDP per capita (US$): **30,263**	Automobiles, spark ignition engine of 1500-3000 cc	2.5	585	Particle accelerators, and parts thereof, nes: Ion implanters for doping semiconductor materials	1.8
	Automobiles, diesel engine of 1500-2500 cc	2.4	485	Methacrylic acid, salts	4.0
	Motor vehicle parts nes	2.3	327	Carbide tool tips etc.: Tool plates/tips/etc., sintered metal carbide & cermets	1.4

Notes: "nes"—not elsewhere specified
*Product complexity ranking

Appendix E. The Ten 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 No. of exports with RCA≥1: **278** GDP per capita(US$): **1,301**	Jerseys, pullovers, cardigans, waistcoats and similar articles of cotton, knitted or crocheted	10.4	5,076	Carbide tool tips etc.: Tool plates/tips/etc., sintered metal carbide & cermets	<0.001	5
	Women's, girl's trousers & shorts, of cotton, not knitted	7.8	5,026	Other electronic measuring, controlling, etc., apparatus: Instruments nes using optical radiations (UV, visible, IR)	<0.001	8
	Jerseys, pullovers, cardigans, waistcoats and similar articles of manmade fibers, knitted or crocheted	7.8	5,016	Motorcycles, spark ignition engine of > 800 cc	0.001	14
	Unused postage; stamp-impressed papers; stock; check books, etc.: Documents of title (bonds, etc.), unused stamps, etc.	7.4	4,681	Microscopes except optical, diffraction apparatus	<0.001	23
	Men's, boy's trousers & shorts, of cotton, not knitted	5.8	4,985	X-rays apparatus, for medical, surgical or veterinary uses	<0.001	24
(123) Papua New Guinea No. of exports with RCA≥1: **101** GDP per capita (US$): **1,899**	Petroleum oils, oils from bituminous minerals, crude	24.8	5,012	Photo, cine laboratories equipment, nes, screens for projectors: Direct write-on-wafer apparatus	<0.001	6
	Copper ores and concentrates	14.1	4,788	Sheet, plates, rolled of thickness 4,75mm plus, of iron or steel or other alloy steel: Cold rolled alloy-steel nes nfw, <600mm wide	0.019	8
	Gold in unwrought forms non-monetary	13.9	4,851	Other electronic measuring, controlling, etc., apparatus: Instruments nes using optical radiations (UV, visible, IR)	<0.001	8
	Logs, non-coniferous nes	10.1	4,948	Motorcycles, spark ignition engine of > 800 cc	<0.001	14
	Palm oil, crude	5.6	5,043	Microscopes except optical, diffraction apparatus	<0.001	23
(122) Nigeria No. of exports with RCA≥1: **77** GDP per capita (US$): **1,625**	Petroleum oils, oils from bituminous minerals, crude	82.5	5,012	Carbide tool tips, etc.: Tool plates/tips/etc., sintered metal carbide & cermets	<0.001	5
	Natural gas, liquefied	5.6	4,905	Photo, cine laboratories equipment, nes, screens for projectors: Direct write-on-wafer apparatus	<0.001	6
	Petroleum oils and oils obtained from bituminous minerals, other than crude	3.4	4,362	Other machinery, mechanical appliances having individual functions: Laser, light and photon beam process machine tools	<0.001	8
	Cocoa beans, whole or broken, raw or roasted	1.1	5,104	Other electronic measuring, controlling, etc., apparatus: Instruments nes using optical radiations (UV, visible, IR)	0.001	8
	Butanes, liquefied	0.8	4,475	Photo, cine laboratories equipment, nes; screens for projectors: Step and repeat aligners	<0.001	11
(121) Haiti No. of exports with RCA≥1: **152** GDP per capita (US$): **1,114**	T-shirts, singlets and other vests, of cotton, knit	26.9	5,040	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	19.1	5,076	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	5.7	4,905	Self-adhesive plates, sheets, film, plastic, w >20 cm	<0.001	29
	Men's, boy's trousers & shorts, of cotton, not knitted	3.4	4,985	Furnace burners for liquid fuel	0.001	33
	Women's, girl's trousers & shorts, of cotton, knit	2.9	5,065	Valves for oleohydraulic or pneumatic transmissions	<0.001	40
(120) Congo No. of exports with RCA≥1: **57** GDP per capita (US$): **3,374**	Petroleum oils, oils from bituminous minerals, crude	73.4	5,012	Carbide tool tips, etc.: Tool plates/tips/etc., sintered metal carbide & cermets	<0.001	5
	Petroleum oils and oils obtained from bituminous minerals, other than crude	5.9	4,362	Other electronic measuring, controlling, etc., apparatus: Instruments nes using optical radiations (UV, visible, IR)	<0.001	8
	Logs, tropical woods nes	5.0	5,108	Plates, sheet, strip and foil, nickel alloy	0.098	21
	Propane, liquefied	1.7	4,445	X-rays apparatus, for medical, surgical or veterinary uses	<0.001	24
	Cobalt, unwrought, matte, waste or scrap, powders	1.6	3,954	Polyurethanes; in primary forms: Silicones in primary forms	<0.001	29
(119) Lao People's Dem. Rep.	Electrical energy	13.8	3,020	Carbide tool tips, etc.: Tool plates/tips/etc., sintered metal carbide & 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
No. of exports with RCA≥1: **213** GDP per capita (US$): **1,776**	Lumber, non-coniferous nes	13.3	4,772	Other electronic measuring, controlling, etc., apparatus: Instruments nes using optical radiations (UV, visible, IR)	<0.001	8
	Copper cathodes and sections of cathodes unwrought	11.4	4,515	Ethylenediamine, its salts	0.052	13
	Logs, non-coniferous nes	6.9	4,948	Microscopes except optical, diffraction apparatus	<0.001	23
	Motorcycles, spark ignition engine of 50-250 cc	5.3	3,688	Supported catalysts, except nickel or precious metal	<0.001	25
(118) Guinea No. of exports with RCA≥1: **101** GDP per capita (US$): **1,034**	Aluminum ores and concentrates	42.7	4,829	Carbide tool tips, etc.: Tool plates/tips/etc., sintered metal carbide & cermets	<0.001	5
	Aluminum oxide, except artificial corundum	13.1	3,954	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	7.9	5,012	Other electronic measuring, controlling, etc., apparatus: Instruments nes using optical radiations (UV, visible, IR)	<0.001	8
	Diamonds (jewelry) unworked or simply sawn, cleaved	7.7	4,681	Motorcycles, spark ignition engine of > 800 cc	<0.001	14
	Aluminum hydroxide	4.4	2,443	Other chemical derivatives of cellulose, non-plasticized: Cellulose ethers nes, in primary forms	0.001	15
(117) Bangladesh No. of exports with RCA≥1: **437** GDP per capita (US$): **1,017**	T-shirts, singlets and other vests, of cotton, knitted	10.9	5,040	Tool plates/tips/etc., sintered metal carbide & cermets	0.001	5
	Men's, boy's trousers & shorts, of cotton, not knitted	8.4	4,985	Other electronic measuring, controlling, etc., apparatus: Instruments nes using optical radiations (UV, visible, IR)	<0.001	8
	Jerseys, pullovers, cardigans, waistcoats and similar articles of manmade fibres, knitted or crocheted	8.0	5,016	Motorcycles, spark ignition engine of > 800 cc	<0.001	14
	Men's, boy's shirts, of cotton, not knit	5.9	4,997	Other chemical derivatives of cellulose, non-plasticized: Cellulose ethers nes, in primary forms	<0.001	15
	Women's, girl's trousers & shorts, of cotton, not knit	5.7	5,026	Orthopaedic appliances to compensate for a defect or disability: Computed tomography apparatus	0.004	15
(116) Madagascar No. of exports with RCA≥1: **451** GDP per capita (US$): **883**	Vanilla beans	10.7	5,082	Particle accelerators, and parts thereof, nes: Ion implanters for doping semiconductor materials	<0.001	3
	Shrimps and prawns, frozen	10.7	5,060	Carbide tool tips, etc.: Tool plates/tips/etc., sintered metal carbide & cermets	<0.001	5
	Jerseys, pullovers, cardigans, waistcoats and similar articles of wool or hair, knitted or crocheted	7.4	4,829	Other electronic measuring, controlling, etc., apparatus: Instruments nes using optical radiations (UV, visible, IR)	0.001	8
	Women's, girl's trousers & shorts, of cotton, not knitted	5.0	5,026	Motorcycles, spark ignition engine of > 800 cc	0.002	14
	Jerseys, pullovers, cardigans, waistcoats and similar articles of cotton, knitted or crocheted	4.9	5,076	Other chemical derivatives of cellulose, non-plasticized: Cellulose ethers nes, in primary forms	0.001	15
(115) Angola No. of exports with RCA≥1: **14** GDP per capita (US$): **3,324**	Petroleum oils, oils from bituminous minerals, crude	90.5	5,012	Hexamethylenediamine, its salts	<0.001	7
	Diamonds (jewelry) unworked or simply sawn, cleaved	5.0	4,681	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	4,362	Motorcycles, spark ignition engine of > 800 cc	<0.001	14
	Propane, liquefied	0.5	4,445	Other chemical derivatives of cellulose, non-plasticized: Cellulose ethers nes, in primary forms	0.001	15
	Petroleum gases & gaseous hydrocarbons nes, liquefied	0.3	4,131	X-rays apparatus, for medical, surgical or veterinary uses	0.002	24

Note: 'nes' – not elsewhere specified; *Product complexity ranking.