The Changing Sophistication of China's Exports

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Abstract: For China to proceed to the next stage of development, it needs to progress to higher value added, innovative, activities. This paper uses the methods of Kwan (2002) and of Hausmann, Hwang, and Rodrik (2007) to investigate the sophistication of China's exports. The results indicate that China's exports are far from the technology frontier. Nevertheless, they have steadily progressed and more of the value-added of the exports are now produced in China. To continue increasing the sophistication of its exports, China should prioritize the education and health of its citizens and especially of children in the rural sector.

1. Introduction

The Chinese miracle emerged as low cost Chinese labor was joined with sophisticated foreign technologies. This combination helped China to become the world's leading exporter. Chinese workers in the past were largely involved in assembling final goods such as computers and mobile phones using semiconductors and other parts and components that were imported from abroad. Much of the research and development and other high value-added activities were performed outside of the country. If China is to proceed to the next stage of development, however, it is important that it take part in innovative, higher value-added activities. This paper takes stock by examining the technological sophistication of China's exports.

To calculate the sophistication of China's exports, the methods of Kwan (2002) and Hausmann, Rodrik, and Zhang (2007) are used. They posited that goods that wealthy countries export have higher productivity levels. The rationale for their assumption is that firms in wealthier countries have to pay higher wage rates, and they thus need to employ more technologically sophisticated processes in order to remain competitive (see Lall et al., 2006).

The findings in this paper indicate that China's export basket is far from the technological frontier. The exports of Japan, the technology leader in Asia, are more concentrated in sophisticated machinery, capital goods, and parts and components than the exports of China are. Nevertheless, China's exports have become more sophisticated. It also has a well-diversified export basket that should make it less vulnerable to shocks to demand, the terms of trade, or technology and it is increasing the domestic content of its exports.

The next section discusses the data and methodology employed to examine the sophistication of China's exports. Section 3 presents the results. Section 4 concludes.

2. Data and Methodology

Kwan (2002) posited that firms in countries with higher per capita incomes will export higher value-added products. This will be the case because they must pay higher wage rates, and to be competitive they will thus need to employ more advanced production techniques. To measure technological sophistication, he constructed a product sophistication index (PSI) for each type of export by calculating a weighted average of the per capita GDPs of the product's exporters, using the countries' shares of global exports as weights. For example, if machine tools were only exported by country 1, country 2, and country 3, and if their respective shares of the global export market were 60%, 30% and 10% and their respective per capita GDP values were $40,000, $10,000, and $1,000, then the PSI for semiconductors would be $40,000*60% + $10,000*30% + $1,000*10% = $28,000.

The product sophistication index for a good k can thus be represented as:

$$PSI(k) = \frac{\sum_j x(jk)Y(j)}{X(k)}, \qquad (1)$$

where PSI(k) is the product sophistication index for product k, x(jk) are exports of product k by country j, Y(j) is per capita gross domestic product in country j, and X(k) are total world exports of product k. Equation (1) is a weighted average of the per capita GDPs of product k's exporters, using the countries' shares of global exports of k as weights.

To understand this index it is useful to consider a couple of examples. Table 1 presents data on the ten leading exporters of pharmaceutical products (ISIC 2423). The ratio of ratio of R&D spending to value-added is very high for pharmaceuticals. Table 2 presents data on the ten leading exporters of knitwear (ISIC 1730). This category includes knitted fabrics, crocheted articles, and other lower technology goods. For pharmaceuticals, apart from China all of the

leading exporters are high income countries. For knitwear, however, the leading exporters include developing and emerging economies such as Bangladesh, Turkey, Vietnam, and India. The value of the PSI for pharmaceutical products was thus high in 2013 ($47,176) while the value of the PSI for knitwear was low ($16,645).

To measure the level of sophistication of a country's overall export basket, Kwan (2002) assumed that the greater the proportion of high PSI products in a country's exports, the more sophisticated its export structure is. For example, assume that the PSI is $40,000 for pharmaceutical products, $30,000 for medical equipment, $20,000 for automobiles, and $10,000 for clothing and that a country's export basket is composed of 50% pharmaceutical products, 30% automobiles, and 20% furniture. Then the country's sophistication index (CSI) would equal $30,000*50% + $20,000 *30% + $10,000*20% = $23,000.

The sophistication index for country j can thus be calculated using the formula:

$$CSI(j) = \frac{\sum_k x(jk)PSI(k)}{X(j)}, \quad (2)$$

where CSI(j) is the country sophistication index for country j, x(jk) are exports of product k by country j, PSI(k) is the product sophistication index for product k, and X(j) are total exports of country j to the world. Equation (2) is thus a weighted average of the product sophistication indexes of the goods that country j exports, using the percentage of country j's total exports in each good as weights.

Hausmann et al. (2007) argued that the weighting scheme in equation (1) gives too much weight to large countries. For example, US exports of wearing apparel in 1996 equaled $5.4 billion while the value of Bangladeshi exports of wearing apparel equaled $1.9 billion. For the US, this equaled less than one percent of total exports while for Bangladesh this equaled more

than fifty percent of exports. Even though clothing exports are more important to Bangladesh than to the US, equation (1) would weigh US income more heavily than Bangladeshi income in calculating the CSI.

To avoid underweighting smaller countries, Hausmann et al. (2007) recommended weighting per capita GDP in equation (1) by each country's revealed comparative advantage in product k. They called the resulting measure the productivity level of good k, and calculated it as:

$$PRODY(k) = \sum_j \frac{\left(\frac{x(jk)}{X(j)}\right)}{\sum_j \left(\frac{x(jk)}{X(j)}\right)} Y(j), \quad (3)$$

where PRODY(k) is the productivity level of good k, x(jk)/X(j) is the share of commodity k in country j's overall export basket, $\sum_j$(x(jk)/X(j)) is the sum of the value shares across all countries j exporting product k, and Y(j) is per capita GDP in country j.

Hausmann et al. (2007) then used PRODY to calculate the overall sophistication of a country's export basket. They called this measure the productivity level associated with a country's exports (EXPY) and calculate it using the formula:

$$EXPY(j) = \frac{\sum_k x(jk) PRODY(k)}{X(j)}, \quad (4)$$

where EXPY(j) is the productivity level associated with country j's export basket, PRODY(k) is the productivity level of good k, and x(jk)/X(j) is the share of commodity k in country j's overall export basket. Equation 4 is thus a weighted average of the productivity levels of the goods that a country exports, with the weights determined by the share of each good in the country's export basket.

To calculate equations (1) through (4), data on 83 country's exports to the world disaggregated to the 4-digit ISIC level are used. The data are measured in U.S. dollars and obtained from the CEPII-CHELEM database. Data on GDP per capita measured in constant US dollars are also obtained from the CEPII-CHELEM database. The data are thus measured in a consistent and coherent way across countries.

Several robustness checks are also employed. One involves employing a different disaggregation of goods (for instance the categories used by Centre D'Etudes Prospectives et D'Information Internationales are employed). Another involves calculating equations (1) and (2) excluding China, since the fact that China has a very large share of world exports in several categories may bias the results.

3. Results

Table 3 presents the country sophistication index for the world's leading and lagging economy and for several Asian economies in 2013. Data for other countries are available on request. Columns (1) and (2) present results for the CSI calculated using Kwan's (2002) method and including China when calculating the PSI, columns (3) and (4) for the CSI calculated using Kwan's method and excluding China when calculating the PSI, and columns (5) and (6) for the CSI calculated using Hausmann et al.'s (2007) method. The results in columns (4) through (6) try to control for the fact that China, as a large exporter, may distort the calculations.

In every case Switzerland is the leading country. This finding occurs across almost every specification and year employed (not reported here). China in columns (1) and (2) ranks 79th out of 83 countries. This low value may be partly because China's status as a major world exporter in several categories distorts the results. In columns (4) and (6), where an attempt is made to

control for this bias, China's ranking rises to 51st and 53rd place. On average across the three specifications, China's CSI is more than 40 percent below the world's leader (Switzerland) and more than 20 percent below Asia's leader (Japan).

To try to understand why China's export structure falls short of Japan's, Table 4 orders China and Japan's exports by PSI for every category that comprises at least one percent of Japan's or China's exports. The table indicates that more of Japan's exports are in sophisticated categories of machinery, automobiles and automobile parts and components, and similar goods. More than 50 percent of Japan's exports are in products with PSIs above 35,000, while less than 17 percent of China's exports are in these categories.

Many of China's exports in Table 4 are in categories with low PSIs, including computers, televisions, mobile phone (ISIC 322), clothing, toys, and footwear. While computers, televisions, and mobile phones may seem like sophisticated products, they have become more commoditized in recent years and much of the competition in these goods is now in terms of price.

To further compare China and Japan's exports, Table 5 focuses on machinery and equipment exports (ISIC category 29). The table shows that almost one quarter of Japan's machinery exports are in category 2929 that has the highest PSI. This category contains sophisticated products such as industrial robots and semiconductor manufacturing machines. Only 8 percent of China's machinery exports are in this category. Another 8 percent of Japan's exports are in the second most sophisticated category, engines excluding vehicle engines. This includes turbines, marine engines, and railway engines. Only 2 percent of China's machinery exports are in this category. By contrast, almost one-quarter of China's machinery exports are in the least sophisticated category, household appliances (ISIC category 2930). This category

includes washing machines, dishwashers, and vacuum cleaners. Only 1 percent of Japan's machinery exports are in this category.

While the evidence above indicates that the sophistication of Japan's exports is greater than the sophistication of China's exports, another question is whether China is catching up with Japan. One way to determine this is to calculate a trade correlation index (TCI) for China and Japan's trade. The United Nations Conference on Trade and Development (UNCTAD) introduced this index.[1] The TCI investigates the similarity between two countries' export baskets. This makes it possible to determine whether they compete or cooperate with each other. Because a consistent series is not available from UNCTAD extending to 2013, TCIs are recalculated in this paper. To construct the TCI, China and Japan's country's trade specializations are first determined at the four digit ISIC levels. Trade specialization for each category is calculated by dividing the net flow of goods (exports minus imports) to the total flow of goods (exports plus imports). The higher the value of this normalized trade balance for a particular product, the more competitive the country is in this product compared to other countries. The TCI is then the simple correlation coefficient between China and Japan's trade specialization values across all products. The correlation coefficient varies from -1 to +1. TCI values greater than 0 imply that the two countries' export structures are competitive, and values less than 0 imply that they are complementary. The closer the trade correlation index between two countries is to +1 (-1), the more the countries' exports are competitive (complementary).

In 1999, the TCI between Japan and China was -0.22; in 2004 it was -0.11; in 2007 it was 0.07; in 2011 it was 0.08; in 2012 it was 0.16; and in 2013 it was 0.18. Thus China is

[1] See www.unctad.org .

increasingly moving into the products that Japan is exporting, even though Tables 4 and 5 indicate that Japan's exports ae still more heavily weighted in products with higher PSIs.

When examining China's exports, it is also necessary to consider how China's value-added is changing. Because of global value chains, part of the value added of China's exports comes from imported parts and components.

One way to gauge what is happening to China's value-added is to examine how processed and ordinary exports are changing over time. Processed exports are produced through East Asian production networks while ordinary exports are produced primarily using domestic inputs (see Gaulier, Lemoine, and Unal-Kesenci, 2005). Processed exports therefore contain much more foreign value-added than ordinary exports (see also Xing and Jinjarak, 2015).

Figure 1 shows that ordinary exports have become progressively more important than processed exports. One implication of this is that China's value-added in its exports has progressively increased.

One other implication of the results reported in this paper is that China's export basket is well diversified. This is evident from Table 4 and from Figure 2. Figure 2 shows that Bangladesh's exports are concentrated in very low PSI products. By contrast, China's export basket is spread across several values. China produces machinery exports, electronics exports, clothing exports, and many other product categories. This implies that China is less exposed to shocks to demand, technology, and the terms of trade that can afflict countries specializing in only a few exports.

4. Conclusion

A number of studies have indicated that the sophistication level of a country's exports matters. For instance, Hausmann *et al.* (2007) found that countries that export what rich countries export tend to subsequently grow more rapidly than other countries. They reported that this is true controlling for initial per capita income, human capital levels, and country-specific characteristics. Jarreau and Poncet (2012), using a similar specification, found that provinces in China that export more sophisticated products tend to grow more rapidly than other provinces.

This paper uses the methods of Kwan (2002) and of Hausmann, *et al.* (2007) to investigate the sophistication of China's exports. The results indicate that, compared with Japan, China's exports are much less sophisticated.

How can China increase the sophistication of its exports. Rozelle (2010) emphasized the importance of education in promoting innovation and productivity growth. To underscored the need for Chinese students to study mathematics, science, English, and computers.

Rozelle (2010) also highlighted the need to invest in children starting at a young age. Rural children cannot afford preschool, and sometime face difficulties attending elementary school because of poor accessibility and long, dangerous commutes. Many problems that students face, such as anemia, vitamin deficiencies, visual difficulties, and worms, can be solved at very low cost.

Rozelle noted that high school tuition in China can be 20 times the per capita annual income of the rural poor. Because of this only 25 percent of rural students finishes high school. In Japan, Korea, and Taipei,China, on the other hand, almost all students finish high school. College tuition is also prohibitively expensive and only three percent of rural students are able to attend a tier 1 or tier 2 university. Promoting education would help China to keep climbing the ladder of comparative advantage.

China has made great strides, first in becoming an export powerhouse and second in increasing the sophistication of its exports. To continue of this path, it should prioritize investing in the health and education of the Chinese people. This can help it to avoid the middle income trap and propel it into high income status.

Table 1. Leading exporters of Pharmaceutical products.

Country	Share of World Exports in 2013
Germany	13.5
Switzerland	11.3
Belgium	9.2
United States	9.1
France	6.8
Ireland	6.8
United Kingdom	5.6
The Netherlands	5.2
Italy	4.4
China	3.5

Note: Pharmaceutical products come from ISIC Category 2423.
Source: CEPII-CHELEM database.

Table 2. Leading exporters of Knitwear

Country	Share of World Exports in 2013
China, People's Rep.	38.9
Bangladesh	6.3
Turkey	6.2
Italy	5.2
Germany	4.6
South Korea	3.8
Vietnam	2.9
India	2.6
Taipei,China	2.3
Spain	2.2

Note: Knitwear comes from ISIC Category 1730.
Source: CEPII-CHELEM database.

Table 3. Country sophistication index (CSI) for the leading and lagging country and for East and Southeast Asian economies.

CSI Calculated using Kwan's Method (including China)		CSI Calculated using Kwan's Method (including China)		CSI Calculated using Hausmann et al.'s Method	
(1)	(2)	(3)	(4)	(5)	(6)
Country	Country Sophistication Index (rank)	Country	Country Sophistication Index (rank)	Country	Country Sophistication Index (rank)
Switzerland	41302 (1)	Switzerland	45013 (1)	Switzerland	37287 (1)
Japan	33381 (16)	Japan	36955 (14)	Japan	27733 (11)
South Korea	30692 (44)	South Korea	34498 (32)	Taipei,China	25429 (23)
Taipei,China	29780 (52)	Taipei,China	34154 (39)	South Korea	25243 (26)
Thailand	29038 (55)	Thailand	33251 (49)	Thailand	23618 (37)
Malaysia	27821 (63)	China, People's Rep.	32564 (53)	Philippines	22663 (47)
Indonesia	27715 (64)	Philippines	32196 (55)	Malaysia	22421 (49)
Philippines	27386 (66)	Malaysia	31388 (57)	China, People's Rep.	22376 (51)
China, People's Rep.	25453 (79)	Indonesia	30123 (63)	Indonesia	20579 (58)
Viet Nam	22599 (82)	Viet Nam	28845 (69)	Viet Nam	18785 (71)
Bangladesh	17592 (83)	Bangladesh	23754 (83)	Bangladesh	10215 (83)

Note: The value in parentheses represents the ranking relative to 83 countries.

Source: Calculations by the authors.

Table 4. Japan's and China's Exports Weighted by the Product Sophistication Index of the Export.

Product (ISIC classification)	Product Sophistication Index in 2013	Percent of Product in Japan's Total Exports	Percent of Product in China's Total Exports	Percent of Japan's Exports Greater than or Equal to the PSI	Percent of China's Exports Greater than or Equal to the PSI
Pharm. prod. (2423)	47176	0.85	0.97	1.11	1.35
Medical equip. (3311)	43941	1.00	0.56	2.18	1.95
Aeronautics (3530)	42393	1.11	0.15	3.29	2.11
O.spec. mach. (2929)	41023	3.80	0.72	7.14	2.86
Engines, Turbines(2911)	40938	1.21	0.22	8.37	3.11
O.chem. prod. (2429)	39607	2.77	0.95	12.46	4.56
Measur. instr. (3312)	39226	2.36	0.80	14.83	5.36
Mach.for mining (2924)	37315	1.78	0.79	17.22	6.91
Machine tools (2922)	37010	2.03	0.80	19.29	7.85
Lifting equip. (2915)	36890	0.77	0.65	20.06	8.50
Motor vehicl. (3410)	36867	16.30	0.72	36.36	9.21
Gears (2913)	36299	1.47	0.47	37.85	9.78
N.ferr. metall. (2720)	36289	3.21	1.85	41.05	11.63
Primary plastic (2413)	36267	2.14	0.55	43.20	12.18
Pumps (2912)	36016	2.28	1.42	45.82	13.92
B.chem. ex fert (2411)	35128	4.63	2.27	50.90	16.81
Parts for vehicles (3430)	34591	6.40	1.32	57.43	18.46
O.gen.p mach. (2919)	33697	1.29	1.52	58.86	20.19
El.dist appar. (3120)	33110	2.14	1.23	61.33	21.72
Plastic prod. (2520)	32257	2.04	2.28	63.41	24.20
Mach.fr textile (2926)	32045	0.46	0.29	63.86	24.50
Cutlery Tools (2893)	31629	0.62	0.77	64.49	25.31

Refined petrol. (2320)	31249	2.15	1.03	66.65	26.64
Iron metallurg (2710)	31097	6.26	2.56	72.91	29.19
O.metal prod. (2899)	30148	1.06	2.19	74.03	31.56
Other textiles (1729)	29819	0.27	0.57	74.58	32.53
Electric. motors (3110)	29685	1.29	1.99	75.87	34.51
Glass and pr. (2610)	29633	0.72	0.72	76.59	35.24
Struct. metal p (2811)	29608	0.07	0.66	76.66	35.89
Preserved fruit (1513)	29160	0.01	0.45	76.67	36.35
Accum. Batter. (3140)	28369	0.58	0.45	77.35	36.93
Electr. compon. (3210)	27706	6.48	3.12	83.84	40.16
Optics Photo (3320)	27158	2.32	1.38	86.16	41.54
Wires Cables (3130)	27111	0.28	0.72	86.46	42.32
Tires (2511)	26144	1.07	0.82	87.87	43.40
O.elec. equip. (3190)	26050	1.68	1.47	89.55	44.87
Ships (3511)	25941	2.05	0.82	91.63	46.29
Preserved fish (1512)	24659	0.26	0.62	92.03	47.21
Motorcycles (3591)	24189	0.56	0.41	92.58	47.64
Rubber products nes (2519)	23840	0.48	0.31	93.06	47.96
Other manuf. (3699)	23244	0.29	1.39	93.35	49.34
Furniture (3610)	22172	0.15	2.30	93.85	52.36
Domestic. appl. (2930)	21230	0.19	2.07	94.09	54.77
Sports goods (3693)	21049	0.093	0.56	94.18	55.34
Elec. lamps (3150)	20945	0.12	1.51	94.30	56.85
Computer equip. (3000)	20505	2.42	10.57	96.74	67.81
Luggage Harness (1912)	20112	0.01	1.47	96.77	69.32
TVradio transmitters (3220)	18320	1.52	9.74	98.34	79.37
Games Toys (3694)	18021	0.13	1.70	98.48	81.07

TVradio receivers (3230)	17769	0.92	3.83	99.39	84.91
Tex.fib Fabrics (1711)	17197	0.42	1.95	99.81	86.86
Footwear (1920)	16982	0.01	2.72	99.82	89.57
Knitwear (1730)	16646	0.11	2.24	99.92	91.82
Wearing apparel (1810)	15212	0.06	6.29	99.98	98.52
Other textile articles (1721)	13982	0.02	1.46	100	99.98

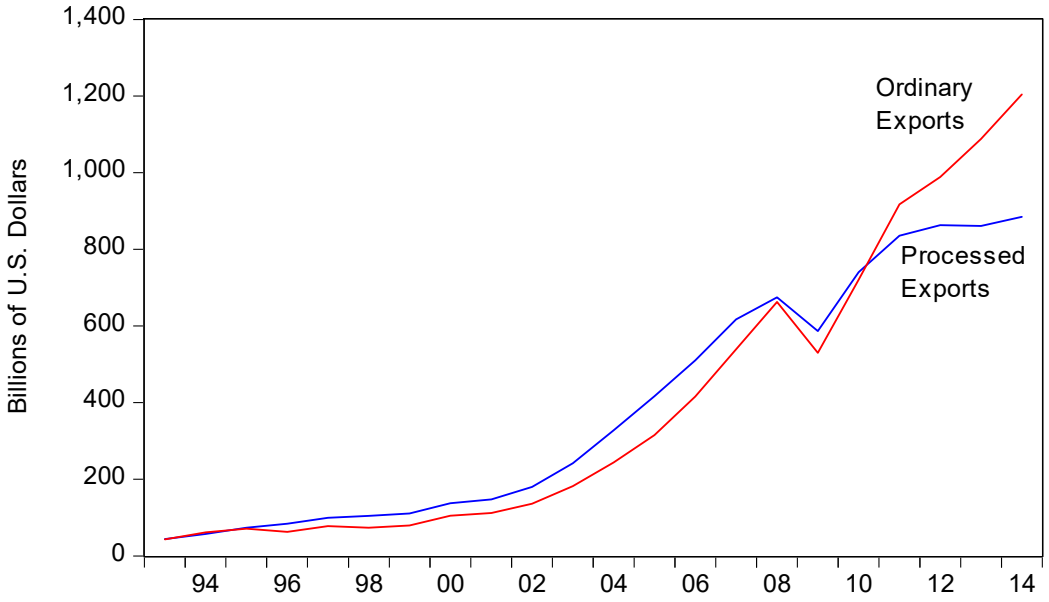
Note: Includes all export categories where the value of exports for either Japan or China exceeds one percent when rounded to one significant digit.
Source: CEPII-CHELEM database and calculations by the authors.

Table 5. Japan's and China's Machinery and Equipment Exports.

Product	Product Sophistication Index in 2013	PSI Ranking in 2013 (out of 147 categories)	Percent of Japan's Machinery and Equipment Exports	Percent of China's Machinery and Equipment Exports
Other special purpose machinery (2929)	41024	9	24	8
Engines, exc. vehicle engines (2911)	40938	10	8	2
Machinery for food processing (2925)	40205	12	0	1
Agric. and forestry machinery (2921)	38340	19	2	2
Ovens, furnaces and burners (2914)	37327	20	1	1
Machinery for mining & constr. (2924)	37315	21	11	9
Machine-tools (2922)	37011	24	13	9
Lifting and handling equipment (2915)	36890	25	5	7
Bearings, gears (2913)	36300	28	9	5
Pumps, taps and valves (2912)	36016	31	14	15
Oth. general purpose machinery (2919)	33697	48	8	16
Machinery for metallurgy (2923)	33523	49	1	1
Machinery for textile prod. (2926)	32045	53	3	3
Domestic appliances n.e.c. (2930)	21230	93	1	22

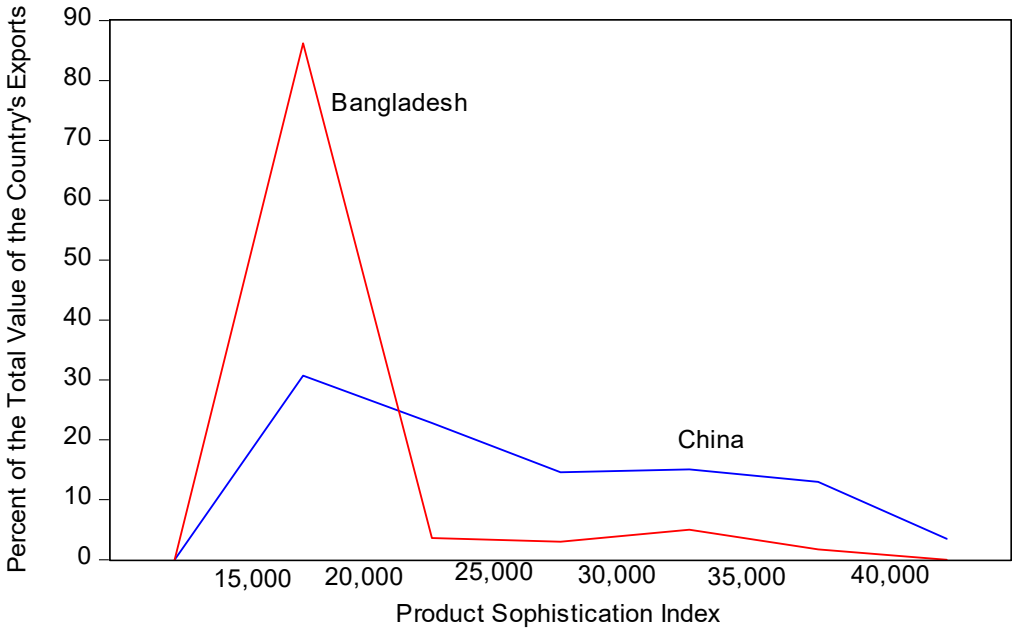
Source: CEPII-CHELEM database and calculations by the authors.

Figure 1. China's Ordinary and Processed Exports.



Source: China Customs Statistics.

Figure 2. Product Sophistication Index Values for China and Bangladesh



Source: Calculations by the author.

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