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The sophistication of exports: Is China special?

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ABSTRACT

Recent studies have found that China is "special" in exporting highly sophisticated goods not comparable with its income level. In this paper we identify two measurement biases that account for this "China is special" observation. First, product quality has not been fully considered in the measurement of sophistication, which has caused an overestimation of the sophistication of China's exports. Second, the average income of China has been used to measure the export capability of China, which has caused an underestimation of China's capability of exporting sophisticated goods. After correcting the two measurement biases, China appears much less as an outlier in the cross-country comparison of the sophistication of exports.

1. Introduction

China has achieved spectacular growth in export volume in the past three decades. Equally impressive is China's rapid upgrade of its export structure. Table 1 reports data on China's 14 manufacturing industries ranked by R&D intensity. In 1992, "Textiles, apparel, leather and footwear", the least R&D-intensive industry, accounted for 44.5% of China's manufacturing exports to the world. By 2005, this industry's export share fell to 18.8%. Taking its place are two R&D-intensive industries, "Electrical machinery; radio, television and communication equipment" and "Machinery and equipment; office, accounting and computing machinery", which represented 42.5% of China's manufacturing exports to the world in 2005.

An even more startling feature of China's exports, identified by Rodrik (2006) and Schott (2008), is that the measured sophistication of China's exports far exceeds what would be expected from its stage of development. Fig. 1 illustrates the relative export sophistication of 141 countries in 1996 (based on data of exports to the U.S.). In both graphs, the vertical axis shows the measured export sophistication of a country (EXPY and ESI are two export sophistication indices, which we will discuss in Section 2), and the horizontal axis shows a country's per capita GDP (PCGDP). The graphs reveal a positive relationship between the export sophistication index and PCGDP, with China (CHN) as a clear outlier above the trend line. This exceptionally high level of export sophistication for China was considered by Rodrik (2006) as "special".[1]

Fig. 1 shows that China's outlier status is determined by the values of two parameters: the relatively high level of China's export sophistication and the relatively low level of China's PCGDP. One would naturally ask: are these two parameters properly measured? The sophistication indices used by Rodrik (2006) and Schott (2008) are constructed from product-level trade data. Schott (2004) found that even with the most detailed product classification (HS 10-digit), the product varieties from different

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[1] China's outlier status looks more pronounced in Fig. 3 of Rodrik (2006). The reader must notice that China is not the only outlier in Fig. 1. This issue will be discussed later.

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Table 1
China's manufacturing exports to the world, 1992–2005.

Industries (ISIC codes)	R&D intensity	Export share		
		1992 (%)	2005 (%)	Growth (%)
Transport equipment (34, 35)	0.698	2.9	3.8	2.0
Electrical machinery; radio, television and communication equipment (31, 32)	0.690	10.5	21.2	5.6
Medical, precision and optical Instruments; watches and clocks (33)	0.677	3.1	3.1	0.1
Machinery and equipment; office, accounting and computing machinery (29, 30)	0.354	5.8	21.3	10.6
Chemicals and chemical products (24)	0.172	6.4	4.8	−2.1
Basic metals (27)	0.170	2.4	4.0	4.0
Coke, refined petroleum products, nuclear fuel (23)	0.154	0.5	6.2	22.0
Rubber and plastics (25)	0.130	2.4	2.6	0.8
Other non-metallic mineral products (26)	0.122	2.4	1.8	−2.3
Food products, beverages and tobacco (15, 16)	0.089	4.9	1.5	−8.8
Fabricated metal products (28)	0.079	3.4	3.4	0.0
Wood, paper, printing, and publishing (20, 21, 22)	0.077	2.4	1.7	−2.7
Furniture, jewelry, musical instruments, sports goods, games and toys, and other manufacturing (36, 37)	0.076	8.7	5.9	−2.9
Textiles, apparel, leather and footwear (17, 18, 19)	0.053	44.5	18.8	−6.4

Notes: R&D intensity is the ratio of R&D expenditure to gross output of Chinese firms in the respective industry in 2001, multiplied by 100. Data on R&D expenditure and gross product are from China's national surveys of firms. Data on China's exports to the world are from UN Commodity Trade Statistics Database. Export share growth is the average annual growth rate of export share of the respective industry in China from 1992 to 2005.

countries are highly heterogeneous despite being in the same product category. For the same HS10 product exported to the U.S., the prices vary considerably across the exporting countries. Schott (2008) viewed this price difference within the same product category as reflecting "within-product sophistication". He found that while China's across-product export sophistication (measured by EXPY or ESI) is exceptionally high, its within-product export sophistication turns out to be exceptionally low. In other words, although many of China's exported goods belong to sophisticated categories, they may well be the low-quality varieties. Without considering the product quality dimension, one would overestimate the sophistication of China's exports.

Theoretically speaking, the sophistication of a country's export structure is determined by the country's technology and capital endowment in producing the exports. To the extent that PCGDP measures a country's export capability, it can serve as the single variable in predicting the country's export sophistication. However, for countries with high regional heterogeneity, the overall PCGDP is a poor measure of export capability. China's coastal provinces, which account for over 90% of China's exports, have an average PCGDP level 1.5 to 2 times that of China's overall PCGDP. Without taking this into account, one would underestimate the export capability against which the relative export sophistication is evaluated.

The purpose of this paper is to evaluate the parameters that establish the "China is special" observation. Our main finding is that China's exports appear "special" because the sophistication measures do not fully consider product quality and because China's overall PCGDP underestimates the development level of its exporting regions. Although both factors have been mentioned in previous studies (e.g. Schott, 2008), this paper makes a distinctive contribution in providing a systematic evaluation of their individual and combined effects. We find that China's outlier status is reduced after introducing product-quality or PCGDP adjustments to the analysis, but the individual effect of each is not large enough to reject the "China is special" hypothesis. However, the combined effect of the two adjustments makes China no longer an outlier in the cross-country comparison of export sophistication. Our finding is useful in the context of the debate on the nature of China's exports. Rodrik (2006) considered China's outlier status as evidence that China's export experience was neither "a simple story of specialization according to comparative advantage," nor "a straightforward story of export growth achieved through trade openness and free market forces." Our finding shows however that China's outlier status can be explained by economic fundamentals if the relevant variables are properly measured.

While this paper focuses on the measurement issues in the evaluation of China's export sophistication, a number of recent papers have explored the reasons behind the high sophistication of China's exports. Wang and Wei (2010) find that improvements in human capital and government policies in the form of tax-favored high-tech zones have been key determinants of China's rising export sophistication. Van Assche and Gangnes (2010) argue that the high sophistication of China's exports may simply be a result of the high sophistication of imported inputs in the processing trade. Using a sophistication index based on production data, they find no evidence that China's electronics production activities are exceptionally sophisticated. Amiti and Freund (2010) also argue that the observed high sophistication of China's exports might be a result of processing trade. Their computation shows that the skill content of China's total exports increased significantly from 1992 to 2005, but little increase was found when processing exports were excluded from total exports. Besides processing trade, foreign firms are also considered a major force behind the rise of China's export sophistication. Xu and Lu (2009) find that foreign firms from advanced countries have contributed significantly to the increase of the sophistication of China's exports.

The remainder of the paper is organized as follows. In Section 2 we discuss the export sophistication measures and replicate the "China is special" result. In Section 3 we introduce the product quality dimension to the measurement of export sophistication, and evaluate the sensitivity of the measured export sophistication of China to the product quality adjustment. In Section 4 we discuss the measurement of a country's capability of exporting sophisticated goods and consider regional heterogeneity. In Section 5 we conclude. We provide a description of our data in Appendix A.

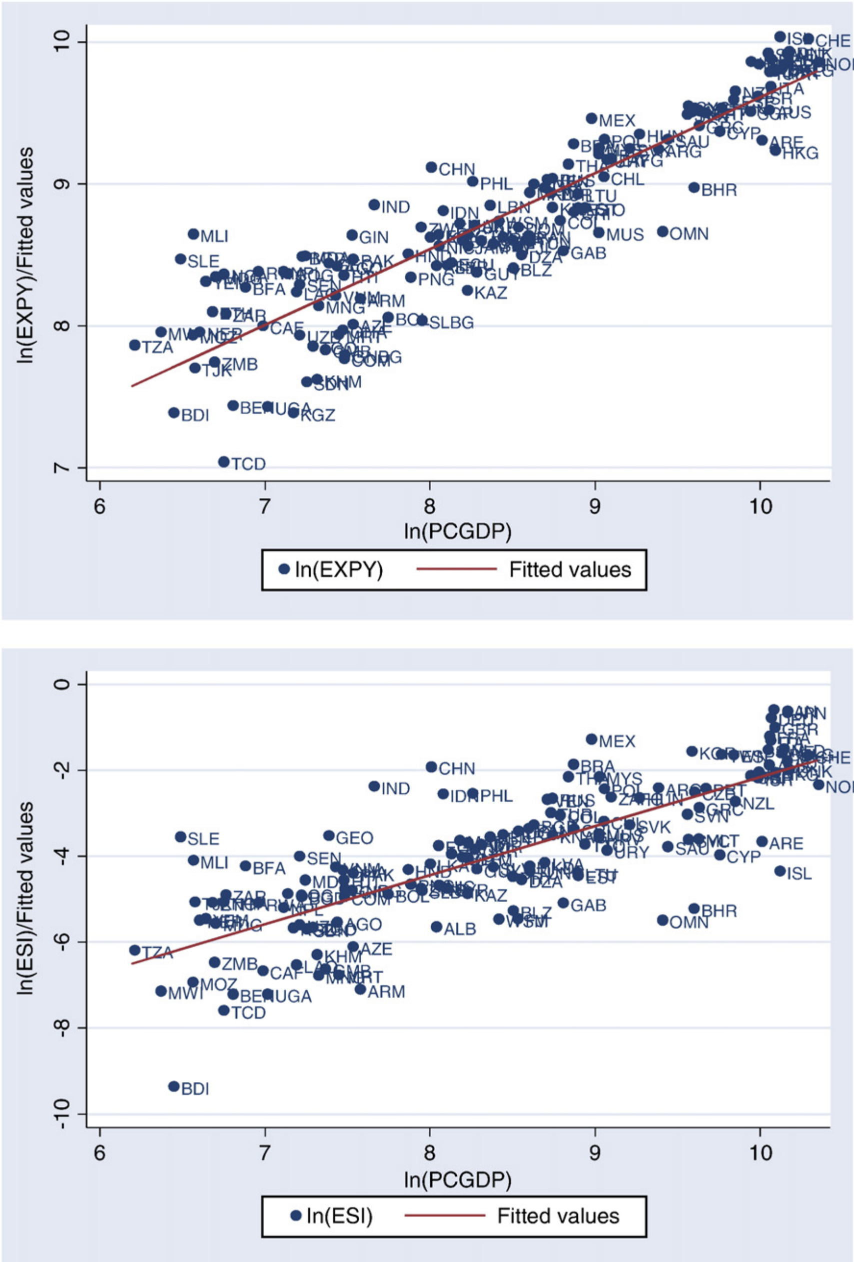

Fig. 1. Export sophistication relative to income, 1996.

2. The sophistication of China's exports

2.1. Measurement

The sophistication of a country's exports is measured by two indices in the recent literature. The first one is an "income content index" constructed by Rodrik (2006) and Hausmann, Hwang and Rodrik (2007).[2] This index, denoted by EXPY, measures the sophistication of country *c*'s exports as

$$EXPY_c = \sum_{j \in I} s_{ic} PRODY_i \tag{1}$$

[2] Similar indices have been constructed by Michaely (1984) and Lall, Weiss and Zhang (2006).

where $PRODY_i$ is the sophistication of good i, I is the set of goods country c exports, and s_{ic} is the share of good i in country c's total export value. Thus a country's export sophistication is the weighted average of the sophistication of all its exported goods. For good i, its sophistication is measured by

$$PRODY_i = \sum_{j \in C_i} \left\{ \frac{S_{ij}}{\sum\limits_{n \in C_i} S_{in}} Y_j \right\} \tag{2}$$

where Y_j is the income level (real GDP per capita) of country j. According to Eq. (2), the sophistication of good i is given by the weighted average of the income levels of all countries in set C_i that export the good, where the weight variable $(s_{ij}/\sum s_{in})$ reflects the importance of good i in country j's exports *relative to* all the other countries that export the good. A good is considered more sophisticated if it is exported more intensively by high-income countries, and a good is considered less sophisticated if it is exported more intensively by low-income countries. Thus the sophistication of a country's exports is revealed by the “income content” of the exports.

The second measure, Export Similarity Index (ESI), computes the overlap of a country's exports with that of a set of advanced countries:[3]

$$ESI_{cd} = \sum_{i \in I} \min(S_{ic}, S_{id}) \tag{3}$$

In Eq. (3), ESI_{cd} is the similarity between country c's export bundle and country d's export bundle. Denoting d as the set of OECD countries, ESI_{cd} reveals the sophistication of country c's exports measured against OECD exports.

2.2. The “China is special” result

Two recent studies (Rodrik, 2006; Schott, 2008) examined the relationship between a country's export sophistication (EXPY or ESI) and its PCGDP. Both studies found a positive relationship between EXPY/ESI and PCGDP, and China stands out as an outlier with its EXPY/ESI significantly higher than the level predicted by its PCGDP.

The results of Rodrik (2006) and Schott (2008) may be replicated using the following regression equation:[4]

$$\log(EXPY_{ct}/ESI_{ct}) = \alpha_t + \beta \log(PCFDP_{ct}) + \gamma CHN + \varepsilon_{ct} \tag{4}$$

where CHN is a dummy variable for China and ε is an error term. The regression is performed on a sample of 141 countries in the period 1992–2005. Table 2 reports the results. In regressions (2.1) and (2.3), the estimated coefficients of CHN are positive and statistically significant at the 1% level, implying that China is a positive outlier in export sophistication relative to countries with similar PCGDP. In regressions (2.2) and (2.4), the effect of CHN is estimated for three sub-periods (1992–1995, 1996–2000, and 2001–2005). The results show that the estimated coefficients of CHN remain positive and statistically significant at the 1% level, and the point estimates show a declining trend over time, as was also noted by Rodrik (2006).

To get a more concrete idea about how “special” China is, we display in Table 3 the group of ten countries at PCGDP levels similar to China's. The table shows that in 1992, China's EXPY (7356) and ESI (0.104) were both significantly higher than the group average (4250; 0.019); India also appears to have been an outlier (7358; 0.059). In 2004, China moved up to a group of countries with higher PCGDP. Again, China's EXPY (12,524) and ESI (0.161) were both significantly higher than the group average (7225; 0.037); Venezuela also appears to have been “special” (10,985; 0.076).

The examples of India and Venezuela indicate that China was not the only outlier in the cross-country relationship between EXPY/ESI and PCGDP. It is also clear from Fig. 1 that in 1996 India (IND) and Mexico (MEX) looked as special as China. Fig. 1 shows that there were also outliers below the fitted line, such as Hong Kong (HKG). Thus there could be many “Country X is special” results. Notice that a country's outlier status in Fig. 1 was established on the values of two parameters: the sophistication index and PCGDP. In the next two sections, we evaluate these two key parameters.

3. The quality of China's exports

We first evaluate the sophistication measures. Conceptually, neither EXPY nor ESI necessarily reflect the sophistication of a country's exports. For example, a rich country might export a high-PRODY good because of its natural resources.[5] On the other hand, a poor country might export a high-PRODY good because of the multinational firms that export it from the country. With

[3] ESI was first developed by Finger and Kreinin (1979). Schott (2008) applied ESI in his study of the sophistication of Chinese exports. Wang and Wei (2010) developed an index of export dissimilarity.

[4] Rodrik (2006) does not specify this regression equation explicitly, but his argument is derived from such a regression equation. Rodrik (2006. p. 6) states that “Fig. 3 shows the scatter plot of EXPY against per-capita GDP for 1992. The correlation coefficient is 0.83. But countries do not lie neatly alongside the regression line….China's exports were associated with an income level that is more than six times higher than China's per-capita GDP at the time.” Schott (2008) specifies the same equation (p. 26, Eq. (3)).

[5] For example, “Dungeness crabmeat, prepared, frozen” (HS = 1,605,104,015) was exported mainly by Canada and its PRODY level is computed to be around 20,000.

Table 2
EXPY and ESI regressions, 141 countries, 1992–2005.

	(2.1)	(2.2)	(2.3)	(2.4)
	log EXPY	log EXPY	log ESI	log ESI
log PCGDP	0.543 (86.89)***	0.543 (86.87)***	1.132 (46.76)***	1.132 (46.76)***
CHN	0.560 (6.59)***		2.396 (7.27)***	
CHN (1992–1995)		0.667 (4.19)***		2.842 (4.61)***
CHN (1996–2000)		0.570 (4.00)***		2.418 (4.39)***
CHN (2001–2005)		0.466 (3.27)***		2.019 (3.66)***
Constant	4.214 (79.10)***	4.213 (79.06)***	−13.577 (65.79)***	−13.580 (65.79)***
Year fixed effects	Yes	Yes	Yes	Yes
Observations	1964	1964	1964	1964
R-squared	0.80	0.80	0.54	0.54

Notes: absolute values of *t* statistics are in parentheses.
*** Significant at 1%.

Table 3
Export sophistication of countries in China's income group.

1992				2004			
Country	PCGDP	ESI	EXPY	COUNTRY	PCGDP	ESI	EXPY
Pakistan	1734	0.012	4977	Jordan	4442	0.015	5233
India	1742	0.059	7358	Albania	4511	0.016	5998
Guinea	1791	0.003	2086	El Salvador	4673	0.016	4895
Comoros	1886	0.000	2186	Peru	5219	0.029	5958
Kyrgyzstan	1887	0.003	2757	Lebanon	5400	0.050	8534
China	1944	0.104	7756	China	5419	0.161	12524
Armenia	2014	0.006	4446	Fiji	5470	0.008	4828
Georgia	2017	0.006	3039	Samoa	5539	0.003	5781
Haiti	2091	0.009	4415	Venezuela	5553	0.076	10985
Bolivia	2126	0.010	3776	Ukraine	5876	0.031	9178
Albania	2186	0.002	3954	Gabon	6088	0.003	5566
Average	1947	0.019	4250	Average	5290	0.037	7225

global offshoring, it is also rather possible that a country exports a highly sophisticated final good after processing imported intermediate goods that are already of high sophistication.

Despite the noise in the EXPI/ESI measures, evidence shows that the indices do reflect the technology content of exports to certain degree. Table 4 reports the estimated correlations between PRODY and R&D intensity for 2-digit ISIC industries of OECD countries, for which the data is available.[6] The estimated correlations are all positive, and only three resource-intensive industries (fuel, rubber, and basic metals) show estimates that are statistically insignificant. We also computed correlations at the country level and found that both EXPY and ESI are positively correlated with R&D-GDP ratio.[7] Thus we conclude that EXPY and ESI are imperfect but useful measures of export sophistication.

3.1. The quality of exports

The indices of EXPY and ESI, however, do not capture one important dimension of export sophistication, i.e., that product quality varies across countries. As documented by Schott (2004), even at the most disaggregated product-level data of international trade statistics (10-digit HS code), the price of the same product differs considerably based on country of origin. Table 5 shows an example. In 1996, there were 26 countries exporting “Line telephone sets with cordless handsets” (HS = 8,517,110,000) to the U.S. market and the average price was $49. Among major exporters, China exported 11.3 million sets at an average price of $44, the Philippines exported 9.2 million sets at $38, Malaysia exported 5.5 million sets at $55, and Japan exported 463274 sets at $117. Schott (2008) pointed out that such price differences signal product-quality differences, and he defined the sophistication related to product quality as “within-product sophistication” in contrast to the “across-product sophistication” measured by EXPY/ESI.

[6] We use industry average R&D intensity of previous five years as industry R&D variable for current year, and compute its correlation with average PRODY of the corresponding industry.
[7] Using the R&D-GDP ratio averaged over 1996–2004 as the R&D variable for 2005, we find that its correlations with the EXPY and ESI indices in 2005 are 0.72 and 0.46 respectively in a sample of 90 countries. Both correlation estimates are statistically significant at the 1% level.

Table 4
Correlation between PRODY and R&D intensity.

Industries (ISIC codes)	Correlation	Observations
Food products, beverages and tobacco (15, 16)	0.25***	226
Textiles, apparel, leather and footwear (17, 18, 19)	0.39***	226
Wood, paper, printing, and publishing (20, 21, 22)	0.45***	226
Coke, refined petroleum products, nuclear fuel (23)	0.09	196
Chemicals and chemical products (24)	0.48***	213
Rubber and plastics (25)	0.04	226
Other non-metallic mineral products (26)	0.43***	226
Basic metals (27)	0.07	214
Fabricated metal products (28)	0.39***	214
Machinery and equipment; Office, accounting and computing machinery (29, 30)	0.43***	222
Electrical machinery; radio, television and communication equipment (31, 32)	0.18**	210
Medical, precision and optical Instruments; watches and clocks (33)	0.18**	197
Transport equipment (34, 35)	0.22***	226
Furniture, jewelry, musical instruments, sports goods, games and toys, and other manufacturing (36, 37)	0.11*	226

Notes: the sample is 18 OECD countries in 1992–2004 (see the Appendix for data detail). Industry-level PRODY is the weighted average of HS10-level PRODY, the weights being export share of HS10 product in industry. R&D intensity is the average of previous five years. ***, **, * indicate statistical significance at the 1%, 5%, and 10% levels.

Table 5
Line telephone sets with cordless handsets (HS = 8,517,110,000), 1996.

Country	Quantity	Share	Price	Average price	q	PRODY	QPRODY ($\theta = 1/2$)
CHN	11,300,000	0.36	44	49	0.90	5634	5345
PHL	9,183,924	0.29	38	49	0.77	5634	4944
MYS	5,510,509	0.17	55	49	1.14	5634	6015
MEX	2,457,304	0.08	46	49	0.95	5634	5491
IDN	1,210,257	0.04	42	49	0.87	5634	5255
TWN	976,943	0.03	50	49	1.03	5634	5718
JPN	463,274	0.01	117	49	2.41	5634	8746
HKG	337,764	0.01	28	49	0.58	5634	4291
KOR	114,344	0	71	49	1.46	5634	6808
THA	51,828	0	53	49	1.10	5634	5909
SGP	24,318	0	66	49	1.35	5634	6546
CAN	18,198	0	109	49	2.25	5634	8451
CHE	11,334	0	47	49	0.96	5634	5520
DEU	4331	0	283	49	5.82	5634	13,592
CRI	4130	0	4	49	0.08	5634	1594
AUT	3300	0	292	49	6.02	5634	13,823
HUN	1800	0	273	49	5.62	5634	13,356
PAN	982	0	97	49	2.00	5634	7968
GBR	496	0	635	49	13.08	5634	20,376
ISR	291	0	325	49	6.70	5634	14,583
SWE	70	0	283	49	5.83	5634	13,604
FIN	50	0	201	49	4.15	5634	11,477
ITA	32	0	156	49	3.22	5634	10,110
ARG	27	0	111	49	2.29	5634	8526
FRA	10	0	1555	49	32.03	5634	31,886
NOR	1	0	1508	49	31.06	5634	31,399

Notes: quantity is country export quantity. Share is country export quantity over total export quantity. Price is country export value over country export quantity. Average price is export-share weighted average of prices. The other variables are defined in the text.

To measure the within-product quality difference, we construct the following relative-price index:

$$q_{ic} = \frac{p_{ic}}{\sum_{n \in C_i} (\mu_{in} p_{in})} \tag{5}$$

In Eq. (5), p_{ic} is the price of good i exported by country c. The denominator is the weighted average of the prices of good i exported by all countries, the weight μ_{in} being country n's export share of good i in all countries' exports of good i, which reflects the relative importance of country n in exporting good i.

It is documented in Schott (2004) that for the same product, there is a positive correlation between the price of a country's exports and its PCGDP. Fig. 2 shows the case of "Line telephone sets with cordless handsets." We may infer from this positive

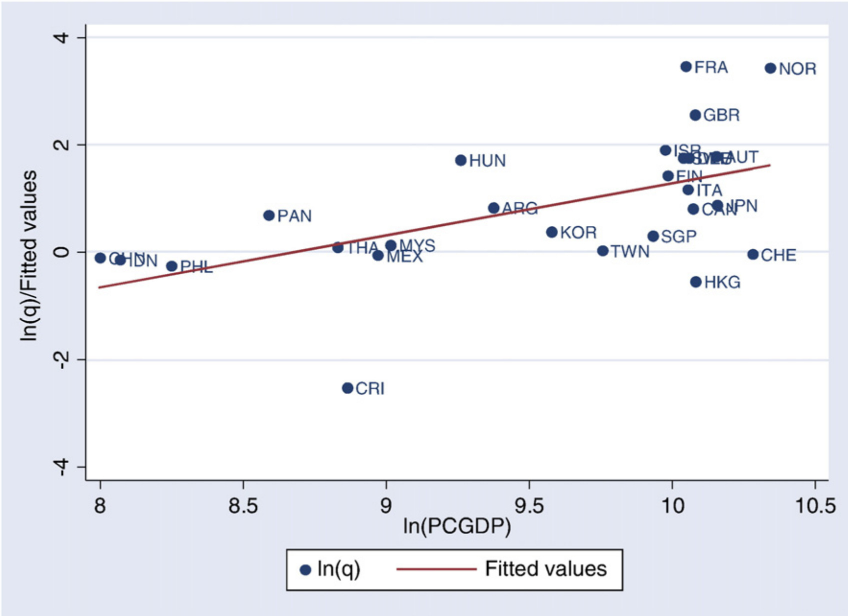

Fig. 2. Relative prices of "line telephone sets with cordless handsets", 1996.

relationship between price and PCGDP that rich countries generally export products of higher quality, and poor countries generally export products of lower quality. Interestingly, Schott (2008) found that China is again an outlier in this cross-country relationship: the average price of Chinese exports is significantly lower than the level predicted by its PCGDP. We can replicate this result by running the following regression:

$$\log(q_{ict}) = \alpha_{it} + \beta\log(PCGDP_{ct}) + \gamma CHN + \varepsilon_{ict} \quad (6)$$

In Eq. (6), α_{it} is a product-year fixed effect that controls for unobserved product-year characteristics. Table 6 reports the results. In regression (6.1), the estimated coefficient of CHN is negative and statistically significant at the 1% level. In regression (6.2), the effect of CHN is estimated for three sub-periods. The estimated coefficients of CHN in the three sub-periods are all negative and statistically significant at the 1% level, and their absolute values show an increasing trend over time.

3.2. Quality-adjusted measure of sophistication

The finding that the prices of China's exports are exceptionally low is important to the evaluation of China's export sophistication. If price signals quality, then EXPY/ESI overestimates the export sophistication of China.

Table 6
Relative-price regressions, HS10 products, 1992–2005.

	(6.1)	(6.2)
log PCGDP	0.369 (8.83) ***	0.371 (8.84) ***
CHN	−0.380 (8.59) ***	
CHN (1992–1995)		−0.204 (4.19) ***
CHN (1996–2000)		−0.314 (6.76) ***
CHN (2001–2005)		−0.512 (12.19) ***
Constant	−3.520 (9.57) ***	−3.540 (9.58) ***
Product-year fixed effects	Yes	Yes
Observations	2,607,879	2,607,879
R-squared	0.26	0.26

Notes: the dependent variable is log *q*. Robust standard errors adjusted for clustering at the country level. Absolute values of *t* statistics are in parentheses.
*** Significant at 1%.

Table 7
Regressions of QEXPY with different degrees of quality adjustment.

	(7.1)	(7.2)	(7.3)	(7.4)	(7.5)	(7.6)	(7.7)
	$\theta=0$	$\theta=1/5$	$\theta=1/3$	$\theta=1/2$	$\theta=2/3$	$\theta=3/4$	$\theta=1$
log PCGDP	0.548 (89.32)***	0.548 (86.22)***	0.547 (81.56)***	0.546 (73.75)***	0.545 (64.94)***	0.544 (60.52)***	0.542 (48.28)***
CHN	0.566 (6.84)***	0.455 (5.31)***	0.381 (4.21)***	0.285 (2.85)***	0.183 (1.62)	0.128 (1.06)	−0.056 (0.37)
IND	0.652 (7.87)***	0.570 (6.65)***	0.514 (5.68)***	0.442 (4.43)***	0.367 (3.24)***	0.328 (2.70)***	0.205 (1.35)
MEX	0.376 (4.55)***	0.341 (3.98)***	0.315 (3.48)***	0.275 (2.75)***	0.226 (2.00)**	0.197 (1.63)	0.086 (0.57)
HKG	−0.460 (5.52)***	−0.505 (5.85)***	−0.533 (5.84)***	−0.568 (5.65)***	−0.606 (5.32)***	−0.627 (5.13)***	−0.702 (4.60)***
Constant	4.163 (79.64)***	4.147 (76.66)***	4.148 (72.60)***	4.166 (66.04)***	4.204 (58.83)***	4.231 (55.25)***	4.338 (45.34)***
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1964	1964	1964	1964	1964	1964	1964
R-squared	0.81	0.80	0.78	0.75	0.70	0.67	0.56

Notes: The dependent variable is QEXPY. Absolute values of t statistics are in parentheses.
**Significant at 5%.
***Significant at 1%.

How do we incorporate product quality in the measurement of sophistication? We propose to introduce a quality multiplier that adjusts the PRODY index. PRODY measures the *average* sophistication of a good without considering within-product quality differences. We define the following quality-adjusted index of sophistication:

$$QPRODY_{ic} = (q_{ic})^{\theta} \times PRODY_i \tag{7}$$

In Eq. (7), $(q_{ic})^{\theta}$ is the quality multiplier, where θ is a parameter that measures the degree of quality adjustment. When there is no quality adjustment ($\theta=0$), $\text{QPRODY}_{ic}=\text{PRODY}_i$. The usefulness of this index is that it recognizes the relatively high sophistication of a high-quality variety (e.g. men's cotton shirts made in Italy, $q=2.91$ in 2001) that belongs to a product category of low sophistication (HS = 6,105,100,010, "Men's shirts of cotton, knit", PRODY = 3323 in 2001), and the relatively low sophistication of a low-quality variety (e.g. video projectors made in China, $q=0.15$ in 2001) that belongs to a product category of high sophistication (HS = 8,528,304,000, "Video projectors, CLR, non-hi def", PRODY = 25093 in 2001).

3.3. Sensitivity of China's export sophistication to quality adjustment

To see the importance of quality adjustment in evaluating China's export sophistication, we perform a sensitivity test using the following regression equation:

$$\log(QEXPY_{ct}) = \alpha_t + \beta\log(PCGDP_{ct}) + \gamma_1 CHN + \gamma_2 IND + \gamma_3 MEX + \gamma_4 HKG + \varepsilon_{ct} \tag{8}$$

where QEXPY_{ct} is the weighted average of the quality-adjusted sophistication of all the goods exported by country c in time t. IND, MEX and HKG are dummy variables for India, Mexico and Hong Kong, respectively.

Table 7 reports the results. We experiment with seven different values of θ. In regression (7.1), the dependent variable is EXPY ($\theta=0$). The result shows that China, India and Mexico all have EXPY levels significantly higher than the predicted levels (so they are all "special"), while Hong Kong has an EXPY level significantly lower than the predicted level. As the value of θ increases (i.e., as more quality adjustment is introduced to the sophistication measure), the estimated coefficients of CHN, IND and MEX all fall steadily, but the one of CHN falls faster than the ones of IND and MEX. Indeed, when $\theta=2/3$, China is no longer an outlier in terms of the statistical significance of the China dummy, while India and Mexico remain outliers. Notice that Hong Kong becomes

Table 8
Quality multipliers, 2005.

Distribution of q	q	$q^{3/4}$	$q^{2/3}$	$q^{1/2}$	$q^{1/3}$	$q^{1/5}$
Minimum	0.01	0.03	0.04	0.09	0.21	0.39
1st percentile	0.02	0.06	0.08	0.14	0.28	0.46
5th percentile	0.09	0.16	0.20	0.30	0.45	0.62
10th percentile	0.19	0.29	0.33	0.44	0.58	0.72
25th percentile	0.51	0.60	0.63	0.71	0.80	0.87
50th percentile	1.00	1.00	1.00	1.00	1.00	1.00
75th percentile	2.24	1.83	1.71	1.50	1.31	1.17
90th percentile	6.04	3.85	3.31	2.46	1.82	1.43
95th percentile	11.56	6.27	5.11	3.40	2.26	1.63
99th percentile	41.77	16.43	12.04	6.46	3.47	2.11
Maximum	92.11	29.73	20.40	9.60	4.52	2.47

Table 9
Economic indicators of China's provinces, 2004.

Province	Provincial PCGDP to China's PCGDP	Provincial export share	Provincial FDI share
Shanghai *	4.48	0.12	0.10
Beijing *	3.00	0.03	0.04
Tianjin *	2.56	0.04	0.03
Zhejiang	1.94	0.10	0.09
Jiangsu	1.68	0.15	0.15
Guangdong	1.60	0.32	0.17
Fujian	1.40	0.05	0.03
Shandong	1.37	0.06	0.14
Liaoning	1.32	0.03	0.09
Heilongjiang	1.13	0.01	0.01
Hebei	1.05	0.02	0.01
Inner Mongolia	0.92	0.00	0.01
Xinjiang	0.91	0.01	0.00
Jilin	0.89	0.00	0.00
Hubei	0.85	0.01	0.03
Chongqing *	0.78	0.00	0.00
Henan	0.77	0.01	0.01
Hainan	0.77	0.00	0.00
Shanxi	0.74	0.01	0.00
Hunan	0.74	0.01	0.02
Qinghai	0.70	0.00	0.00
Jiangxi	0.66	0.00	0.03
Sichuan	0.66	0.01	0.01
Ningxia	0.64	0.00	0.00
Tibet	0.63	0.00	0.00
Anhui	0.63	0.01	0.01
Shaanxi	0.63	0.00	0.00
Guangxi	0.58	0.00	0.00
Yunnan	0.55	0.00	0.00
Gansu	0.48	0.00	0.00
Guizhou	0.34	0.00	0.00

Source: *China's Statistical Yearbook*, 2005. PCGDP denotes per capita GDP.
* Municipality directly under the central government (equivalent to province).

increasingly an outlier as θ increases, which is consistent with the fact that a large portion of Hong Kong's exports come from mainland China so Hong Kong's export sophistication is adjusted downward after considering the quality of its exports.

What is a proper value of θ? Table 8 shows the size of the quality multiplier (q^{θ}) at different values of θ. For example, an adjustment of $\theta = 1/2$ implies the following effects: for a product at the 1st percentile of the q distribution, QPRODY = 0.14 × PRODY; for a product at the 99th percentile of the q distribution, QPRODY = 6.46 × PRODY.[8]

There is no theoretically "correct" value of θ. However, we can rule out $\theta = 0$ since it ignores entirely the quality dimension of sophistication. We may also rule out $\theta = 1$ since it seems to introduce too much quality adjustment, making QPRODY only 2% of PRODY for the products at the 1st percentile of the q distribution, and 42 times PRODY for the products at the 99th percentile of the q distribution. We observe from Table 7 that the threshold value of θ for China is 2/3 above which the estimated coefficient of CHN is statistically insignificant. In our subsequent analysis, we choose $\theta = 1/2$ as the benchmark value of the quality adjustment parameter.[9] As Table 7 shows, with this moderate quality adjustment, China, India and Mexico remain outliers in the cross-country relationship between export sophistication (measured by QEXPY) and PCGDP.

It is worth pointing out that irrespective of the value of θ, our results show that the "China is special" observation is sensitive to the quality adjustment of the sophistication index. Thus our results establish the importance of the quality dimension in evaluating the sophistication of China's exports.

4. Regional heterogeneity

So far we have used China's overall PCGDP as a measure of its capability to export sophisticated goods. This measure ignores, however, the considerable heterogeneity among Chinese regions and the fact that most of China's exports are from its more developed coastal provinces. Table 9 displays some key statistics of China's provinces in 2004. The second column shows the ratio of provincial PCGDP to China's PCGDP; the numbers reveal that the income level of the richest region (Shanghai) was 13 times that of the poorest region (Guizhou) in 2004. The third column shows provincial export shares. The top-nine exporting provinces

[8] The quality multipliers reported in Table 8 are based on the q distribution of 2005. The quality multipliers are stable across years. In 1992, for example, the 1-percentile product has $q = 0.022$, so its quality multiplier is 0.15; the 99-percetile product has $q = 29.47$, so its quality multiplier is 5.43.

[9] As an example of this adjustment, the last column of Table 5 shows QPRODY ($\theta = 1/2$) of "Line telephone sets with cordless handsets" of the 26 countries that exported this product to the U.S. in 1996.

Table 10
China's PCGDP weighted by provincial export shares.

	PCGDP	$PCGDP_e$	$PCGDP_e$ to PCGDP
1992	1944	2788	1.43
1993	2199	3327	1.51
1994	2457	4019	1.64
1995	2734	4366	1.60
1996	2971	5030	1.69
1997	3204	5487	1.71
1998	3438	6113	1.78
1999	3666	6689	1.82
2000	3928	7278	1.85
2001	4233	7769	1.84
2002	4568	8387	1.84
2003	4966	9547	1.92
2004	5419	10694	1.97
2005	5878	11461	1.95
Mean (SD)	3686 (1211)	6640 (2702)	1.75 (0.16)

Notes: PCGDP is China's per capita GDP. $PCGDP_e$ is the weighted average of China's provincial PCGDP, with provincial export shares as the weights.

accounted for 90% of China's total export value in 2004. Notice that the top exporting provinces are the ones with high income levels (second column) and high shares of foreign direct investment (last column). It is evident that China's overall GDP significantly underestimates the capital and technology capacity possessed by China's major export regions.[10]

To account for the high income heterogeneity of Chinese provinces and the uneven distribution of exports across the provinces, we construct the following income variable that uses provincial export shares as weights:

$$PCGDP_e = \sum_{r \in R} s_r \, PCGDP_r \tag{10}$$

In Eq. (10), R denotes the set of export regions, $PCGDP_r$ is the per capita GDP level of region r, and s_r is the export share of region r. Table 10 reports the results from the computation. The numbers show that China's $PCGDP_e$ is significantly higher than China's overall PCGDP, and the gap has increased steadily from 1992 to 2005.[11]

The income differences between exporting regions and non-exporting regions exist in all countries. Defining λ_c as the ratio of country c's export-region-weighted PCGDP to the country's overall PCGDP, we have

$$PCGDP_{ec} = \lambda_c PCGDP_c \tag{11}$$

We consider $PCGDP_{ec}$ as a better indicator of a country's capacity to export sophisticated goods than $PCGDP_c$. The problem, however, is that we do not have data to compute λ_c for all countries. Still, we can gain useful insights by doing some experiments. It seems reasonable to assume that the degree of regional heterogeneity is relatively low in high-income countries and relatively high in middle- and low-income countries. In our first experiment, we assume $\lambda_c = 1.2$ for high-income countries and $\lambda_c = 1.4$ for middle- and low-income countries except China. With this assumption, we compute $PCGDP_{ec}$ for all countries except China and denote it as PCGDP1. For China, we use $PCGDP_e$ from Eq. (10) as its PCGDP1.

The first two regressions of Table 11 show the effects of this adjustment of the income variable. In regression (11.1), the income variable is PCGDP. In regression (11.2), the income variable is PCGDP1. We see that after introducing the adjustment for regional income differences, the estimated coefficient of CHN remains positive and statistically significant, but the size of its point estimate falls to 0.422 from 0.566.

Regression (11.3) of Table 11 shows the results of replacing EXPY with the quality-adjusted sophistication measure (QEXPY) as the dependent variable. We see that after introducing the quality adjustment in the measurement of export sophistication, the estimated coefficient of CHN remains positive and statistically significant, but the size of its point estimate falls to 0.285 from 0.566 in regression (11.1).

In regression (11.4), we introduce both the quality adjustment and the PCGDP adjustment. The results show that the estimated coefficient of CHN falls to 0.142 and is statistically insignificant. From this benchmark experiment, we see that China disappears as an outlier in the cross-country comparison of the sophistication of exports once the measurement of sophistication considers product quality *and* the measurement of a country's export capability considers regional heterogeneity.

We experimented with a number of plausible assumptions on λ_c to see the sensitivity of the results of regression (11.4). We report in regression (11.5) one of the experiments in which $\lambda_c = 1.6$ is assumed for all middle- and low-income countries including

[10] Schott (2008) noted the importance of considering the inter-regional relative endowment disparities within China, but did not incorporate them in his regression analysis.

[11] Note that $PCGDP_e$ may overestimate the income level of China's export regions. First, the exports of the coastal provinces may contain goods produced by the inland provinces that are shipped to the coastal provinces prior to being shipped abroad. Second, the reported income level of coastal provinces may not reflect the income level of migrant workers. These measurement biases do not affect our main results as shown by the regression results under different assumptions on China's PCGDP (Table 9).

Table 11
Regressions of EXPY and QEXPY.

	(11.1)	(11.2)	(11.3)	(11.4)	(11.5)
	log EXPY	log EXPY	log QEXPY ($\theta=1/2$)	log QEXPY ($\theta=1/2$)	log QEXPY ($\theta=1/2$)
log PCGDP	0.548 (89.32)***		0.546 (73.75)***		
log PCGDP1		0.572 (87.78)***		0.569 (72.45)***	
log PCGDP2					0.589 (70.93)***
CHN	0.566 (6.84)***	0.422 (5.03)***	0.285 (2.85)***	0.142 (1.40)	0.199 (1.94)*
IND	0.652 (7.87)***	0.645 (7.68)***	0.442 (4.43)***	0.435 (4.29)***	0.427 (4.15)***
MEX	0.376 (4.55)***	0.338 (4.03)***	0.275 (2.75)***	0.238 (2.35)**	0.204 (1.98)**
HKG	−0.460 (5.52)***	−0.435 (5.15)***	−0.568 (5.65)***	−0.542 (5.32)***	−0.516 (4.99)***
Constant	4.163 (79.64)***	3.795 (66.17)***	4.166 (66.04)***	3.805 (55.04)***	3.575 (48.41)***
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	1964	1964	1964	1964	1964
R-squared	0.81	0.81	0.75	0.74	0.73

Notes: absolute values of *t* statistics are in parentheses.
* Significant at 10%.
** Significant at 5%.
*** Significant at 1%.

China, and $\lambda_c=1.2$ is assumed for high-income countries. The results show that the estimated coefficient of CHN is 0.199 and is statistically significant at the 10% level. This and other experiments confirm that the outlier status of China is considerably reduced (if not completely removed) once the export sophistication and export capability of countries are properly measured. Notice that the estimated coefficients on IND and MEX remain positive, sizable and statistically significant in regressions (11.4) and (11.5). This suggests that the measurement biases are a more significant factor in accounting for the outlier status of China than that of India and Mexico.[12]

5. Conclusion

China's rapid upgrade in export structure has attracted much attention recently. Two influential papers by Rodrik (2006) and Schott (2008) found that China is “special” in exporting highly sophisticated goods that are not comparable with its development level. In this paper, we provide an evaluation of the two key parameters that establish the outlier status of China in cross-country comparisons, namely the export sophistication index and the country's development level. We find that it was the improper measurement of the two parameters that led to the “China is special” result. First, product quality has not been fully considered in the sophistication measurement which has caused an overestimation of China's export sophistication. Second, the average income of the whole country has been used to measure export capacity, which has caused an underestimation of the capacity of China's coastal regions to export sophisticated goods. We show that China is much less “special” in the cross-country comparison of export sophistication once these two measurement biases are corrected.

In assessing the impact of product quality on the “China is special” result, we develop a quality-adjusted measure of sophistication. Our experiments show that China's measured export sophistication is particularly sensitive to product quality in comparison with other developing countries, notably India and Mexico. We argue that a country's overall PCGDP is a poor measure of its endowment and technology capacity to export sophisticated goods, as exporting regions within the country are usually more developed than non-exporting regions. Our experiments show that the consideration of regional heterogeneity is one of the keys to a proper evaluation of China's export sophistication.

Our study has examined the “China is special” result from the angle of measurement biases. As discussed in the introduction of the paper, several recent studies have started to explore the reasons behind China's increasingly sophisticated export structure, and have examined the roles of foreign direct investment, processing trade, and certain government policies. Our results on China, India and Mexico suggest that different countries may have different reasons to be “special” in a cross-country comparison of export sophistication. Further research based on micro-level data of individual countries should be useful in this research area.

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[12] Table 11 shows that Hong Kong is a downward-biased outlier in all the regressions. This finding is not surprising as a large portion of Hong Kong's manufacturing exports are from mainland China.

References

Amiti, Mary, & Freund, Caroline (2010). An Anatomy of China's Export Growth. In Robert Feenstra, & Shang-Jin Wei (Eds.), *China's Growing Role in World Trade*. : University of Chicago Press.

Feenstra, Robert C., Romalis, John, & Schott, Peter K. (2002). *"U.S. Imports, Exports and Tariff Data, 1989–2001." NBER Working Paper No. 9387*. Cambridge, MA: NBER.

Finger, J. Michael, & Kreinin, M. E. (1979). A measure of 'export similarity' and its possible uses. *Economic Journal*, *89*, 905−912.

Hausmann, Ricardo, Hwang, Jason, & Rodrik, Dani (2007). What you export matters. *Journal of Economic Growth*, *12*(1), 1−25.

Lall, Sanjaya, Weiss, John, & Zhang, Jinkang (2006). The 'sophistication' of exports: a new trade measure. *World Development*, *34*(2), 222−237.

Michaely, Michael (1984). *Trade, Income Levels, and Dependence.* North-Holland, Amsterdam.

Rodrik, Dani (2006). What is so special about China's exports? *China & World Economy*, *14*(5), 1−19.

Schott, Peter K. (2008). The relative sophistication of Chinese exports. *Economic Policy*, *53*, 5−49.

Schott, Peter K. (2004). Across-product versus within-product specialization in international trade. *Quarterly Journal of Economics*, *119*(2), 647−678.

U.S. General Accounting Office. (1995). *"U.S. Imports: Unit Values Vary Widely for Identically Classified Commodities," Report GAO/GGD-95-90.*

Van Assche, Ari, & Gangnes, Byron (2010). Electronics production upgrading: is China exceptional? *Applied Economics Letters*, *17*(issue 5), 477−482.

Wang, Zhi, & Wei, Shang-Jin (2010). What accounts for the rising sophistication of China's exports? In Robert Feenstra, & Shang-Jin Wei (Eds.), *China's Growing Role in World Trade*. : University of Chicago Press.

Xu, Bin, & Lu, Jiangyong (2009). Foreign direct investment, processing trade, and the sophistication of China's exports. *China Economic Review*, *20*(2009), 425−439.