The Impact of Foreign Firms on the Sophistication of Chinese Exports

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ABSTRACT

Recent studies find that China exported goods of relatively high product sophistication, which are not compatible to China's economic development level. In this paper we use detailed product-level and firm-level data to examine the determination of product sophistication level of Chinese exports in the period 1998-2005, in particular the role of foreign firms. In our study we distinguish between wholly-owned, majority-owned and minority-owned foreign firms, and between HMT (Hong Kong, Macao, Taiwan) and non-HMT foreign firms. We find that the increasing presence of wholly-owned non-HMT foreign firms and the decreasing presence of minority-owned non-HMT foreign firms in China have a positive effect on China's export sophistication, accounting for about 20 percent. We find China's WTO entry contributed a large positive effect to growth of product sophistication of China's exports. We also identify a number of factors that have made China increasingly difficult to raise its export sophistication.

Our study examines several other hypotheses related to China's export sophistication. We find that export sophistication is positively associated with the development level of China's exporting regions in 1998-2001, but this location effect disappeared in 2002-2005. We do not detect much of an effect from domestic competition except that Chinese industries' falling degree of market concentration had some negative impact on China's export sophistication growth in 2002-2005. We find however that China's export sophistication is positively related to the degree of foreign competition in the export market. While traditional comparative advantage variables do not appear to have significant effects in our panel-data regressions, we find that their effects are absorbed in firm identity variables or industry fixed effects. This finding is consistent with recent trade models of firm heterogeneity that show comparative advantage endogenously determined by organizational characteristics of firms.

1. Introduction

Product characteristics of exports have received great attention in recent research. Hausman, Hwang and Rodrik (2005) developed a model that shows a country's export bundle matters for its economic growth, and they present cross-country evidence that economic growth depends on an index of product sophistication of exports. Rodrik (2006) found that China's overall product sophistication was significantly higher than what its development level implies, and considers this as one important reason for China's fast economic growth. Schott (2006) examined the similarity between a country's exports and that of the OECD's, and found that China's export bundle is more sophisticated than countries with similar relative factor endowments.[1]

It is not surprising that China has become a major subject of research in this topic. From 1978 to 2005, China's GDP (current value) increased from 362 billion yuan to 18.23 trillion yuan, an average annual growth rate of 15 percent.[2] During the same period, China's export volume increased from $9.75 billion to $762 billion, an average annual growth rate of near 17 percent. The Chinese recent experience in international trade and economic growth is so rich that it provides a great opportunity for researchers to uncover unexplored relationships between trade and growth.

A well-known feature of China's economic growth is that it replies much more on foreign direct investment than Japan and the four Asian tigers in their growth periods. Out of China's total exports, more than half are by foreign firms in China. Many analysts hold the view that foreign firms are mainly responsible for China's exporting of more sophisticated products (e.g. Gilboy, 2004). Some even criticizes China to have relied too much on foreign direct investment (e.g. Huang, 2003).

To better understand China's export characteristics and the underlying reasons, one needs to conduct careful studies at micro levels. In this paper, we use product-level and firm-level data to investigate the product sophistication of China's exports, in particular the role played by foreign firms. The product-level data we use is collected by the U.S. Customs at the 10-digit level of Harmonized System (HS10). The firm-level data

[1] Hummels and Klenow (2005) defined three product characteristics of exports and tested the theoretical predictions of various trade models on these characteristics.

[2] In December 2005, China revised its 2004 GDP to 15.99 trillion yuan, an increased of 16.8 percent. Over 90 percent of the newly-added 2.3 trillion yuan is from better data about the services sector.

we use is collected by the National Bureau of Statistics of China in the Annual Survey of Industrial Firms. Our sample period is from 1998 to 2005.

As the recent international trade literature shows, exporting firms are not a random group. Exporting firms are found to be bigger and more productive than domestic firms, and their behavior is largely determined by their organizational forms.[3] In China, foreign firms contain two distinctive groups: those invested by Hong Kong, Macao, and Taiwan (HMT) and those invested by other foreign economies (non-HMT), mainly OECD countries. There is evidence that HMT firms have better connections in China than non-HMT firms, and they tend to be smaller and more labor-intensive (Table 5).[4] Like in other countries, wholly-owned, majority-owned and minority-owned behave differently in China. In this paper, we classify foreign firms in six groups according to the two dimensions mentioned above, and examine their respective impact on the product sophistication of China's exports.

The micro-level data also allows us to investigate several other hypotheses. First, does local development level matter for export sophistication? China is a country with great diversity in regional development. In existing studies (e.g. Rodrik, 2006), China's development level is measured by China's per capita GDP. However, China's exports are mainly from costal provinces where per capita GDP levels are much higher (Table 6). In our study, we construct export-weighted per capita GDP of exporting regions by 4-digit ISIC industry to see if local development level matters for export sophistication. Second, does market competition affect export sophistication? Many industries in China are characterized with fragmented markets and furious competition, which impact firms' choice of export characteristics. Chinese firms are also known to compete with low prices in the export market. In our study, we examine the implications of both domestic and foreign competition on China's export sophistication. Third, do factor intensity and technology intensity matter for export sophistication? The traditional trade theory characterizes exports by factor intensity and technology intensity. Our study examines these traditional comparative advantage variables as determinants of export sophistication in addition to organizational features of firms and market structure.

[3] For a survey of the literature on trade, FDI and the organization of firms, see Helpman (2006).
[4] Buckley, Clegg and Wang (2002) provide useful discussions of the different characteristics of HMT firms and non-HMT firms.

A major advantage of our data is that it covers the years before and after China's entry into WTO in December 2001, which has significant implications on the Chinese economy. Our data allows us to investigate the differences in export sophistication between the pre-WTO period (1998-2001) and post-WTO period (2002-2005), and estimate the impact of WTO entry on growth of China's export sophistication.

The remainder of the paper is organized as follows. In section 2 we discuss measurement of export sophistication and display China's overall export sophistication in the period 1998-2005. In section 3 we discuss theoretical hypotheses regarding the determination of export sophistication. In section 4 we link product-level data and firm-level data at the 4-digit ISIC industry level, and present regression results on the determinants of industry-level export sophistication. In section 5 we conclude. We describe details of data in an appendix (to be written).

2. Export Sophistication

Recent studies have used different measures of product sophistication of exports (Lall, *et al*, 2006; Rodrik, 2006; Schott, 2006), but the basic idea is the same: to infer sophistication of a product from characteristics of its exporting countries. Both Lall *et al* (2006) and Rodrik (2006) assume that an export is more sophisticated the higher the weighted average income of its exporting countries; they differ in the weights to construct the index. Schott (2006) uses the export similarity index of Finger and Kreinin (1979); a country's exports are more sophisticated the higher the similarity to the OECD's exports. Experiments on our data reveal that these measures are highly correlated. In what follows, we use Rodrik's (2006) measure.

Rodrik (2006) measures export sophistication of good i as

$$\text{PRODY}_i = \sum_c \left\{ \frac{x_{ic} / \sum_k x_{kc}}{\sum_m (x_{im} / \sum_k x_{km})} Y_c \right\} \qquad (1)$$

In this equation, Y_c is country c's real GDP per capita. The ratio in front of Y_c serves as a weight. The numerator of the weight ($x_{ic}/\Sigma x_{kc}$) is the export share of good i in country c's

total exports; the denominator is the sum of export shares of all the countries exporting good i, so that the sum of the weights equals one. Thus $PRODY_i$ is a trade-importance-weighted average of real GDP per capita of all the countries that export good i.

$PRODY_i$ has a few of shortcomings. Notice that this measure is linked to locations of exporting countries and to export values. We know that same-name products from different countries may be quite different in quality. In addition, there are location-specific factors (e.g. natural resources) that make a product to be exported from a particular country, which may have little to do with technology sophistication of the product. Furthermore, exchange rates, transportation costs, and trade policies can also impact the value of exports and thereby distort the measure. To alleviate these concerns, we use the most detailed export data (HS10), concentrate on exports of manufactured goods, and use PPP-adjusted per capita GDP. Note that we do not interpret $PRODY_i$ as a measure of technology content of exports. It is just a measure that mirrors a product to the average development level of its exporting countries.

One useful feature of $PRODY_i$ is that it can be easily aggregated to industry and country levels. At the industry level, we construct

$$PRODYI_{jc} = \sum_i \left\{ \frac{x_{ijc}}{\sum_i x_{ijc}} PRODY_{ic} \right\} \qquad (2)$$

where $PRODYI_{jc}$ is the sophistication level of exports of country c's industry j. Here the weight is share of good i in total export value of industry j of country c. Rodrik (2006) aggregated $PRODY_i$ to the country level and named it EXPY. Following his notation, we define country c's overall export sophistication index as

$$EXPY_c = \sum_k \left\{ \frac{x_{kc}}{\sum_k x_{kc}} PRODY_{kc} \right\} \qquad (3)$$

Here the weight is share of good i in country c's total export value.

Table 1 reports summary statistics of variables used in our study. In the sample of 140 countries used by us to construct PRODY and EXPY, the mean of EXPY is $8510 and the standard deviation is $5778. During the period 1998-2005, this sample's EXPY grew by 18.7 percent (about 2.7 percent annually). GDPPC is PPP-adjusted per capita GDP from World Bank's World Development Indicators. The mean of GDPPC is $8507 and the standard deviation is $8772. During the period 1998-2005, this sample's GDPPC grew by 17.9 percent (about 2.6 percent annually). Thus EXPY and GDPPC grew at about the same rate for the world as a whole.

Hausman, Hwang and Rodrik (2005) showed that while GDPPC predicts EXPY well for most countries, there are some outliers. In particular, Rodrik (2006) found that China was special: in 1992, 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. Regression (2.1) in Table 2 confirms Rodrik's (2006) finding that China was special in EXPY. In this regression, we pool the data from 1998 to 2005. After controlling the GDPPC level, we find that China had significantly higher EXPY. Table 3 shows regressions by year from 1998 to 2005. We find that the China dummy has a positive effect in all years, but the size of the estimated effect declines steadily over time. Moreover, the estimated effect of the China dummy becomes statistically insignificant after 2000.[5]

One hypothesis about China being special in export sophistication is foreign direct investment. For example, Gilboy (2004) argues that the technologically advanced goods exported by China are mainly from foreign firms in China. To see the role of FDI at the country level, we construct FDIGDP as ratio of FDI stock to GDP using data from *World Investment Report*. In regression (2.2) of Table 2, we find that EXPY is positively associated with FDIGDP but the relationship is not statistically significant; including FDIGDP does not affect the China dummy. In regression (2.3) we include dummies for all countries, and find that FDIGDP is statistically significant at the 1 percent level. In regression (2.4) we include both country dummies and year dummies, and find that FDIGDP is only marginally significant. These results suggest that EXPY has a positive partial correlation with FDIGDP that is more pronounced across time than across

[5] Rodrik (2006) also found that China was much less an outlier in 2003 in terms of this cross-country relationship between EXPY and GDPPC.

countries. In Table 4 we include FDIGDP in yearly regressions and find it not statistically significant in all years. Given that FDI is of different nature in different countries, such mixed findings at the aggregate country level are not surprising. This is exactly why we need to use micro-level data to identify the EXPY-FDI relationship.

3. Theoretical Hypotheses

In this section we discuss some theoretical hypotheses on determination of export sophistication. How is product sophistication of exports determined? Recent literature on firm heterogeneity and international trade suggests that the answer lies at the firm level. A firm first chooses whether to export, and the model of Melitz (2003) predicts that more productive firms export. An exporting firm then chooses the characteristics of goods that it produces for the export market. While there is no clear theory about the choice of product sophistication by exporting firms, we have four hypotheses regarding the determination of export sophistication in China.

(1) Organizational form of foreign firms

We can classify foreign firms in China into wholly-owned, majority-owned and minority-owned. In China, foreign firms can also be classified into firms invested by Hong Kong, Macao, and Taiwan (HMT) and non-HMT firms mainly invested by OECD countries. These two classifications give rise to six groups: wholly-owned non-HMT foreign firms (WHO-F), wholly-owned HMT firms (WHO-H), majority-owned non-HMT foreign firms (MAJ-F), majority-owned HMT firms (MAJ-H), minority-owned non-HMT foreign firms (MIN-F), and minority-owned HMT firms (MIN-H). We have the following hypothesis. There is a large literature that shows that wholly-owned foreign firms tend to choose more advanced technology than joint ventures, and also non-HMT firms are more technology-intensive than HMT firms (Table 5).[6] These considerations lead to the following hypothesis:

Hypothesis 1: *Export sophistication of an industry is higher the larger the presence of wholly-owned foreign firms and non-HMT firms.*

[6] Wei and Liu (2006) provide evidence that non-HMT firms played a much greater role in inter-industry productivity spillovers than HMT firms.

(2) Local development level

One assumption in recent studies is that product sophistication of a country is determined by its development level. For a large and vastly diversified country like China, however, country-level per capita GDP is not a good proxy for the development level of exporting regions. According to Table 5, China's top-ten exporting provinces account for 92 percent of China's exports in 2004, and the average per capita GDP of these ten provinces is 2.38 times of China's overall per capita GDP.

We construct a variable (DEV) that is export-share-weighted per capita GDP of China's exporting provinces. The variable is constructed for each 4-digit ISIC industry. We expect that industries whose exporting firms are located in more advanced provinces export goods that are more sophisticated. This leads to the following hypothesis.

Hypothesis 2: *Export sophistication of an industry is higher the larger the share of the exports from more developed regions.*

(3) Market competition

Most manufacturing industries in China are now operated under market competition. Indeed, the concentration ratios (measured by HHI) of Chinese industries are quite low; the mean of HHI of Chinese manufacturing industries in our sample is only 256 (Table 1). Casual observations and news reports indicate that competition in Chinese domestic markets is furious. In the export market, the competition that Chinese firms face is also quite high, as indicated by industry-level share of non-Chinese exports to the U.S. (FSHARE), which is on average 87.8 percent (Table 1). Although there is no clear theory, market competition is expected to promote the export of more sophisticated goods. To deal with both domestic and foreign competition, Chinese firms may need to increase the sophistication of their exports. We propose the following hypothesis.

Hypothesis 3: *Export sophistication of an industry is higher the higher the degree of competition in domestic and foreign markets.*

(4) Technology and capital inputs

Traditional trade theory (Ricardian and HO models) considers export characteristics as determined by national differences in technology and factor abundance, and export characteristics are reflected in technology intensity and factor intensity. Recent trade models of heterogeneous firms (e.g. Bernard, Redding, and Schott, forthcoming) show that HO-type comparative advantage and Ricardian-type comparative advantage are positively correlated and are endogenously determined by degree of firm heterogeneity within industries. This implies that it may be difficult to separate the effects of technology and factor inputs from the effects of organizational features of firms. Nevertheless, we still need to empirically estimate to see if the traditional comparative advantage variables have an impact on export sophistication. In our study, we use share of new product sale in total sale (NP) as a proxy for technology intensity, capital-labor ratio (KL) as capital intensity, and average wage rate (WAGE) as a proxy for human capital intensity. This leads to the following hypothesis.

Hypothesis 4: *Export sophistication of an industry is higher the higher the technology intensity, capital intensity and human capital intensity of firms in the industry.*

4. Empirical Evidence

Guided by the theoretical hypotheses in section 3, we specify the following regression equation:

$$PRODYI_{it} = \alpha_i + \alpha_t + \alpha_x \log X_{it} + \alpha_d \log DEV_{it} + \alpha_h \log HHI_{it} + \alpha_f \log FSHARE_{it} + \alpha_n \log NP_{it} + \alpha_k \log KL_{it} + \alpha_w \log WAGE_{it} + \varepsilon_{it} \quad (4)$$

where α_i denotes industry fixed effects, α_t denotes time fixed effects, X_{it} denotes a set of variables reflecting the presence of various types of foreign firms in industry i at time t, α's are parameters, and ε_{it} is an error term.

Table 7 reports the regression results. In regression (7.1), variable FH is the output share of all foreign firms (both HMT and non-HMT) in the respective industry.

We find this variable to be statistically insignificant, which does not support Hypothesis 1, which states that export sophistication increases with the presence of foreign firms.

In regression (7.2), we divide foreign firms into six groups. We find that WHO-F has a positive estimated effect that is statistically significant at the 1 percent level, and MIN-F has a negative estimated effect that is statistically significant at the 1 percent level. In addition, we find that none of the HMT variables are statistically significant. Note that the reference group of this regression is non-FH exporting firms. Thus the results indicate that relative to indigenous exporting firms, wholly-owned non-HMT foreign firms export goods that have higher product sophistication, minority-owned non-HMT foreign firms export goods that have lower product sophistication, and HMT firms export goods that have export sophistication indifferent from indigenous firms. In regressions (7.3) and (7.4) we include more control variables and the above results remain valid. These results indicate that it is organizational nature rather than the simple presence of foreign firms that is the key to the level of export sophistication.

Regression (7.3) supports Hypothesis 2: one percent increase in per capita GDP of exporting regions raises the export sophistication index by 1769. The estimated coefficient of DEV becomes statistically insignificant in regression (7.4) when year dummies are added, suggesting that the effect of DEV is mainly across time. In terms of Hypothesis 3, we find that the degree of domestic competition (HHI) does not have a significant effect on export sophistication. However, foreign competition (FSHARE) has a large and statistically significant effect; one percent increase in the share of foreign exports to the US market of an industry is associated with an increase of more than 4000 in China's export sophistication index of this industry.

Regressions (7.3) and (7.4) show that the variables of new product share in sales (NP), capital intensity (KL), and average wage (WAGE) are all not statistically significant. It is easy to jump to the conclusion that this evidence suggests that export sophistication does not depend on traditional comparative advantage variables. We decide however to scrutinize this issue. In Table 8, we first regress PRODYI against NP, KL, and WAGE without controlling other variables, and report results in regression (8.1). The results show that all three variables are positive and statistically significant. One may think that these partial positive correlations reflect the fact that EXPY, NP, KL, and

WAGE all grow over the sample period (Table 1). To control for this time trend, we include time fixed effects in regression (8.2). The results show that both NP and KL remain statistically significant at the 1 percent level, and WAGE becomes insignificant. In regression (8.3), we include industry fixed effects but not time fixed effects, and find that WAGE is statistically significant at the 1 percent level. Comparing (7.3) and (8.3), we conclude that the positive effect of WAGE, which serves as a proxy of human capital intensity, is absorbed in the effects of WHO-F and DEV. Notice from Table 5 that WHO-F firms pay high wage to employ more skilled workers, and more developed regions have more workers with higher skill levels. Taking the evidence together, human capital matters for export sophistication, supporting Hypothesis 4. Returning to Table 8, we find in regression (8.4) that when both industry and time dummies are included, all three comparative advantage variables become statistically insignificant. Comparing regressions (7.4) and (8.2)-(8.4), we find that the effects of technology intensity (NP) and capital intensity (KL) are absorbed in industries fixed effects. Taking the evidence together, we cannot reject Hypothesis 4 that industry technology intensity and capital intensity are relevant to industry export sophistication.

In studying China's export sophistication, it is important to identify the role of policy. During the sample period of 1998-2005, one major event is China's entry into WTO in December 2001. There are many policy changes associated with this event. For example, China has reduced trade barriers to deeper levels since 2001, especially in several previously highly protected sectors. China has also removed more restrictions on foreign direct investment, allowing wholly-owned foreign firms to be established in some previously restricted areas. Facing foreign competition, some of the Chinese indigenous firms have restructured. The Chinese government has also taken actions to promote economic development in inner regions. All these make pre-WTO and post-WTO two distinctive periods. To examine the implications of WTO entry on product sophistication of Chinese exports, we divide our sample into two periods. In Table 9, we report results from regressions using the pre-WTO sample of 1998-2001 and the post-WTO sample of 2002-2005 respectively. The results reveal sharp differences between these two periods. First, WHO-F firms had significantly higher export sophistication in 1998-2001; one percent increase in the industry output share of WHO-F firms corresponds to an increase

of 400 in the index of export sophistication. In the period 2002-2005, however, this effect becomes much smaller (about 100) and is statistically insignificant. We interpret this change as reflecting technology catch-up; over time Chinese indigenous firms learn from foreign firms in producing more sophisticated goods.

The second difference is that DEV is positive and statistically significant in regression (9.1), but insignificant in regression (9.3). Notice also that WAGE becomes marginally significant in regression (9.3), suggesting that human capital becomes more important to export sophistication. The reason for local income level becoming less important and human capital becoming more important to export sophistication is worth further examination. In Table 9, we also find that foreign competition (FSHARE) had a large and statistically significant effect on China's export sophistication in 1998-2001, but insignificant in 2002-2005. Finally, we find that export sophistication is negatively correlated with new product share in sales (NP) in 2002-2005. This implies that new products exported by China tend to be from less sophisticated industries.

So far we have examined the distribution of export sophistication across Chinese industries. In this examination we explored the variation across industries to identify several economic factors that correlate with industry export sophistication. Recall that in our cross-country regressions (Table 3) we found that China's overall export sophistication has been declining steadily since 1998 and China's export sophistication is no longer special (in statistical sense) after 2001. In the last column of Table 1 we display the growth rates of some of China's key economic variables. How are the changes in these variables linked to the trend of product sophistication of Chinese exports? To answer this question, we run the following growth regression:

$$\Delta PRODYI_{it} = \beta_i + \beta_x \Delta\log X_{it} + \beta_d \Delta\log DEV_{it} + \beta_h \Delta\log HHI_{it} + \beta_f \Delta\log FSHARE_{it} + \beta_n \Delta\log NP_{it} + \beta_k \Delta\log KL_{it} + \beta_w \Delta\log WAGE_{it} + \beta_v WTO + \nu_{it} \qquad (5)$$

We obtain this growth regression equation from time-differencing the level regression equation (4). Instead of having time dummies, we include the dummy variable WTO, which equals one for 2002-2005, for the purpose of detecting the effect of China's WTO entry. In equation (5), β's are parameters and ν is an error term.

Table 10 reports the results. The variable PRODYI(–1) is one-year lag of PRODYI. We use this variable to capture the difficulty of raising export sophistication; the higher the initial level of export sophistication of an industry, the more difficult for firms in the industry to raise export sophistication further. In regression (10.1), we look at foreign firms as a whole, and find that output-share growth of foreign exporting firms in China has no statistically significant effect on growth of China's export sophistication. This suggests that it is not the magnitude of foreign firms, but the structure of foreign firms, that matters for China's export sophistication.

Regression (10.2) reports several results. First, a one-percent increase in output share of WHO-F corresponds to an increase in export sophistication index of 192, and a one-percent increase in output share of MIN-F corresponds to a decrease in export sophistication index of 156. During the period 1998-2005, WHO-F grew by 16.1 percent, while MIN-F fell by 5.6 percent (Table 1). Thus the total effect of WHO-F and MIN-F on export sophistication index is equal to $192\times0.161+156\times0.056=40$. Since PRODYI increased by 227 in this period, the shift of organizational forms from MIN-F to WHO-F contributed about 18 percent. In other words, the trend of more wholly-owned foreign firms and less minority-owned foreign firms in China constitutes a positive force in raising China's export sophistication. Notice that the estimates of other types of foreign firms are small and statistically insignificant, so the above result reflects the overall effect of the changes in organizational forms of foreign firms in China.

Second, we find the estimated coefficient on DEV is negative and statistically significant. A one-percent increase in average per capita GDP of China's exporting regions corresponds to a decrease of export sophistication index of 2221. We view this result as another dimension of difficulty of raising export sophistication. As a region becomes more developed, the product sophistication level of its exports is high, and hence it becomes increasingly difficult to increase export sophistication. This result supports Rodrik's (2006) view that it will be increasingly difficult for China to raise its export sophistication. Given that DEV grew by 7.8 percent during the sample period, its negative effect on PRODYI growth equals $0.078\times2221=173$.

Third, we find that growth of export sophistication is positively associated with growth of export-market competition (FSHARE). A one-percent increase in non-Chinese

export share in the U.S. market of an industry corresponds to an increase of China's export sophistication index of 8099. In the period 1998-2005, industry average FSHARE decreased by 1.6 percent (Table 1). Note that there is great variation in FSHARE growth rates of Chinese industries, ranging from –87 percent (ISIC=3599, other transport equipment, 1999-2000) to 55 percent (ISIC=3511, building and repairing of ships, 2001-2002); in our sample, 630 industry-year observations (75 percent) have negative FSHARE growth rates, while 203 industry-year observations (25 percent) have positive FSHARE growth rates. Given that FSHARE decreased by 1.6 percent during the sample period, it has a negative effect on PRODYI growth of 0.016×8099=130.

Fourth, we find that WTO dummy is positive and statistically significant, raising China's export sophistication index by 273. Note that the change in the organizational forms of foreign investment (from MIN-F to WHO-F) is largely induced by policy changes due to WTO entry, so the estimated effect on the WTO dummy is an underestimate of the positive effect of WTO entry on China's export sophistication.

Regressions (10.3) and (10.4) report results on the pre-WTO period and post-WTO period, respectively. Organizational changes of foreign firms play an important role in both periods. Notice first that the size of the effects of WHO-F and MIN-F has declined from 1998-2001 to 2002-2005, implying convergence of export sophistication levels as foreign firms adjust their organizational forms. Notice also that WHO-H shows a negative effect in 1998-2001 but a positive effect in 2002-2005. This may be due to the policy of Chinese government to attract overseas Chinese to establish companies in high-tech sectors; casual observations and news reports indicate that many overseas Chinese returned China and established such firms after 2001.

Comparison of regressions (10.3) and (10.4) also shows that DEV is insignificant in the early period but negative and significant in the latter period. This suggests the increasing difficulty for China's advanced regions to raise export sophistication after their export sophistication reached relatively high level. Notice that domestic market structure becomes an important factor in 2002-2005; export sophistication of Chinese industries becomes sensitive to the trend of market concentration (HHI). Notice also that the effect of export market competition has a positive effect on export sophistication, but the size of the effect declines over time. Finally, we find that capital intensity has a

negative effect on the growth rate of export sophistication. We interpret this as reflecting another dimension of difficulty to raise export sophistication; industries with higher capital intensity experienced slower growth in export sophistication.

5. Conclusion

Recent studies found that China exported goods of relatively high product sophistication, which are not compatible to China's economic development level. There were various views and hypotheses about reasons for this observation, but no formal analysis has been done to investigate the reasons.

In this paper we use detailed product-level and firm-level data to examine the determination of product sophistication level of Chinese exports. The product data are from U.S. Customs containing information on 10-digit HS imports from all countries including China. The firm data are from the Annual Survey of Industrial Firms of China's National Bureau of Statistics, which cover all Chinese industrial state-owned firms and all large-scale non-state owned firms (annual sales of five million RMB or more).

The main focus of our research is the role of foreign firms in the determination of China's export sophistication. Following recent literature on firm heterogeneity and international trade, we consider organizational forms of foreign firms to be an important factor. We distinguish between wholly-owned, majority-owned and minority-owned foreign firms in one dimension, and between HMT (Hong Kong, Macao, Taiwan) firms and non-HMT foreign firms in another dimension, and classify foreign firms into six groups. Our main finding is that the increasing presence of wholly-owned non-HMT foreign firms and the decreasing presence of minority-owned non-HMT foreign firms in China during the sample period had a positive effect on China's export sophistication, accounting for about 20 percent. In addition, we find HMT firms are on average indifferent from domestic indigenous firms in export sophistication, but in recent years wholly-owned HMT firms started to ahve a positive effect on China's export sophistication. We consider this positive effect possibly a result of returnees of overseas Chinese who are encouraged by the Chinese government to establish high-tech firms in China. In our sample of 1998-2005, we find distinctive differences between pre-WTO period of 1998-2001 and post-WTO period of 2002-2005. Our estimation shows that after

controlling for the indirect positive effect of WTO entry on organizational changes of foreign firms (e.g. switching from joint ventures to wholly-owned), the WTO entry has a large positive direct effect on the growth of product sophistication of China's exports. In our micro-level study, we find evidence in several dimensions that shows increasing difficulty for China to raise its export sophistication. This is consistent with the evidence at the cross-country level that while China was special before 2001 in exporting goods whose product sophistication is higher than what China's development level implies, China's outlier status has declined steadily after 2001 and indeed China's current overall export sophistication is compatible to its development level.

Our study also examines several other hypotheses related to China's export sophistication. We find that in the 1998-2001 period China's industry-level export sophistication is positively associated with the development level of its exporting regions, but this location effect disappeared in the 2002-2005 period. We do not detect much of an effect from domestic competition except that Chinese industries' falling degree of market concentration had some negative impact on growth of China's export sophistication in 2002-2005. We find however that China's export sophistication is positively related to the degree of foreign competition in the export market. While traditional comparative advantage variables such as technology and capital intensities do not appear to have significant effects in our panel-data regressions, we find that their effects are absorbed in firm identity variables or industry fixed effects. This finding is consistent with recent trade models of firm heterogeneity that show comparative advantage endogenously determined by organizational characteristics of firms.

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Table 1: Variable Description and Summary Statistics, 1998–2005

Variable	Description	Mean	SD	Growth
EXPY	Country export sophistication index	8510	5778	0.187
GDPPC	PPP-adjusted real GDP per capita	8507	8722	0.179
FDIGDP	FDI stock-GDP ratio×100	22.096	26.950	0.928
CHINA	China dummy	NA	NA	NA
PRODYI	Industry (ISIC4) export sophistication index	14268	4629	0.020
FH	Output share of all foreign firms	0.487	0.231	–0.020
WHO–F	Output share of wholly-owned non-HMT	0.121	0.120	0.161
WHO–H	Output share of wholly-owned HMT	0.100	0.110	0.099
MAJ–F	Output share of majority-owned non-HMT	0.079	0.081	–0.056
MAJ–H	Output share of majority-owned HMT	0.034	0.038	–0.034
MIN–F	Output share of minority-owned non-HMT	0.085	0.085	–0.056
MIN–H	Output share of minority-owned HMT	0.067	0.079	–0.093
DEV	Average GDPPC of exporting provinces	9487	2114	0.078
HHI	Herfindahl-Hirschman Index	256	790	–0.017
FSHARE	Share of non-Chinese exports to U.S.	0.878	0.169	–0.016
NP	Output share of new products	0.109	0.116	0.098
KL	Capital labor ratio	96.616	85.078	0.039
WAGE	Average wage rate	13.403	6.933	0.099
WTO	WTO dummy (WTO=1 for 2002-2005)	NA	NA	NA

Note: HMT refers to Hong Kong, Macao, and Taiwan

Table 2: Cross–Country Regressions, 1998–2005, Pooled

	(2.1)	(2.2)	(2.3)	(2.4)
log GDPPC	0.542	0.538	0.629	0.378
	(85.54)***	(81.84)***	(16.07)***	(8.09)***
log FDIGDP		0.009	0.024	0.009
		(1.44)	(4.46)***	(1.53)
CHINA	0.555	0.546		
	(6.46)***	(6.40)***		
Country Fixed Effects	No	No	Yes	Yes
Year Fixed Effects	No	No	No	Yes
Observations	1929	1827	1827	1827
R – squared	0.79	0.79	0.92	0.93

Notes: The dependent variable is log (EXPY). Absolute values of t statistics are in parentheses.
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 3: Cross–Country Regressions, 1998–2005, Yearly

	1998	1999	2000	2001	2002	2003	2004	2005
log GDPPC	0.544	0.569	0.523	0.552	0.540	0.510	0.471	0.504
	(25.29)***	(25.02)***	(23.74)***	(23.70)***	(21.06)***	(20.03)***	(18.55)***	(20.31)***
CHINA	0.554	0.551	0.550	0.510	0.495	0.435	0.462	0.423
	(1.90)*	(1.76)*	(1.80)*	(1.59)	(1.41)	(1.24)	(1.32)	(1.24)
Constant	4.210	3.988	4.426	4.164	4.285	4.556	4.922	4.645
	(22.98)***	(20.53)***	(23.47)***	(20.82)***	(19.41)***	(20.73)***	(22.36)***	(21.53)***
Observations	138	138	139	139	137	138	138	138
R – squared	0.83	0.82	0.81	0.81	0.77	0.75	0.72	0.75

Notes: The dependent variable is log (EXPY). Absolute values of t statistics are in parentheses.
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 4: Cross–Country Regressions, 1998–2005, Yearly

	1998	1999	2000	2001	2002	2003	2004	2005
log GDPPC	0.557	0.574	0.535	0.543	0.521	0.510	0.469	0.501
	(25.17)***	(24.16)***	(22.37)***	(22.34)***	(20.35)***	(19.46)***	(17.77)***	(19.18)***
log FDIGDP	–0.009	0.011	–0.003	0.007	–0.009	–0.009	0.012	0.003
	(0.47)	(0.52)	(0.12)	(0.34)	(0.37)	(0.29)	(0.43)	(0.10)
CHINA	0.566	0.547	0.553	0.502	0.484	0.439	0.468	0.423
	(1.95)*	(1.74)*	(1.80)*	(1.60)	(1.44)	(1.25)	(1.33)	(1.23)
Constant	4.113	3.926	4.328	4.235	4.483	4.584	4.905	4.659
	(21.19)***	(19.58)***	(22.09)***	(20.88)***	(19.93)***	(19.80)***	(21.58)***	(20.75)***
Observations	132	130	130	134	131	137	137	136
R–squared	0.83	0.83	0.81	0.81	0.77	0.75	0.72	0.75

Notes: The dependent variable is log (EXPY). Absolute values of t statistics are in parentheses.
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 5: Key Economic Indicators of China's Firms, 2001

	Output	Export/Sales	NP	Labor	Labor Productivity	WAGE	KL
Non-FH	112954	0.22	0.14	622.24	181.53	10.90	88.97
WHO-F	116650	0.69	0.10	375.15	310.94	14.11	97.36
MAJ-F	200658	0.42	0.25	401.03	500.35	18.10	167.82
MIN-F	166290	0.27	0.34	505.68	328.85	13.43	117.74
WHO-H	62035	0.77	0.05	395.26	156.95	10.94	47.69
MAJ-H	84490	0.55	0.09	384.05	220.00	12.23	78.14
MIN-H	112367	0.34	0.15	424.56	264.67	13.49	108.16

Table 6: Key Economic Indicators of China's Provinces, 2004

Province	GDPPC/China's GDPPC	Export Share	FDI Share
Shanghai*	5.24	0.12	0.10
Beijing*	3.51	0.03	0.04
Tianjin*	2.99	0.04	0.03
Zhejiang	2.27	0.10	0.09
Jiangsu	1.96	0.15	0.15
Guangdong	1.87	0.32	0.17
Fujian	1.63	0.05	0.03
Shandong	1.60	0.06	0.14
Liaoning	1.54	0.03	0.09
Heilongjiang	1.32	0.01	0.01
Hebei	1.22	0.02	0.01
Inner Mongolia	1.07	0.00	0.01
Xinjiang	1.06	0.01	0.00
Jilin	1.04	0.00	0.00
Hubei	0.99	0.01	0.03
Chongqing*	0.91	0.00	0.00
Henan	0.90	0.01	0.01
Hainan	0.89	0.00	0.00
Shanxi	0.87	0.01	0.00
Hunan	0.86	0.01	0.02
Qinghai	0.81	0.00	0.00
Jiangxi	0.78	0.00	0.03
Sichuan	0.77	0.01	0.01
Ningxia	0.75	0.00	0.00
Tibet	0.74	0.00	0.00
Anhui	0.74	0.01	0.01
Shaanxi	0.73	0.00	0.00
Guangxi	0.68	0.00	0.00
Yunnan	0.64	0.00	0.00
Gansu	0.57	0.00	0.00
Guizhou	0.40	0.00	0.00

* Municipality directly under the central government (equivalent to province)

Table 7: Cross–Industry Regressions, 1998–2005, Level

	(7.1)	(7.2)	(7.3)	(7.4)
log FH	75.885			
	(0.52)			
log WHO–F		283.154	191.444	173.790
		(3.98)***	(2.53)**	(2.29)**
log WHO–H		-1.980	-100.194	-108.840
		(0.03)	(1.39)	(1.51)
log MAJ–F		-113.561	-82.708	-84.743
		(1.49)	(1.05)	(1.07)
log MAJ–H		-95.999	-88.736	-95.728
		(1.56)	(1.43)	(1.51)
log MIN–F		-234.898	-208.371	-212.650
		(3.27)***	(2.80)***	(2.86)***
log MIN–H		2.436	71.494	74.560
		(0.04)	(1.09)	(1.13)
log DEV			1,768.930	1,289.910
			(2.50)**	(0.59)
log HHI			-318.839	-256.146
			(1.39)	(1.08)
log FSHARE			4,375.431	4,921.367
			(3.47)***	(3.85)***
log NP			-55.539	-98.643
			(0.59)	(1.02)
log KL			-209.482	-87.654
			(0.46)	(0.19)
log WAGE			433.651	-282.563
			(0.73)	(0.43)
Industry Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	No	No	No	Yes
Observations	906	906	906	906
R–squared	0.79	0.80	0.81	0.81

Notes: The dependent variable is PRODYI. Absolute values of t statistics are in parentheses.
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 8: Cross–Industry Regressions (Technology and Factor Inputs), 1998–2005, Level

	(8.1)	(8.2)	(8.3)	(8.4)
log NP	864.605	865.970	-9.079	-75.430
	(8.49)***	(8.45)***	(0.10)	(0.78)
log KL	869.556	876.477	-90.093	177.346
	(3.54)***	(3.41)***	(0.21)	(0.39)
log WAGE	900.735	871.337	1,423.327	-144.863
	(2.03)**	(1.54)	(4.08)***	(0.22)
Industry Fixed Effects	No	No	Yes	Yes
Year Fixed Effects	No	Yes	No	Yes
Observations	906	906	906	906
R-squared	0.13	0.13	0.80	0.80

Notes: The dependent variable is PRODYI. Absolute values of t statistics are in parentheses.
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 9: Cross–Industry Regressions, 1998–2001 and 2002–2005, Level

	(9.1)	(9.2)	(9.3)	(9.4)
	1998–2001		2002–2005	
log WHO–F	376.325	408.239	144.303	117.079
	(2.61)***	(2.82)***	(1.30)	(1.04)
log WHO–H	-180.159	-165.029	130.081	125.067
	(1.49)	(1.36)	(1.46)	(1.38)
log MAJ–F	-122.593	-133.503	-23.230	-15.368
	(0.79)	(0.85)	(0.26)	(0.17)
log MAJ–H	-157.749	-175.839	-17.435	-15.864
	(1.36)	(1.53)	(0.25)	(0.21)
log MIN–F	-77.187	-98.400	-134.354	-136.677
	(0.55)	(0.68)	(1.54)	(1.57)
log MIN–H	126.204	107.402	24.043	45.447
	(1.11)	(0.95)	(0.27)	(0.51)
log DEV	3,062.128	6,135.973	360.893	382.527
	(2.00)**	(0.52)	(0.33)	(0.17)
log HHI	-537.724	-582.657	-154.288	-30.974
	(0.92)	(1.00)	(0.54)	(0.10)
log FSHARE	12,494.636	12,410.548	-3,164.856	-882.577
	(5.41)***	(5.36)***	(1.32)	(0.34)
log NP	-113.055	-97.794	-209.315	-269.938
	(0.75)	(0.64)	(1.59)	(1.98)**
log KL	-378.611	-561.002	-210.351	72.245
	(0.40)	(0.58)	(0.31)	(0.10)
log WAGE	1,429.063	1,764.838	1,104.552	-55.194
	(1.19)	(1.42)	(1.61)	(0.06)
Industry Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	No	Yes	No	Yes
Observations	449	449	457	457
R–squared	0.86	0.86	0.90	0.90

Notes: The dependent variable is PRODYI. Absolute values of t statistics are in parentheses.
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 10: Cross–Industry Regressions, 1998–2005, Growth

	(10.1)	(10.2)	(10.3)	(10.4)
	1998–2005		1998–2001	2002–2005
PRODYI(–1)	-0.788	-0.754	-1.085	-0.869
	(22.17)***	(21.43)***	(16.98)***	(18.33)***
Δlog FH	-115.436			
	(1.11)			
Δlog WHO–F		191.641	413.720	155.401
		(3.03)***	(3.84)***	(2.16)**
Δlog WHO–H		-12.029	-158.817	162.856
		(0.22)	(1.78)*	(2.48)**
Δlog MAJ–F		-85.154	-312.505	-22.412
		(1.33)	(2.37)**	(0.35)
Δlog MAJ–H		0.363	-51.302	46.747
		(0.01)	(0.58)	(0.89)
Δlog MIN–F		-156.336	-303.715	-115.994
		(2.75)***	(2.85)***	(1.95)*
Δlog MIN–H		44.940	7.434	-35.136
		(0.84)	(0.09)	(0.54)
Δlog DEV		-2,220.512	-297.286	-3,063.524
		(2.13)**	(0.04)	(3.34)***
Δlog HHI		236.719	-495.758	424.068
		(1.00)	(0.82)	(1.81)*
Δlog FSHARE		8,099.165	10,789.949	4,031.119
		(5.89)***	(5.82)***	(1.69)*
Δlog NP		-80.975	-302.024	-59.973
		(1.13)	(2.57)**	(0.73)
Δlog KL		-365.519	-648.504	-1,575.939
		(0.77)	(0.85)	(2.81)***
Δlog WAGE		82.569	-640.259	381.266
		(0.15)	(0.67)	(0.61)
WTO		272.917		
		(1.80)*		
Industry Fixed Effects	Yes	Yes	Yes	Yes
Observations	790	790	336	454
R–squared	0.45	0.50	0.73	0.64

Notes: The dependent variable is ΔPRODYI, where Δ denotes yearly difference. PRODYI(–1) is one-year lag of PRODYI. Absolute values of t statistics are in parentheses.