The Impact of Foreign MNEs on Export Sophistication of Host Countries: Evidence from China

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Abstract

In this paper we assess the impact of foreign MNEs on China's rapidly rising export sophistication during 1998-2005. We use a measure of export sophistication newly developed in the literature, and distinguish MNEs between wholly foreign owned enterprises (WFOEs) and joint ventures (JVs), and between MNEs from OECD and from Hong Kong, Macao and Taiwan (HMT). We test several hypotheses based on MNE heterogeneity against a hypothesis based on the conventional trade theory. We find that China's rising export sophistication is largely explained by the increasing presence of OECD-WFOEs, and also HMT-WFOEs after China's WTO entry in 2001.

Keywords: MNEs; export sophistication; firm heterogeneity; WTO entry; China

1. Introduction

How do multinational enterprises (MNEs) impact the export structure of host countries? There exists much research on this topic in both international business (IB) literature (Dunning, 1993, Chapter 14) and international economics (IE) literature (Markusen, 2002). While the two strands of literature were once very distinctive from each other (Markusen, 2001),[1] the situation has greatly changed recently as trade economists started to shift their focus from countries, industries and homogeneous firms (as in the conventional trade theory of Ricardian, Heckscher-Ohlin, and monopolistic competition models) to heterogeneous firms (as in Melitz, 2003; Helpman, 2006; Bernard, *et al*. 2007).[2] In the new trade models of firm heterogeneity, traditional determinants of export structure (variables associated with comparative advantage and market structure) are shown to be endogenously linked to firm characteristics. These models place individual firm behavior at the center of export structure explanations.[3]

Guided by the new research methodology in the IE literature, we examine role of heterogeneous MNEs in the determination of export structure of host countries. Existing studies have not paid sufficient attention to MNE heterogeneity in export structure determination. For example, in a recent study of Indian export structure, Banga (2006) distinguishes between U.S. and Japanese MNEs, but does not distinguish between

[1] Markusen (2001, p. 69) states that "International trade theory and the study of international business have never had much to say to each other…there are fundamental differences in the types of questions, objectives, and tools of analysis in the two fields."

[2] The newly emerging trade theory of heterogeneous firms is a current research frontier in international trade economics. Melitz (2003) is widely recognized as the pioneering work in this new literature. Helpman (2006) offers a comprehensive survey of this new literature, and Bernard, *et al*. (2007) provides a non-technical summary of the empirical issues in this new literature.

[3] Bernard, Redding and Schott (2007) shows the impact of firm heterogeneity on trade patterns and gains from trade in a general-equilibrium model in which countries differ in factor abundance, industries vary in factor intensity, and firms possess heterogeneous productivity.

different forms of MNEs. In our study, we consider MNE heterogeneity in both investment source and organizational form. First, we distinguish between wholly foreign owned enterprises (WFOEs) and joint ventures (JVs). There is motivated by the IB literature that shows different technology choices of WFOEs and JVs (Dunning and Pearce, 1977; Mansfield and Romeo, 1980; Blodgett, 1991). Second, we distinguish between firms invested by Hong Kong, Macao and Taiwan (HMT), and firms invested by non-HMT economies, which are mainly OECD countries. Both existing studies (Luo, 1999; Buckley, *et al*., 2002; Wei and Liu, 2006) and our data indicate that OECD firms are more intensive in technology, physical and human capital, and have higher productivity than HMT firms. These two dimensions of MNE heterogeneity give us four distinctive firm combinations: OECD-WFOE, HMT-WFOE, OECD-JV, and HMT-JV. The four firm groups vary considerably in their presence (measured by output share) both across Chinese industries and over the sample period of 1998-2005.

Existing studies do not have direct measures of technology sophistication of export structure, which is often indirectly captured by ranking of export shares. For example, Sakakibara and Porter (2001) use world export share (WES) to rank Japanese industries and find that WES is positively related to industry R&D intensity. Banga (2006) uses WES to categorize Indian industries into traditional and non-traditional industries; she defines traditional (non-traditional) industry as the one whose WES is high (low) in a developing country. Ranking of export shares, however, does not provide a satisfactory measure of sophistication of exports, which exhibit considerable heterogeneity at the product level. A recent development in the IE literature is construction of measures of export sophistication (Lall, *et al*., 2006; Rodrik, 2006; Hausmann, *et al*., 2007; Schott, 2007; Wang and Wei, 2007). The basic assumption is that the sophistication level of an exported product is revealed by the income levels of the countries that export the product. For example, passenger jets are exported mainly by high-income countries, so they have a high sophistication level; shirts are exported mainly by low-income countries, so they have a low sophistication level (details in section 2). Our study taps on this new literature of measuring export structure with export sophistication levels.

The Chinese experience provides a golden opportunity to investigate the impact of foreign MNEs on export structure of the host country. First, China has seen rapid upgrading in export structure. Statistics show that in 1992, more than half of China's manufacturing exports to the U.S. were from low-tech industries of "Textiles, apparel, leather and footwear"; this share fell to less than one quarter in 2005. By contrast, "Machinery and equipment; office, accounting and computing machinery" accounted for only 7 percent in 1992, and its share rose to 26 percent in 2005. "Electrical machinery; radio, television and communication equipment" accounted for 12 percent in 1992, and its share rose to 24 percent in 2005. These two more sophisticated industries now account for half of China's manufacturing exports to the U.S. market (Xu, 2007, Table 1). Second, involvement of foreign MNEs in China's exports is both large and dynamic. As Table 1 shows, the share of foreign-invested firms (FIEs) in China's exports ranges from 31.5 percent in 1995 to 58.3 percent in 2005. Among FIEs, the share of WFOEs increased from 11.7 percent in 1995 to 38.4 percent in 2005, while the share of JVs decreased from 24.9 percent in 1996 to 19.9 percent in 2005. Table 2 shows that the share of FDI by HMT firms fell from 79 percent in 1992 to 34 percent in 2005, while the share of FDI by non-HMT firms rose from 21 percent in 1992 to 66 percent in 2005.

The remainder of the paper is organized as follows. In Section 2 we introduce our measure of export sophistication and provide summary information on the dynamics of China's export sophistication in the sample period 1998-2005. In Section 3 we formulate a benchmark hypothesis based on conventional trade theories and three alternative hypotheses that predict the effects of different types of FIEs on China's export sophistication, and discuss the related literature. In Section 4 we explain our empirical methodology and provide summary information on the data. In Section 5 we report and discuss the results of our empirical investigation. In Section 6 we conclude. The Data Appendix provides more details about data sources and variable construction.

2. Export Sophistication

Exported products differ in technology sophistication. Ideally one would like to compute the R&D content embodied in an exported product as a measure of its sophistication level, but product-level R&D data are usually not available. As a result, researchers often rely on indirect information revealed from ranking of industry export shares in their studies (Sakakibara and Porter, 2001; Banga, 2006). Recently a number of researchers construct measures of export sophistication that do not require the use of product-level R&D data (Lall, *et al*., 2006; Rodrik, 2006; Hausmann, *et al*., 2007; Schott, 2007; Wang and Wei, 2007). In this paper we use Rodrik's (2006) method that specifies the following measure for product sophistication level of good i:[4]

$$\text{PRODY}_\text{i} = \sum_{c \in C_i} \left\{ \frac{s_{ic}}{\sum_{n \in C_i} s_{in}} Y_c \right\} \qquad (1)$$

[4] PRODY is the original notation used by Rodrik (2006), as it measures a product's (PROD) content of income (Y). This measure is similar to an earlier measure developed by Michaely (1984).

In this equation, $PRODY_i$ denotes product sophistication level of good i and is measured as the weighted average of GDP per capita (Y_c) of all countries in set C_i that export good i. The weight variable is $s_{ic}/\Sigma s_{in}$, where s_{ic} is the share of good i in country c's total export value, which reflects the importance of good i in country c's exports. Dividing s_{ic} by Σs_{in} makes the sum of weights equal to one, so the weight variable reflects the importance of good i in country c's exports *relative to* all the other countries that export the good.

A numerical example helps to explain the computation of PRODY. Suppose there are three countries. A low-income country (L) exports goods 1, 2, 3 (export shares: 0.5, 0.3, 0.2), a middle-income country (M) exports goods 2, 3, 4 (export shares: 0.5, 0.3, 0.2), and a high-income country (H) exports goods 3, 4, 5 (export shares: 0.5, 0.3, 0.2). Per capita income levels of the three countries are \$5,000, \$10,000, and \$20,000 respectively. Using equation (1) we can compute PRODY of each good. In our example, Good 1 is exported only by country L, so $PRODY_1$=5,000. Good 2 is exported by both country L and country M, so $PRODY_2=(0.3/0.8)\times5000+(0.5/0.8)\times10000=8125$. Similarly we obtain $PRODY_3$=14,000, $PRODY_4$=16,000, and $PRODY_5$=20,000.

One useful property of PRODY is that it can be easily aggregated to industry and country levels. Let N be the set of goods exported by industry I. We can obtain the export sophistication level of industry I from

$$\mathrm{PRODY}_{\mathrm{I}} = \sum_{i\in N} s_{iI}\ \mathrm{PRODY}_i\,, \qquad (2)$$

where s_{iI} is export share of good i in industry I. Thus, an industry's export sophistication level is the weighted average of sophistication levels of the goods exported by this industry. Notice that this industry-level measure of export sophistication has incorporated the heterogeneity of products exported by the industry.

To see if PRODY captures technology sophistication of exports, we perform correlation tests and report the results in Table 3. The sample is 18 OECD countries, for which R&D data (1992-2004) are available for comparison. We find that industry PRODY is highly correlated with industry R&D intensity in this sample, which supports the use of PRODY for empirical investigation of export sophistication.

China has experienced rapid growth in overall level of export sophistication, and is quickly catching up the export sophistication level of advanced countries. By our calculation, China's overall sophistication level of exports to the U.S. market was 7,756 in 1992; 54 percent of the average export sophistication level of the rest of the world. In 2005, China's overall sophistication level of exports to the U.S. market rose to 12,419; 73 percent of the average export sophistication level of the rest of the world.

While most Chinese industries experienced rising export sophistication, their growth rates differ considerably. Table 4 reports the levels and growth rates of PRODY of Chinese industries at the two-digit ISIC industry level from 1998 to 2005. Our analysis will be performed at the more disaggregated level of four-digit ISIC industries, in which variations are much larger. Among the 119 four-digit ISIC industries, the average annual growth rate of PRODY in the period 1998-2005 ranges from -14.3% (ISIC=2022, "manufacture of builders' carpentry and joinery") to 17.5% (ISIC=2695, "manufacture of articles of concrete, cement and plaster"), with mean 1.9% and standard deviation 4.5%. It is important to note that level of PRODY of an industry reflects both the sophistication levels of individual products exported by the industry, and the composition of the exported products of the industry. Similarly, growth of an industry's PRODY reflects both the growth of sophistication levels of individual products exported by the industry, and changes in the composition of the exported products of the industry.

3. Hypotheses

As discussed in the introduction, the IE literature has recently shifted its focus towards heterogeneous firms, narrowing the gap with the IB literature that has always given great attention to MNE heterogeneity. In this paper, we follow an approach that combines the IE focus of identifying aggregated patterns with the IB focus on various dimensions of heterogeneity of MNEs, and formulate hypotheses of export sophistication industry patterns in connection with patterns of MNE heterogeneity.

Before going down to the firm level, we first establish a benchmark hypothesis based on the conventional trade theories of Ricardian, Heckscher-Ohlin (HO), and imperfect competition models of the 1980s. Ricardian and HO models rank sophistication of exports by their technology intensity, physical capital intensity and human capital intensity, and explain a country's export structure by its comparative advantage in technology capability and resource abundance. On the other hand, the imperfect competition trade theory of the 1980s (Helpman and Krugman, 1985), now part of the conventional trade theory, introduces economies of scale and imperfect competition in trade modeling, making market structure variables (degree of industry concentration and competition) key determinants of export structure. From these conventional trade theories, we establish the following hypothesis:

Hypothesis 1: Export sophistication level of an industry is higher the greater the industry's technological intensity, physical capital intensity, and human capital intensity, and the greater the degree of competition in the industry.

Newly-developed trade models of firm heterogeneity (Melitz, 2003; Bernard, Jensen and Schott, 2007) show that the traditional determinants of export structure are endogenously linked to firm characteristics. Firms make decisions on technology, employment of labor, and capital. Thus the technology and factor intensity variables identified by the Ricardian and HO models are themselves endogenously determined by the nature of firms. Firm strategy also impacts the degree of competition in an industry, and hence market structure variables as identified by the imperfect competition trade theory are also endogenously influenced by the nature of firms.

An important dimension of MNE firm heterogeneity is the distinction between WFOEs and JVs. Most empirical evidence (Caves, 1996, section 3.4) indicates that WFOEs tend to adopt higher-level technologies than JVs. Dunning and Pearce (1977, p. 13) find that subsidiaries under less than 100 percent parent firm control accounted for a majority of all subsidiaries in low-technology British industries but only 11 percent in the high-technology industries. Mansfield and Romeo (1980) find that the technologies transferred by U.S. multinational enterprises to its JVs are of an older vintage than those transferred to WFOEs. Blodgett (1991) shows empirical evidence that multinational enterprises protect their technology assets from appropriation by local partners by taking a larger ownership share in the joint venture. Recently Javorcik and Saggi (2004) build a model of entry mode choice, which identifies a trade-off between using a JV to secure a better position in the product market and allowing the local partner to share profits. Their model predicts that foreign investors with more sophisticated technologies will prefer WFOEs to JVs. Based on the above theoretical consideration and empirical evidence, we lay out the following hypothesis:

Hypothesis 2: Export sophistication level of an industry is higher the larger the presence of WFOEs relative to JVs in the industry.

With regard to MNEs in China, there is another important dimension of firm heterogeneity, which is given by the distinction between firms invested by HMT (Hong Kong, Macao, and Taiwan) and firms invested by non-HMT nations (mainly OECD countries). It is well documented that these two types of MNEs in China are of very different natures. Luo (1999) presents survey data of 178 foreign firms in China and finds that Asian firms (mainly HMT) are inferior in technological and organizational competencies but superior in host country-specific knowledge such as marketing tactics and environmental familiarity, compared to Western counterparts. Buckley *et al*. (2002) name the two types of MNEs in China by OC (overseas Chinese) and NC (non-Chinese), and find that NC firms generated technological and international market access spillover benefits for indigenous Chinese firms, while OC firms conferred only market access benefits. Wei and Liu (2006) find evidence that non-HMT firms played a much greater role in inter-industry productivity spillovers than HMT firms. Table 5 (upper panel) reports summary statistics of HMT and non-HMT (OECD) firms over the period of 1998-2005. On average OECD firms are higher in physical capital intensity (176 > 132), human capital intensity (5639 > 4484), and technology intensity (0.041 > 0.027), higher in labor productivity (449 > 325), and about the same in export intensity (0.43 vs. 0.45).[5] The differences between HMT and OECD firms lead to the following hypothesis:

Hypothesis 3: Export sophistication level of a Chinese industry is higher the larger the presence of OECD firms relative to HMT firms in the industry.

One important fact about MNEs in China is that their characteristics change over time, sometimes quite significantly. For example, Table 5 (middle and lower panels) shows that while HMT firms have lower technology and capital intensities than OECD firms averaged over 1998-2005, the gaps have narrowed considerably over time. Such variations in the time dimension provide us with additional information for identification of the effects of MNEs on China's export sophistication.

In our sample period the most significant policy event was China's WTO entry on December 11, 2001. There is strong evidence that WTO membership promotes trade (Subramanian and Wei, 2007). More importantly, China's WTO entry brought significant changes in policies towards FDI. Before 2002, the Chinese government implemented *The Catalogue for the Guidance of Foreign Investment Industries* (1997) which specifies various restrictions on foreign investors. In early 2002, the Chinese government replaced the old *Catalogue* with a new one. In the new catalogue, the number of items under "Encouraged Foreign Investment Industries" was increased from 186 to 262, and the number of items under "Restricted Foreign Investment Industries" was decreased from

[5] Buckley et al. (2002) noted that HMT FDI is primarily export market oriented as encouraged by China's incentive policies, while OECD FDI tends to be local market oriented. Our data shows that the market orientations (measured by export intensities) of the two firm types are about the same in recent years.

112 to 75. One important change of China's FDI policy after WTO entry is the removal of restrictions on foreign ownership in various industries. For example, according to *The Catalogue for the Guidance of Foreign Investment Industries* (2002), for cross-border automobile transportation companies, foreign majority ownership will be permitted no later than December 11, 2002, and wholly foreign owned enterprises will be permitted no later than December 11, 2004. In response to such policy incentives, the share of WFOEs increased significantly after 2002 (Table 1). After China's WTO entry in 2001, Chinese central and local governments also enhanced their encouragement policies towards FDI in high-tech projects. For example, the Shanghai municipal government offered funds to overseas Chinese who set up software or integrated circuit design companies in Shanghai. If an overseas Chinese sets up such a company after January 1, 2002, with a minimum registered capital of RMB500,000, he or she may apply to the Shanghai municipal government for special funding up to RMB100,000.[6] Given these policy incentives, we expect that China's export sophistication would increase significantly in the post-WTO period of 2002-2005, which would be shown in both the effects specific to certain types of MNEs (such as WFOEs and HMT firms) and the general effects that go beyond MNEs. This leads to the following hypothesis:

Hypothesis 4: China's WTO entry had a positive impact on export sophistication levels of Chinese industries.

To summarize, we derive from theory and observations four hypotheses for empirical investigation. The four hypotheses are both distinctive and interdependent with

[6] Source: Wen Hui Bao, June 1, 2002.

each other. Hypothesis 1 tests the variables that determine China's export sophistication as identified by the conventional trade theory. Hypotheses 2 and 3 are intended for identifying the determinants of China's export sophistication as related to the patterns of MNEs in China, which are distinctive from the comparative advantage and market structure variables for understanding China's export sophistication. Hypothesis 4 is intended for identifying the impact of an important policy event that drives the dynamics of the patterns of MNEs in China, namely China's WTO entry. By examining this chain of hypotheses, we hope to gain deeper insights into the role played by foreign MNEs in China in the observed rapid growth of China's export sophistication.

4. Methodology and Data

Our empirical investigation tests the hypotheses laid out in the previous section. Following the recent IE and IB literature, we adopt the methodology of identifying aggregated patterns of export structure from heterogeneous firm behavior. Our export structure variable is Rodrik's (2006) measure of export sophistication, PRODY, which has the useful feature of being easily aggregated from product level to industry and country levels. The data for computing product-level PRODY are from the U.S. Customs database, which is disaggregated by Harmonized System (HS) to the 10 digit level. We use only manufactured goods to avoid the bias in PRODY that may be caused by goods of natural resources. The U.S. imported around 200,000 HS10-level manufactured products each year in the sample period of 1998-2005. We compute for each product a level of export sophistication (see the Data Appendix for details). To identify aggregated patterns of export sophistication, we aggregate product-level PRODY to industry-level

PRODY, which we use as the dependent variable in our regression analysis. Our industry classification is 4-digit ISIC. There are 119 applicable industries.

Our explanatory variables are constructed from firm data collected by China's National Bureau of Statistics in the Annual Survey of Industrial Firms (ASIF), which covers all state-owned enterprises and other types of enterprises with annual sales of five million RMB or more. We aggregate firm data to the industry level to obtain industry intensities of technology, physical capital, and human capital. Because R&D data are not available in years before 2001, we measure technology intensity (TEC) by industry output share of new products. Physical capital intensity (CAP) is measured by industry fixed assets per worker, and human capital intensity (HUM) is measured by industry average wage rate. To capture the degree of industry concentration, we compute the Herfindahl-Hirschman Index (HHI) for each industry, which equals the sum of the square of percentage market shares of all firms in the industry.

We measure the presence of FIEs in an industry by their output share in the industry, and the overall presence is denoted as FIE. We distinguish between WFOEs and JVs, and between OECD firms and HMT firms, and measure the presence of each group. Table 6 gives descriptions of all variables and their summary statistics.

We use two regression specifications in our empirical estimation. The first regression equation is specified as follows:

$$\log \mathrm{PRODY}_{it} = \alpha_i + \alpha_t + \alpha_{1t} \log \mathrm{TEC}_{it} + \alpha_{2t} \log \mathrm{CAP}_{it} + \alpha_{3t} \log \mathrm{HUM}_{it} + \alpha_{4t} \log \mathrm{HHI}_{it} + \alpha_{5t} \log \mathbf{FOR_{it}} + \varepsilon_{it}. \quad (3)$$

In equation (3), α_i denotes industry fixed effects, α_t denotes time fixed effects, $\mathbf{FOR_{it}}$ denotes the set of variables that measure the presence of various types of FIEs, and ε_{it} is an error term. Equation (3) links variation in industry export sophistication level (PRODY) with variations of industry technology intensity (TEC), physical capital intensity (CAP), human capital intensity (HUM), industry concentration (HHI) and presence of FIEs (**FOR**). Hypothesis 1 states that PRODY is positively associated with TEC, CAP, and HUM, which implies $\alpha_{1t} > 0$, $\alpha_{2t} > 0$, and $\alpha_{3t} > 0$. Hypothesis 1 also states that PRODY is positively associated with the degree of industry competition, which implies a negative association between PRODY and the degree of industry concentration (HHI), and thereby $\alpha_{4t} < 0$.

Hypotheses 2 and 3 relate PRODY with different types of FIEs in China. We test Hypotheses 2 by splitting the set of **FOR** into WFOE and JV, and we test Hypotheses 3 by splitting the set of **FOR** into OECD and HMT. Hypotheses 2 and 3 are supported if the estimated coefficients of WFOE and OECD are positive. Moreover, we split the set of **FOR** into four groups (OECD-WFOE, HMT-WFOE, OECD-JV, and HMT-JV) to further investigate the impact of MNE heterogeneity on the distribution of export sophistication across Chinese industries.

Equation (3) also allows us to test Hypothesis 4. For WTO effects not specific to MNEs, we detect them from time fixed effects. Hypothesis 4 is supported if the estimated time fixed effects for the post-WTO period (2002-2005) are significantly higher than that of the pre-WTO period (1998-2001). As for WTO effects through MNEs, we detect them from the estimated coefficients of all α_{kt} (k=1,…,5). Specifically, we define a pre-WTO dummy (m=1 for 1998-2001, and zero otherwise) and a post-WTO dummy (n=1 for 2002-2005, and zero otherwise). The modified regression equation is given by

$$\begin{aligned}\log PRODY_{it} = {} & \alpha_i + \alpha_t + \alpha_1 m\log TEC_{it} + \alpha_2 m\log CAP_{it} + \alpha_3 m\log HUM_{it} + \alpha_4 m\log HHI_{it} \\ & + \alpha_5 m\log \mathbf{FOR_{it}} + \alpha_6 n\log TEC_{it} + \alpha_7 n\log CAP_{it} + \alpha_8 n\log HUM_{it} \\ & + \alpha_9 n\log HHI_{it} + \alpha_{10} n\log \mathbf{FOR_{it}} + \varepsilon_{it}. \qquad (3A)\end{aligned}$$

In equation (3A), α_5 and α_{10} are the effects of **FOR** in the pre-WTO period and the post-WTO period respectively. A comparison of α_5 and α_{10} tells us the relative magnitude of these two effects. For example, we expect $\alpha_{10}>\alpha_5$ for **FOR**=WFOE as China's WTO entry led to more favorable policies towards WFOEs.

There is one concern about level regression equations. Table 7 (upper panel) reports the correlation matrix between level variables in logarithm. We find that some of the variables are highly correlated. For example, the correlation between OECD-WFOE and HMT-WFOE is 0.63, and the correlation between CAP and HUM is 0.54. High correlations between explanatory variables may affect the identification of their individual effects. One way to overcome this is to take time difference of variables. Table 7 (lower panel) shows that the correlations between variables in time difference are quite low (except for the correlation between ΔlogCAP and ΔlogHUM, which is 0.44). This leads us to specify the following difference regression equation:

$$\begin{aligned}\Delta\log PRODY_{it} = {} & \beta_i + \beta_t + \beta_{1t}\,\Delta\log TEC_{it} + \beta_{2t}\,\Delta\log CAP_{it} + \beta_{3t}\,\Delta\log HUM_{it} \\ & + \beta_{4t}\,\Delta\log HHI_{it} + \beta_{5t}\,\Delta\log \mathbf{FOR_{it}} + \nu_{it}. \qquad (4)\end{aligned}$$

Equation (4) links industry export sophistication growth (Δlog PRODY) with technology intensity growth (Δlog TEC), physical capital intensity growth (Δlog CAP), human capital intensity growth (Δlog HUM), change in industry concentration (Δlog HHI), and changes in MNE presence (Δlog **FOR**). Hypothesis 1 is supported if $\beta_{1t} > 0$, $\beta_{2t} > 0$, $\beta_{3t} > 0$, and $\beta_{4t} < 0$. Hypotheses 2 and 3 are supported if the estimated coefficients of WHOE and OECD are positive. To detect the WTO effects, we modify equation (4) as

$$\begin{aligned}\Delta\log \text{PRODY}_{it} = {} & \beta_i + \beta_t + \beta_1 m\Delta\log \text{TEC}_{it} + \beta_2 m\Delta\log \text{CAP}_{it} + \beta_3 m\Delta\log \text{HUM}_{it} \\ & + \beta_4 m\Delta\log \text{HHI}_{it} + \beta_5 m\Delta\log \mathbf{FOR_{it}} + \beta_6 n\Delta\log \text{TEC}_{it} + \beta_7 n\Delta\log \text{CAP}_{it} \\ & + \beta_8 n\Delta\log \text{HUM}_{it} + \beta_9 n\Delta\log \text{HHI}_{it} + \beta_{10} n\Delta\log \mathbf{FOR_{it}} + \nu_{it}. \qquad (4A)\end{aligned}$$

Equation (4A) distinguishes between pre-WTO effects and post-WTO effects in estimated coefficients of the explanatory variables. It also allows us to see (from time fixed effects β_t) if there are any general trends of WTO effects that promote the growth of export sophistication of Chinese industries.

5. Empirical Results

We report regression results in five tables. In Tables 8-10, the dependent variable is industry export sophistication level (log PRODY), and in Tables 11-12 the dependent variable is industry export sophistication growth (Δlog PRODY). The sample contains 119 industries and covers the period 1998-2005.

5.1. PRODY Level Regressions

Table 8 tests Hypothesis 1. In regression (8.1), we assume that the four explanatory variables: technology intensity, physical capital intensity, human capital intensity, and Herfindahl-Hirschman Index (TEC, CAP, HUM, and HHI) suggested by the conventional trade theory capture all the variations in industry characteristics, and hence the regression does not control for industry fixed effects. The results of regression (8.1) indicate that PRODY is positively related to TEC, CAP, and HHI, but the estimated coefficient on HUM is not statistically significant. We learn from Table 7 (upper panel) that HUM and CAP have a correlation of 54 percent in logarithm, so a regression may fail to identify the individual effects of both variables. Regression (8.2) shows that if we drop CAP, the estimated effect of HUM becomes statistically significant. Thus the estimated effects of TEC, CAP, and HUM are found to be consistent with Hypothesis 1. The estimated effect of HHI, however, is inconsistent with Hypothesis 1, which hypothesizes that industries with higher degree of concentration tend to have less competition and hence less incentive to raise product sophistication level. To explain this, we note that degree of concentration of Chinese industries is very low. Table 6 reports that the mean of HHI is only 200. Given that most Chinese industries have low industry concentration levels, HHI may not reflect degree of competition. The estimated positive effect of HHI may be capturing the effects of other industry-specific variables. For example, if industries with higher HHI are more R&D intensive, the R&D effect can show in the estimated coefficient of HHI. This highlights the importance of controlling for industry-specific fixed effects.

Regression (8.3) adds the variable of FIE presence (FIE). This variable turns out to be positive and statistically significant, indicating that FIE presence has a distinctive impact on the industry variation of PRODY. Notice that the explanatory power (R-squared) of regressions (8.1)-(8.3) is rather small (0.13-0.15), which means that there are other important explanatory variables missing in these regressions. In regression (8.4) we include industry fixed effects to account for the effects of unobserved industry-specific explanatory variables, which help to raise the R-squared to 0.78. After controlling for industry fixed effects, however, all the explicit explanatory variables (including FIE) become statistically insignificant. It is not surprising that industry intensity and concentration variables lose their statistical significance since their effects are absorbed into industry fixed effects. However, the finding that FIE has no distinctive impact beyond industry fixed effects suggests that overall FIE presence is too aggregated to identify the effects of FIEs in China, which are very heterogeneous.

Table 9 reports results from regressions that consider heterogeneity of FIEs in China. Regression (9.1) estimates the effects of WFOEs and JVs. We find that WFOE has a positive estimated coefficient that is marginally significant at the 15 percent level, while JV has a statistically insignificant estimated coefficient, which is consistent with Hypothesis 2. Regression (9.2) estimates the effects of OECD and HMT. We find that OECD has a positive estimated coefficient that is statistically significant at the 1 percent level, while HMT has a statistically insignificant estimated coefficient, which is consistent with Hypothesis 3. In regression (9.3), we consider the four distinctive groups of FIEs and find that the estimated effect of OECD-WFOE is positive, the estimated effects of HMT-WFOE and OECD-JV are statistically indifferent from zero, and the estimated effect of HMT-JV is negative, which are consistent with Hypotheses 2 and 3.[7] To see if these effects are distinctively associated with the respective variables, we include industry fixed effects in regression (9.4). Despite the fact that industry fixed effects render most of the explanatory variables statistically insignificant, the estimated effect of OECD-WFOE remains statistically significant. We consider this result as strong evidence that the pattern of foreign firm heterogeneity is a distinctive factor in accounting for variation of export sophistication across Chinese industries.

Next we use regression equation (3A) to estimate coefficients distinctive to the pre-WTO period (1998-2001) and the post-WTO period (2002-2005). Table 10 reports the results in Regression (10). We find that the estimated effect of OECD-WFOE is positive and statistically significant at the 5 percent level in both periods. We also find two interesting patterns. First, the presence of HMT-WFOEs had a negative effect on industry PRODY in the pre-WTO period, but a positive effect (although statistically insignificant) in the post-WTO period. This result is consistent with the policy incentive of the Chinese government in the post-WTO period that encourages high-tech FDI projects from overseas Chinese, and with the trend of HMT firms becoming more technology-intensive (Table 5). Second, capital intensity (CAP) has a positive and statistically significant effect in the pre-WTO period, but not in the post-WTO period.

One important finding from regression (10) is shown in the year dummies, which reveal the significance of WTO entry to the sophistication level of China's exports. In the pre-WTO period, the year dummies show estimated effects below 0.1. By contrast, in the

[7] These regressions include variables of FIE presence but no variables of domestic firm presence, so the estimated coefficients on FIE variables are relative to the effects of domestic firms. Thus, the negative estimated effect of HMT-JV means that the PRODY level associated with HMT-JVs is on average lower than the PRODY level associated with domestic firms (after controlling the effects of other variables).

post-WTO period, the year dummies show estimated effects above 0.35. This evidence supports Hypothesis 4 which states that China's WTO entry had a positive impact on export sophistication levels of Chinese industries.

5.2. PRODY Growth Regressions

As discussed in Section 4, PRODY level regressions contain explanatory variables that are highly correlated, which may cause problems in identification. This leads us to use difference regression equations for estimation. The cost of doing time difference is the loss of information contained in levels and as a result, the explanatory power (R-squared) is likely to be significantly lower. The benefit is that we obtain more reliable estimates of the individual effects of explanatory variables.

Tables 11 and 12 report results from PRODY growth regressions. The dependent variable is yearly growth rate of PRODY of 4-digit ISIC industries, from 1998 to 2005. In regression (11.1), we find that PRODY growth rate is *negatively* related to the growth rate of FIE presence (Δlog FIE). This means that export sophistication grows more slowly in industries with a faster growth rate of FIE presence. On possible explanation for this result is that the industries with faster growth of FIE presence may be the ones with the highest PRODY levels, and hence it is more difficult for them to increase PRODY levels further (leading to slower PRODY growth rates). In regression (11.2), we distinguish between WFOEs and JVs, and find that PRODY growth rate is negatively related to the growth rate of JV presence (Δlog JV), and is unrelated to the growth rate of WFOE presence (Δlog WFOE). In regression (11.3), we distinguish between OECD and HMT, and find that the estimated effects are zero for both firm groups. The statistically insignificant results in Table 1 imply that FIE variables are not distinctive enough for identifying the impact of FIE growth on PRODY growth.

In Table 12 we distinguish FIEs in China in four types. As regression (12.1) shows, once we split FIEs into four groups, we find statistically significant estimated effects on OECD-WFOE and OECD-JV: an industry's PRODY growth is higher the higher the OECD-WFOE growth in the industry, and the lower the OECD-JV growth in the industry. During the sample period of 1998-2005, presence of OECD-WFOEs in Chinese industries grew on average by 17.3 percent annually, while presence of OECD-JVs in Chinese industries declined on average by 6.6 percent annually. This change reflects the trend of OECD-FIEs to increasingly use the WFOE form instead of JV. We can calculate the total effect of this change on PRODY growth as equal to $0.026\times0.173 + 0.017\times0.066 = 0.0056$. Since PRODY grew by 2 percent annually during the period, the compositional change of FIEs contributed about $0.0056/0.02 = 28$ percent to PRODY growth. Regression (12.1) shows that the estimated effects of year dummies are statistically insignificant except for 2001. We interpret this as evidence that China's WTO entry has no additional effect on PRODY growth after controlling for changes in FIE presence and other industry-specific variables.

To see the effects of China's WTO entry on PRODY growth, we use regression equation (4A) which estimates effects of explanatory variables distinctive to the pre-WTO period (1998-2001) and the post-WTO period (2002-2005). Regression (12.2) reports the results. We find that PRODY growth is positively associated with OECD-WFOE growth in both periods, but the size of the estimated effect declines from 0.047 in the pre-WTO period to 0.019 in the post-WTO period. By contrast, the estimated effect of HMT-WFOE is statistically insignificant in the pre-WTO period but becomes statistically significant at the 1 percent level in the post-WTO period. Notice that the estimated effects of OECD-WFOE (0.019) and HMT-WFOE (0.017) are similar in the post-WTO period. This evidence suggests that HMT-WFOEs have been catching up with OECD-WFOEs in their contributions to China's upgrading of export sophistication.

We use estimates from regression (12.2) to compute the contributions of FIEs to PRODY growth. For the pre-WTO period, we calculate the total effect of FIEs on PRODY growth from the estimated effects of OECD-WFOE and OECD-JV, which is equal to $0.047 \times 0.204 + 0.034 \times 0.034 = 0.0107$, and the contribution to PRODY growth is about $0.0107/0.021 = 51$ percent. For the post-WTO period, we can calculate the total effect of FIEs on PRODY growth from the estimated effects of OECD-WFOE and HMT-WFOE, which is equal to $0.019 \times 0.150 + 0.017 \times 0.087 = 0.0043$, and the contribution to PRODY growth is about $0.0043/0.02 = 22$ percent. To summarize, we find that in the pre-WTO period the increasing presence of OECD-WFOEs and the decreasing presence of OECD-JVs accounted for about 51 percent of China's PRODY growth, while in the post-WTO period the increasing presence of WFOEs from both OECD and HMT economies accounted for about 22 percent of China's PRODY growth.

We also find from regression (12.2) that physical capital intensity (CAP) and industry concentration (HHI) had distinctive impacts on China's PRODY growth in the pre-WTO period. The estimated coefficient on CAP is 0.173; since capital intensity increased by 6.8 percent annually in the pre-WTO period, capital deepening contributed $0.173 \times 0.068/0.021 = 56$ percent to PRODY growth. The estimated effect of increasing industry concentration is -0.13; since HHI increased by 4.1 percent annually in the pre-

WTO period, increasing industry concentration (decreasing industry competition) had a negative contribution to China's PRODY growth of $-0.13\times0.041/0.021 = -25$ percent. Both effects are consistent with Hypothesis 1. It is useful to point out that the degree of industry concentration increased by 4.1 percent annually in the pre-WTO period, but decreased by 6 percent annually in the post-WTO period. This is evidence that industry competition increased significantly after China entered the WTO.

In both regressions (12.1) and (12.2), the year dummies in the post-WTO period show effects that are statistically insignificant. This result suggests that China's WTO entry has no additional effect on PRODY growth of Chinese industries beyond the ones identified explicitly in the regressions.

6. Summary and Conclusions

How do MNEs impact the export structure of host countries? This is an important research topic in both the field of international business (IB) and the field of international economics (IE). Traditionally the IE research concentrates mainly on the issues at the national level, while the IB research focuses mainly on the issues at the firm level. Recently there has been a new development in the IE literature that examines patterns of international trade from heterogeneous firm modeling. This bridges the gap between research in international economics and research in international business.

This paper is an application of the new research methodology in the IE literature, in connection with the IB literature. We study China's rapidly upgrading export structure in 1998-2005 to estimate the impact of foreign MNEs. In our investigation we consider two dimensions of heterogeneity with regard to foreign MNEs in China: type of organization (WFOE vs. JV) and source of investment (OECD vs. HMT). Our purpose is to identify distinctive effects from foreign MNEs on China's export structure that are consistent with the hypotheses established from IB and IE theory.

Two new methodological elements of this study are worth mentioning. First, we use a newly developed measure of export sophistication called PRODY, which is an index of product sophistication reflecting the development levels of the countries who export it. This measure has several advantages over the measures of industry intensities used in previous studies. Second, we construct variables from product-level and firm-level data, and perform industry-level regression analyses. This allows us to identify the industry-level patterns driven by firm and product heterogeneity.

This paper yields three main results. First, we find that the comparative advantage and market structure variables from the conventional trade theory are not sufficient to account for the levels and growth rates of export sophistication of Chinese industries. We find also that it is not sufficient to consider the presence of MNEs without distinguishing between MNEs of different types and sources. Our results show that the explanatory power of the aforementioned variables is quite low, and their estimated effects become statistically insignificant once industry and time fixed effects are controlling for. These results provide support for the newly emerging trade theory (Melitz, 2003; Helpman, 2006) that emphasizes the consideration of heterogeneous firms in explaining international trade dynamics and going beyond the comparative advantage and market structure considerations of the conventional trade theory.

Second, we find that the impact of foreign MNEs on the sophistication of China's exports depends strongly on the organizational form of MNEs, and to some degree on the source of MNEs. Our most robust result is a positive correlation between an industry's export sophistication and the presence of OECD-WFOEs in the industry. During the period of 1998-2005, the increasing presence of OECD-WFOEs and the decreasing presence of OECD-JVs contributed 28 percent to Chinese industries' rising export sophistication. On the impact of HMT firms, we find that there is no association of their presence with high export sophistication in the period 1998-2001, but a positive association in the period 2002-2005. Over time, the distinction between OECD and HMT as sources of FDI has decreased in terms of their impact on China's export sophistication. The estimated effects of OECD-WFOEs and HMT-WFOEs are about the same in the period 2002-2005, with a combined contribution of 22 percent to China's rising export sophistication in the period.

Third, we find that the impact of foreign MNEs on the sophistication of China's exports is significantly influenced by the policy changes resulting from China's WTO entry in 2001. Our results show that the average export sophistication level of Chinese industries is higher by about 30 percent in the post-WTO period than in the pre-WTO period. We also estimate the WTO-related effects specific to different types of MNEs, and find that China's rising export sophistication became associated with both OECD-WFOEs and HMT-WFOEs in the post-WTO period, as compared to only OECD-WFOEs in the pre-WTO period, and the magnitudes of the impact of OECD-WFOEs and HMT-WFOEs are converging. We view this as evidence of a growing role of overseas Chinese firms in raising the export sophistication of Chinese industries.

There are several limitations to this paper and they suggest directions of future research. First, although our computation of export sophistication is performed at the 10-

digit HS product level, there is still significant heterogeneity within each 10-digit HS product category (Schott, 2004). It has been found that prices of Chinese exports are significantly below the prices of exports from the other countries in the U.S. market in the same product category (Schott, 2007). How MNEs impact this quality dimension of export sophistication is not explored in this paper.[8] Second, a large fraction of Chinese exports is processing trade carried out by MNEs (Wang and Wei, 2007; Zhang and Song, 2000). Due to lack of data we do not consider the role of processing trade in this paper. Third, in formulating our hypotheses we borrow piece by piece theoretical justifications from the related IB and IE literature. For better interpretation of empirical results, it would be useful to develop an integrated theoretical framework for evaluating the impact of foreign MNEs on export sophistication of host countries.

[8] Blonigen and Ma (2007) and Wang and Wei (2007) have found some evidence that foreign MNEs have contributed to the improvement of China's within-product (quality-related) export sophistication.

Data Appendix

We use U.S. merchandise import data from Feenstra, Romalis and Schott (2002) for 1992-2001 and the USA Trade Online Database for 2002-2005. The data is disaggregated by Harmonized System (HS) to the 10 digit level and recorded by U.S. Customs. For each HS10 product, there is information on exporting country, value, and quantity. We use value and quantity of "general imports", which are imports as they come off the dock. The HS10 data are distinguished by a source country sub-code that describes the trade treatment received by the import (e.g. free-trade agreements, Generalized System of Preferences); consequently, a country may have multiple observations of exports of the same good recorded by the U.S. Customs. In such cases, we aggregate the value and quantity for every country-product observation. Using 2001 as an example, there are 247,104 country-product observations in the raw data, from which we obtain 226,583 unique country-product observations that show positive import values. Among these observations, there are 36,112 observations for which the quantity units could not be measured (the dataset shows positive import value but zero import quantity), which gives rise to a sample of 190,471 observations. We use concordances from the UNCTAD to assign products to 4-digt ISIC (revision 3) industries, and use manufacturing industries (classified as 15-37 by 2-digit ISIC codes) in our study.

To compute the export sophistication index (PRODY), we use PCGDP (GDP per capita, PPP, constant 2000 international $) from World Development Indicator (WDI) of the World Bank. The compatible data for Taiwan is from IMF World Economic Outlook Database. There are 173 countries with PCGDP in some years. We drop countries with missing PCGDP in any year, which leaves us 157 countries. There are some cases where U.S. import data contains country code values that are actually data for a country group. Among the 157 countries, there are seven such country groups. We use GDP and population data from WDI to compute PCGDP for such country groups. In the end we have 141 countries (including seven country groups) that have PCGDP for every year from 1992 to 2005. We choose 1992 as the starting year mainly because it allows a maximum number of countries in our sample. All the 141 countries exported to the U.S., with only Iran and Vietnam having no recorded exports in some years. This gives us a consistent sample of countries so as to avoid the omitted country bias discussed in Hausmann, Hwang, and Rodrik (2007).

The R&D intensity data in Table 3 of the text are industry-level data of 18 OECD countries. The OECD R&D data are from SourceOECD Science and Technology Database, and the industry gross product data are from SourceOECD STAN Structural Analysis Database. OECD data are classified in ISIC (Rev. 3) manufacturing industries. The R&D data are available for most countries when ISIC industries are grouped into 14 industries. We compute an industry's R&D intensity as the ratio of R&D spending to gross product (multiplied by 100).

Data on firms are drawn from China's Annual Survey of Industrial Firms (ASIF) for the time period of 1998-2005. Conducted by the National Bureau of Statistics of China, the annual survey covers all state-owned enterprises and other types of enterprises with annual sales of five million RMB or more, and provides detailed information on firms' identification, operations and performance. Industries are classified by the 1994 version of Chinese Standard Industry Classification (GB/T 4754-1994) in years before 2003 and by the 2002 version (GB/T 4754-2002) in years after 2003. We first convert 1994 codes to 2002 codes, and then to ISIC codes (revision 3). The U.S. import data and the Chinese firm data are linked at the 4-digit ISIC level. We define foreign-invested firms (FIEs) as firms with 10 percent or more equity shares held by MNEs from other countries and regions (including Hong Kong, Macao and Taiwan).

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Table 1: Export Shares by Firm Ownership (%), 1995-2005

Year	Wholly Foreign Owned	Joint Ventures	State-Owned	Collectively-Owned	Private-Owned
1995	11.7	19.8	66.7	1.5	0.0
1996	15.7	24.9	57.0	2.0	0.0
1997	17.1	23.9	56.2	2.5	0.0
1998	20.0	24.1	52.6	2.9	0.1
1999	22.2	23.2	50.5	3.5	0.3
2000	23.8	24.2	46.7	4.2	1.0
2001	25.9	24.1	42.6	5.3	2.0
2002	29.5	22.7	37.7	5.8	4.2
2003	33.3	21.5	31.5	5.7	7.9
2004	36.1	21.0	25.9	5.4	11.7
2005	38.4	19.9	22.2	4.8	14.7

Source: Wang and Wei (2007, Table 2). Data based on official trade statistics from the China Custom Administration.

Table 2: Foreign Direct Investment in China, by Source, 1992-2005

Year	Share of FDI Inflow from HMT	Share of FDI Inflow from Non-HMT
1992	79%	21%
1993	76%	24%
1994	70%	30%
1995	63%	37%
1996	59%	41%
1997	48%	52%
1998	48%	52%
1999	48%	52%
2000	45%	55%
2001	43%	57%
2002	42%	58%
2003	40%	60%
2004	37%	63%
2005	34%	66%

Source: *China Statistical Yearbook*. HMT refers to Hong Kong, Macao and Taiwan.

Table 3: Correlation between Industry PRODY and Industry R&D Intensity

Industries (ISIC Codes)	Correlation	Observations
Food products, beverages and tobacco (15, 16)	0.25***	226
Textiles, 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 Data Appendix for detail). Industry-level PRODY is a weighted sum 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 percent levels.

Table 4: Level and Growth of PRODY of Chinese Industries, 1998-2005

ISIC	Industry	PRODY 1998	PRODY 2005	Growth (%) 1998-2005
15	Food and Beverages	9981	12473	3.2
16	Tobacco	8137	5915	-4.6
17	Textiles	8248	9322	1.7
18	Apparel	6570	6823	0.5
19	Leather and Footwear	7659	8022	0.7
20	Wood except Furniture	6395	8700	4.4
21	Paper	12292	15432	3.2
22	Publishing and Printing	12533	15509	3.0
23	Petroleum and Nuclear Fuel	13560	11574	-2.3
24	Chemicals	15444	17902	2.1
25	Rubber and Plastics	9633	13627	5.0
26	Non-metal Minerals	11832	13119	1.5
27	Basic Metals	10571	14329	4.3
28	Fabricated Metals	14164	15586	1.4
29	Machinery and Equipment, n.e.c.	13471	15684	2.2
30	Computing Machinery	13324	11916	-1.6
31	Electrical Machinery	12485	14139	1.8
32	Communication Equipment	8999	14143	6.5
33	Precision Instruments	11650	14898	3.5
34	Vehicles and Trailers	16207	16902	0.6
35	Other Transport Equipment	14850	15859	0.9
36	Furniture and Miscellaneous	8168	12558	6.1

Note: Growth rate is average annual rate.

Table 5: Firm Characteristics, 1998-2005

	Export Intensity	Technology Intensity	Physical Capital Intensity	Human Capital Intensity	Labor Productivity
			Full Sample Period (1998-2005)		
Non-FIE	0.09	0.026	89	3134	245
FIE	0.44	0.033	152	5017	382
WFOE	0.54	0.020	131	4939	366
JVs	0.34	0.046	173	5094	398
OECD	0.43	0.041	176	5639	449
HMT	0.45	0.027	132	4484	325
OECD-WFOE	0.52	0.026	185	5561	464
HMT-WFOE	0.56	0.015	88	4447	288
OECD-JV	0.35	0.053	169	5703	436
HMT-JV	0.33	0.039	180	4525	364
			Pre-WTO Period (1998-2001)		
Non-FIE	0.08	0.024	70	2879	166
FIE	0.44	0.035	150	4083	305
WFOE	0.58	0.019	147	3717	299
JV	0.34	0.045	151	4330	309
OECD	0.42	0.044	192	4671	361
HMT	0.45	0.028	115	3620	261
OECD-WFOE	0.56	0.025	230	4118	373
HMT-WFOE	0.60	0.015	89	3431	247
OECD-JV	0.34	0.054	171	4979	354
HMT-JV	0.33	0.037	136	3762	271
			Post-WTO Period (2002-2005)		
Non-FIE	0.10	0.027	102	3320	309
FIE	0.44	0.032	154	5615	437
WFOE	0.52	0.020	123	5506	400
JV	0.35	0.046	192	5751	481
OECD	0.44	0.039	166	6216	506
HMT	0.45	0.026	143	5073	373
OECD-WFOE	0.51	0.026	166	6164	507
HMT-WFOE	0.54	0.016	87	4957	310
OECD-JV	0.37	0.052	167	6271	506
HMT-JV	0.33	0.040	221	5235	457

Notes: Intensity variables are defined in Table 6. Labor productivity is output per worker.

Table 6: Variable Description and Summary Statistics

Variable	Description	Mean 98-05	Average Annual Growth (%) 98-05	98-01	02-05
PRODY	Industry export sophistication index	14110	2.0	2.1	2.0
FIE	Industry output share of all foreign firms	0.487	-2.0	0.8	-4.1
WFOE	Industry output share of wholly foreign owned firms	0.223	12.8	15.5	10.8
JV	Industry output share of foreign joint ventures	0.264	-6.5	-4.1	-8.3
OECD	Industry output share of foreign firms not from Hong Kong, Macao, and Taiwan	0.289	0.9	4.3	-1.7
HMT	Industry output share of foreign firms from Hong Kong, Macao, and Taiwan	0.205	-2.7	-0.3	-4.5
OECD-WFOE	Industry output share of wholly foreign owned non-HMT firms	0.121	17.3	20.4	15.0
HMT-WFOE	Industry output share of wholly foreign owned HMT firms	0.100	9.8	11.4	8.7
OECD-JV	Industry output share of non-HMT foreign joint ventures	0.167	-6.6	-3.4	-8.9
HMT-JV	Industry output share of non-HMT foreign joint ventures	0.105	-8.9	-6.1	-11.0
TEC	Industry output share of new products	0.109	10.0	10.5	9.3
CAP	Industry fixed assets-labor ratio	96.6	3.8	6.8	1.6
HUM	Industry average wage rate	13.4	9.9	9.7	10.1
HHI	Industry Herfindahl-Hirschman Index	200	-1.7	4.1	-6.0

Notes: Number of observations is 906 for mean value of listed variables, 791 for average annual growth rate in 1998-2005, 336 for 1998-2001, and 455 for 2002-2005.

Table 7: Correlation Matrix

	log PRODY	log WF-O	log WF-H	log JV-O	log JV-H	log TEC	log CAP	log HUM	log HHI
log PRODY	1								
log O-WF	-0.0241	1							
log H-WF	-0.1537	0.6343	1						
log O-JV	0.0411	0.3266	0.1898	1					
log H-JV	-0.0804	0.4094	0.3956	0.432	1				
log TEC	0.3019	-0.0465	-0.1376	0.1228	-0.003	1			
log CAP	0.2223	-0.2397	-0.3762	0.0185	-0.0376	0.1105	1		
log HUM	0.2265	0.0086	-0.1417	-0.0617	-0.1687	0.2305	0.5442	1	
log HHI	0.1546	-0.2486	-0.3866	-0.2378	-0.3508	0.0496	0.1345	0.2603	1

	Δlog PRODY	Δlog WF-O	Δlog WF-H	Δlog JV-O	Δlog JV-H	Δlog TEC	Δlog CAP	Δlog HUM	Δlog HHI
Δlog PRODY	1								
Δlog O-WF	0.1571	1							
Δlog H-WF	0.0088	-0.0663	1						
Δlog O-JV	-0.0899	-0.1468	-0.0299	1					
Δlog H-JV	0.0192	-0.0006	-0.0148	0.0384	1				
Δlog TEC	-0.0372	-0.0505	0.0051	0.103	0.0427	1			
Δlog CAP	0.033	0.1368	0.1426	-0.0572	-0.0341	-0.0975	1		
Δlog HUM	0.0081	0.1181	0.0042	-0.0661	-0.1439	-0.1304	0.4367	1	
Δlog HHI	0.001	-0.023	-0.0911	-0.308	-0.2003	-0.1197	0.1316	0.1502	1

Table 8: PRODY Level Regressions, 4-Digit ISIC Industries, 1998-2005

	(8.1)	(8.2)	(8.3)	(8.4)
log TEC	0.066	0.065	0.069	-0.006
	(8.44)***	(8.24)***	(8.73)***	(-0.75)
log CAP	0.082		0.091	0.019
	(4.16)***		(4.56)***	(0.52)
log HUM	0.019	0.127	0.002	-0.047
	(0.41)	(3.39)***	(0.05)	(-0.87)
log HHI	0.037	0.034	0.043	0.014
	(3.51)***	(3.18)***	(3.99)***	(0.79)
log FIE			0.027	0.002
			(2.53)***	(0.21)
Constant	9.078	9.194	9.082	9.359
	(93.54)***	(97.97)***	(93.85)***	(62.49)***
Industry Fixed Effects	No	No	No	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Observations	906	906	906	906
R-squared	0.15	0.13	0.15	0.78

Notes: The dependent variable is log PRODY of 4-digit ISIC industries. Values of t statistics are in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 9: PRODY Level Regressions, 4-Digit ISIC Industries, 1998-2005

	(9.1)	(9.2)	(9.3)	(9.4)
log WFOE	0.010			
	(1.46)			
log JV	0.003			
	(0.34)			
log OECD		0.027		
		(2.55)***		
log HMT		-0.004		
		(-0.48)		
log OECD-WFOE			0.017	0.012
			(2.29)**	(1.89)*
log HMT-WFOE			-0.009	-0.006
			(-1.39)	(-1.03)
log OECD-JV			0.012	-0.011
			(1.27)	(-1.28)
log HMT-JV			-0.014	-0.002
			(-1.74)*	(-0.41)
log TEC	0.068	0.066	0.065	-0.007
	(8.49)***	(8.35)***	(8.09)***	(-0.88)
log CAP	0.092	0.089	0.087	0.015
	(4.41)***	(4.48)***	(4.00)***	(0.41)
log HUM	0.010	-0.001	0.002	-0.045
	(0.22)	(-0.01)	(0.05)	(-0.83)
log HHI	0.043	0.041	0.034	-0.001
	(3.86)***	(3.72)***	(2.92)***	(-0.06)
Constant	9.066	9.105	9.117	9.424
	(92.70)***	(93.31)***	(92.29)***	(60.74)***
Industry Fixed Effects	No	No	No	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Observations	906	906	906	906
R-squared	0.15	0.15	0.16	0.79

Notes: The dependent variable is log PRODY of 4-digit ISIC industries. Values of t statistics are in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 10: PRODY Level Regressions, Pre-WTO and Post-WTO Effects

Regression (10)	Pre-WTO (1998-2001)	Post-WTO (2002-2005)
log OECD-WFOE	0.015 (1.97)**	0.017 (2.16)**
log HMT-WFOE	-0.016 (-2.46)**	0.008 (1.09)
log OECD-JV	-0.004 (-0.36)	-0.012 (-1.23)
log HMT-JV	0.004 (0.48)	-0.011 (-1.55)
log TEC	-0.006 (-0.65)	0.003 (0.27)
log CAP	0.077 (1.77)*	0.039 (1.00)
log HUM	-0.026 (-0.39)	-0.046 (-0.80)
log HHI	-0.000 (-0.00)	-0.002 (-0.09)
Constant		9.128 (53.48)***
Industry Fixed Effects		Yes
D1999		0.037 (1.54)
D2000		0.094 (3.59)***
D2001		0.053 (1.81)*
D2002		0.351(3.08)***
D2003		0.361(3.14)***
D2004		0.380(3.21)***
D2005		0.410 (3.47)***
Observations		906
R-squared		0.79

Notes: The dependent variable is log PRODY of 4-digit ISIC industries. Values of t statistics are in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 11: PRODY Growth Regressions, 4-Digit ISIC Industries, 1998-2005

	(11.1)	(11.2)	(11.3)
Δlog FIE	-0.021		
	(-1.91)*		
Δlog WFOE		0.003	
		(0.39)	
Δlog JV		-0.028	
		(-2.68)***	
Δlog OECD			-0.014
			(-1.39)
Δlog HMT			-0.005
			(-0.68)
Δlog TEC	-0.006	-0.003	-0.006
	(-0.80)	(-0.39)	(-0.78)
Δlog CAP	0.050	0.054	0.054
	(1.02)	(1.11)	(1.11)
Δlog HUM	-0.027	-0.032	-0.009
	(-0.04)	(-0.53)	(-0.15)
Δlog HHI	-0.013	-0.027	-0.011
	(-0.52)	(-1.07)	(-0.43)
Constant	0.033	0.034	0.035
	(1.54)	(1.60)	(1.63)
Industry Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Observations	791	791	791
R-squared	0.07	0.08	0.07

Notes: The dependent variable is Δlog PRODY, where Δ denotes yearly difference. Values of t statistics are in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 12: PRODY Growth Regressions, 4-Digit ISIC Industries, 1998-2005

	(12.1)	(12.2)	
		Pre-WTO (1998-2001)	Post-WTO (2002-2005)
Δlog OECD-WFOE	0.026 (3.99)***	0.047 (4.14)***	0.019 (2.22)**
Δlog HMT-WFOE	0.003 (0.55)	-0.010 (-1.15)	0.017 (2.08)***
Δlog OECD-JV	-0.017 (-1.81)*	-0.034 (-2.13)**	-0.004 (-0.31)
Δlog HMT-JV	0.004 (0.64)	0.007 (0.67)	0.006 (0.72)
Δlog TEC	-0.004 (-0.47)	-0.005 (-0.42)	-0.003 (-0.31)
Δlog CAP	0.025 (0.50)	0.173 (2.30)**	-0.074 (-1.11)
Δlog HUM	-0.020 (-0.33)	-0.126 (-1.28)	0.080 (1.01)
Δlog HHI	-0.004 (-0.17)	-0.130 (-2.29)**	0.030 (1.03)
Constant	0.035 (1.65)*		0.034 (1.52)
Industry Fixed Effects	Yes		Yes
D2000	0.021 (0.71)		0.029 (0.99)
D2001	-0.080 (-2.74)***		-0.078 (-2.66)***
D2002	-0.024 (-0.81)		-0.024 (-0.77)
D2003	-0.021 (-0.71)		-0.030 (-0.96)
D2004	-0.026 (-0.88)		-0.037 (-1.13)
D2005	-0.004 (-0.14)		0.001 (0.03)
Observations	791		791
R-squared	0.10		0.13

Notes: The dependent variable is Δlog PRODY, where Δ denotes yearly difference. Values of t statistics are in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.