Multiproduct Firms, Export Product Scope, and Trade Liberalization: The Role of Managerial Efficiency*

Larry Qiu† Miaojie Yu‡
University of Hong Kong Peking University

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Abstract

This paper provides a theoretical and empirical analysis of the effects of unilateral tariff cuts on firms' export product scope. The theoretical model explicitly incorporates cost of management, in addition to the commonly used production cost. Firms are heterogeneous in terms of managerial efficiency but homogenous in terms of production productivity. The analysis predicts that the home country's tariff cut reduces all home firms' export product scope, whereas in response to the foreign country's tariff cut, a home firm's export product scope expands (shrinks) if the firm's management cost is low (high). These predictions are supported by our empirical analysis based on data on Chinese firms from 2000 to 2006.

JEL: F12, F13, F15

Keywords: Multiproduct firm; Management cost; Managerial efficiency; Export product scope; Trade liberalization; China

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†Faculty of Business and Economics, the University of Hong Kong, Hong Kong, Tel: (852)28591043, Email: larryqiu@hku.hk.

‡China Center for Economic Research (CCER), National School of Development, Peking University, Beijing 100871, China, Tel: (86)10-62753109, E-mail: mjyu@nsd.pku.edu.cn.

1 Introduction

Multiproduct firms contribute a large percent to production and international trade in the global economy. These firms frequently adjust their product scope in response to changes in the economic environment and policies (Bernard et al., 2009). Product scope adjustments affect a firm's and an industry's average productivity (Bernard et al., 2010 and 2011). Recent literature on multiproduct firms has increased our understanding of firms' adjustment in response to trade liberalization (see the most recent discussion by Qiu and Zhou, 2013). However, our knowledge about this issue is far from complete. This paper addresses such an issue by examining how firms that differ in managerial efficiency adjust their export product scope (the number of products *exported*), which is different from the total product scope (the number of products *produced*), in response to unilateral trade liberalization, namely, domestic tariff or foreign tariff cut.

Some discrepancies exist between theoretical and empirical literature on multiproduct firms and trade. First, most existing theoretical models analyze how multiproduct firms adjust their product scope in response to globalization, which is represented by bilateral (or bilateral) trade liberalization. In reality, although multilateral trade liberalization exists through multilateral trade negotiations under the framework of the GATT and bilateral trade liberalization exists under free trade agreements, unilateral trade liberalization, or asymmetric bilateral trade liberalization occurs. For example, since 1979 when China started to open its economy, China has unilaterally reduced its average tariffs from above 40 percent to approximately 15 percent prior to its accession to the WTO in 2001. This evidence indicates that our understanding would not be complete if we do not know how firms adjust their product scope in response to unilateral trade liberalization. Moreover, theoretical analysis on the effects of unilateral trade liberalization offers a better foundation for empirical investigation, which explores the sensitivity of exporters' extensive margins to each country's tariff changes. On the one hand, domestic trade liberalization exerts a negative impact (the competition effect) on a firm's profit from each product. On the other hand, a foreign country's trade liberalization provides a positive opportunity (the market expansion effect) to a firm's profit from each product. Although existing theoretical studies focus on the effects of bilateral trade liberalization on firms' adjustment in product scope, they all appear to suggest that the qualitative effects of unilateral trade liberalization on all firms with high or low productivity are similar. However, empirical studies (e.g., Dhingra, 2013) show that firms respond differently. In this paper, we argue that firms differ not only in production productivity, but also in many other aspects, such as managerial efficiency. Firm heterogeneity in management cost could generate results different from firm heterogeneity in production cost.[1]

[1] Nocke and Yeaple (2014) introduced two dimensions of firm heterogeneity: organizational capital and organizational efficiency. These two types of capability result in a trade-off between producing more products with lower productivity and producing less products with higher productivity. Managerial efficiency is very different from organizational capability.

Our model, which focuses on firm heterogeneity in managerial efficiency, assumes that firms are homogeneous in terms of production productivity. Specifically, domestic firms are of two types, efficient ones with low management cost and inefficient ones with high management cost. All firms produce multiple products and employ the same production structure for their products. Every firm has a core competency and faces increasing marginal costs of production for its other products. In addition, introducing each new product at the firm level incurs a fixed cost. A product will be produced if the fixed cost of product introduction is lower than the sum of the profit derived from the domestic market and that derived from the foreign market. The home country's tariff cut increases competition in the domestic market and thus reduces a domestic firm's profit from all its products. Marginal products are no longer profitable to be produced, and consequently, each domestic firm reduces its total product scope. If the total product scope of a firm is reduced to a large extent, the products available for exports are also reduced. Therefore, our model predicts that a drastic domestic tariff cut reduces a firm's export product scope.

A firm decides its optimal export product scope such that its marginal product of export (defined as the least productive product exported) earns zero profit from the foreign market. This zero profit condition implies that all firms' marginal products of export have the same unit cost, which is the sum of production cost and management costs. Thus, an efficient firm's marginal product has a higher production cost than that of an inefficient. Foreign tariff cuts exert two effects on each product exported by a domestic firm. First, a reduction in the iceberg-type foreign tariff lowers the marginal costs of production of all the home country's export products by the same percentage. This phenomenon can be considered an individual shock (positive) because products with different marginal costs of production face different cost reductions in the absolute term. As a result, an efficient firm's marginal product receives a larger reduction (in the absolute term) than that of an inefficient firm. Second, all the home country's export products lower their prices because of cost reduction and thus makes the foreign market competition tougher. This can be considered as a common shock (negative) to all products. Our analysis shows that under certain conditions, the positive individual shock outweighs the negative common shock for the marginal products of efficient firms; however, the opposite is true for the marginal products of inefficient firms. Consequently, efficient firms expand their export product scope in response to foreign tariff cuts, whereas inefficient firms reduce theirs.

An empirical analysis based on Chinese firms' export product scope data from 2000 to 2006 is conducted in this study. Since home tariff reductions of some products in an industry are not directly relevant to a firm in the same industry if the firm does not and will not produce those products, the pro-competitive effects of tariff reduction would be over-estimated if home tariffs were measured at the industry level (Yu, 2013). By the same token, using industry-level measure of foreign tariffs would also lead to a similar estimation bias. To avoid such a bias, we construct and use firm-specific measures of home tariffs and foreign tariffs in all our count-data estimation. Our preliminary empirical analysis which does not consider firm heterogeneity in managerial efficiency finds that firms reduce their export product scope in response to both the home tariff reductions and foreign tariff reductions. Such a finding holds for both low-productivity and high-productivity firms. By contrast, our main empirical analysis which accounts for the role of managerial efficiency finds strongly support for our theoretical prediction: in response to Chinese tariff cuts, Chinese firms reduce their export product scope; in response to foreign tariff cuts, Chinese firms expand their export product scope, whereas those with low-managerial efficiency reduce theirs. In this analysis, we need to separate the true production efficiency from the usual measured TFP, we use a firm's overhead expenses to proxy for management costs, and we construct two indicators, high overhead indicator and low overhead indicator, of managerial efficiency for each firm within an industry. Our estimation results are very robust.

The present study differs from existing ones in literature in many ways. As pointed out earlier, the present study focuses on the effect of unilateral trade liberalization as opposed to bilateral trade liberalization. More importantly, this study introduces managerial efficiency as a source of firm heterogeneity and shows that this heterogeneity, rather than heterogeneity in production productivity, differentiates the responses of firms to foreign countries' trade liberalization. The importance of managerial efficiency and its difference from production productivity have been emphasized in management science literature. For example, Gort and Lee (2003) utilized American industrial data and found that managerial efficiency contributes substantially to the total factor productivity (TFP) in American manufacturing sectors. They identified three sources of managerial efficiency, namely, superior initial managerial endowments, the accumulation of managerial knowledge through learning, and the impact of an effective market for managerial resources internal to the firm. These sources of managerial efficiency are different from a firm's production productivity.

In the theoretical literature of multiproduct firms, all studies assume firm heterogeneity in production productivity and most, with the exception of Nocke and Yeaple (2014) and Qiu and Zhou (2013), predict that in response to bilateral trade liberalization, all firms (less productive and more productive) reduce their product scope (Arkolakis and Muendler, 2011; Baldwin and Gu, 2009; Bernard et al., 2011; Dhingra, 2013; Eckel and Neary, 2010; Feenstra and Ma, 2008). Qiu and Zhou (2013) showed that with an increasing fixed cost of product introduction, the marginal products of firms acquire different productivities; thus, firms may adjust their product scope in response to trade liberalization in the opposite directions.[2] The present study does not rely on the assumption of increasing fixed cost of product introduction to show that firms with different managerial efficiencies may still exhibit opposite responses to foreign tariff cuts even though they have the same production productivity.

[2] If a firm is very productive, its marginal product is also productive. In this case, the positive effect of market expansion dominates over the negative effect of increased competition; the firm then expands its product scope. By contrast, if a firm is not very productive, its maginal product is also not productive. The negative effect dominates, and the firm reduces its product scope.

Not all existing studies are about the effects of bilateral trade liberalization. The implications of unilateral trade liberalization can be obtained from the study of Mayer et al. (2013). The main result of Mayer et al.'s (2013) study indicates that in tough markets, the production distribution of firms is skewed towards their core competencies and firms reduce their product scope. A foreign tariff cut suggests that the foreign market has become less tough and thus more profitable to exporting firms. A direct implication of this result to our model is as follows: extremely tough competition in the domestic market (because of domestic tariff cuts) induces all domestic firms to reduce the set of produced products, and minimal competition in the export market (because of foreign tariff cuts) induces all exporters to expand the set of exported products. This implication is confirmed in our model *without* firm heterogeneity in managerial efficiency. However, a tariff cut in the foreign market has both cost (positive for exporters) and competition (negative) effects. These effects are different for firms with different managerial efficiencies; thus firms adjust their export product scope differently.

Existing empirical studies on multiproduct firms generally find that trade liberalization has significant effects on firms' product scope choice. Despite the fact that most theoretical studies focus on bilateral trade liberalization, many empirical studies highlight unilateral trade liberalization. Dhingra (2013) showed that from 2003 to 2006 in Thailand, less export-oriented domestic firms increased their product lines in response to a unilateral tariff cut, whereas more export-oriented domestic firms reduced their product lines. Iacovone and Javorcik (2010) documented the phenomenon of product "churning" among Mexican firms as a result of improved access to foreign markets, that is, a substantial number of Mexican firms discontinued several existing products and simultaneously developed new products for export. Goldberg et al. (2010) showed that from 1989 to 2003 when intensive trade and other reforms took place in India, Indian firms added more product lines than what they discontinued; the discontinuance was unrelated to tariff reduction. Empirical studies on bilateral or multilateral trade liberalization include those of Baldwin and Gu (2009), Bernard et al. (2011), and Berthou and Fontagne (2011).[3] Previous empirical findings are far from complete or conclusive. The empirical findings of the present study contributes to this literature. Chinese exporters' data are utilized to examine the effects of tariff cuts in China and foreign countries on export product scope. The results show that managerial efficiency is important in determining the extent to which firms adjust their export product scope.[4]

The present study is also related to a recent one by Caliendo and Rossi-Hansberg (2012) in that both emphasize the importance of the other aspects of firm heterogeneity, in addition to heterogenous productivity.

[3] Baldwin and Gu (2009) found that tariff cuts between 1973 and 1997 induced scope contraction in small or non-exporting Canadian firms, but had no effect on large or exporting firms. Bernard et al. (2011) demonstrated that U.S. firms exposed to numerous tariff reductions under the Canada–U.S. Free Trade Agreement reduced the number of products they produced relative to firms exposed to only a few tariff reductions. Berthou and Fontagne (2011) found that after the eurozone was established in 1999, productive French firms increased their export product scope in the eurozone destinations, whereas slightly productive French firms reduced their export product scope.

[4] Manova and Zhang (2013) also employed Chinese data to explore the behavior of multiproduct firms. An important feature of their study is the linkage between multiple products and multiple quality level. Eckel et al.'s (2011) study on Mexican firms also has the same feature.

As Caliendo and Ross-Hansberg (2012) pointed out, a firm is merely a technology to produce goods at a given marginal cost. In reality, a firm has many facets aside from its production technology. Caliendo and Rossi-Hansberg (2012) added organization structure to firms; we introduce management dimension to firms. Moreover, Caliendo and Rossi-Hansberg (2012) assumed that firms are heterogeneous with respect to demand for their products to show the importance of the other aspects of firms; we assume that firms are heterogenous in terms of their managerial efficiency. These added features of firms enrich our understanding of firms' responses to globalization.[5]

The rest of this paper is organized as follows. In Section 2, Chinese data are utilized to conduct a preliminary empirical analysis on Chinese firms' response to trade liberalization without differentiating them by managerial efficiency. The theoretical model with firm heterogeneity in managerial efficiency is introduced in Section 3, and an equilibrium analysis is conducted to derive results related to the effects of trade liberalization on firms' export product scope. Chinese data are employed in Section 4 to test the main theoretical predictions. Section 5 provides the concluding remarks.

2 Preliminary Empirical Analysis

The first empirical analysis on Chinese firms' export product scope adjustment in response to the reduction in trade costs is conducted in this section.

2.1 Estimation Framework and Measures

A firm's *total product scope* is defined in this study as the total number of products that the firm produces and sells to the markets (either domestic or foreign). *Export product scope* is defined as the total number of products that the firm sells to the foreign market. A firm's export product scope is mainly determined by the profitability of a firm's products in the foreign market, which in turn is affected by many factors, including GDP, productivity, and trade costs. A firm's domestic market profitability affects its total product scope, but may or may not affect its export product scope.

We focus on two explanatory variables to determine how changes in trade costs affect a Chinese firm's export product scope. The first variable is the home country's import tariffs (referred to as *home tariff* and denoted by HT hereafter), and the second one is the foreign countries' import tariffs (referred to as *foreign tariff* and denoted by FT hereafter). Accordingly, the following empirical equation is established.

$$e_{it} = \beta_0 + \beta_1 TFP_{it} + \beta_2 HT_{it} + \beta_3 FT_{it} + \boldsymbol{\theta}\boldsymbol{\Psi}_{it} + \epsilon_{it}, \tag{1}$$

where e_{it} is firm i's export product scope, TFP_{it} is firm i' total factor productivity, HT_{it} is the home (Chinese)

[5] Nocke and Yeaple (2014) also introduced another dimension of firm heterogeneity in addition to production productivity.

tariff level faced by firm i, and FT_{it} is the foreign tariff level faced by firm i (all in year t). $\boldsymbol{\Psi}_{it}$ is a vector of control variables, including firm i's export market size (foreign countries' GDP), ownership type (state-owned enterprise, multinational firm, or others), and trade mode (processing or ordinary trade).

Although a country has many tariff lines, tariffs that are not relevant to a particular firm may not have an impact on the firm's export product scope. Hence, we construct *firm-specific tariff* to better evaluate the effects of tariff changes on firms' export product scope. For home tariffs, suppose that a firm produces a set of products for the domestic market. The firm's profit will be affected directly by all tariff lines in this product set. A tariff line will have a significant effect if the firm has a larger share of the corresponding product in its total domestic sales. This condition suggests that a firm-specific tariff should be the average of all relevant tariffs weighted by the share of each product's sales. However, data on product-level domestic sales are unavailable. Thus, we adopt a less satisfactory approach by using the share of a firm's export to substitute the share of its domestic sales, as in Yu (2013). Specifically, we introduce the following measure as firm i's home tariff:

$$HT_{it} = \sum\nolimits_{k\in E_{it}} \left(\frac{X^k_{i,initial\_year}}{\sum_{k\in E_{it}} X^k_{i,initial\_year}} \right) \tau^k_t, \tag{2}$$

where E_{it} is the set of firm i's export products in year t, $X^k_{i,initial\_year}$ is firm i's exports of product k in the first year the firm appears in the sample, and τ^k_t is the home country's ad valorem tariff on product k in year t. Inspired by Topalova and Khandelwal (2011) and Yu (2013), we fix exports for each product at the initial period to avoid possible reverse causality (endogeneity problem) in firm's export scope with respect to measured home tariffs. However, such a measure still faces some possible caveats which will be discussed later.

The construction of firm-specific foreign tariffs is more complicated than the construction of home tariffs because firms not only export multiple products, but also export them to multiple countries, with different subsets of products for different countries. The following measure of FT_{it} is proposed in this study to capture the relative importance of different tariffs of different foreign countries.

$$FT_{it} = \sum_{k\in E_{it}} \left[\frac{X^k_{i,initial\_year}}{\sum_{k\in E_{it}} X^k_{i,initial\_year}} \sum_{c\in C_{it}} \left(\frac{X^{kc}_{i,initial\_year}}{X^k_{i,initial\_year}} \right) \tau^{kc}_t \right], \tag{3}$$

where τ^{kc}_t is product k's ad valorem tariff imposed by country c in year t, $X^{kc}_{i,initial\_year}$ is the value of firm i's export of product k to country c in the first year the product appears in the sample, $X^k_{i,initial\_year} = \sum_{c\in C_{it}} X^c_{ik,initial\_year}$, and C_{it} are the sets of countries where firm i has exports in year t. The ratio $\frac{X^{kc}_{i,initial\_year}}{X^k_{i,initial\_year}}$ represents the share of firm i's product k exported to country c in the first year the firm appears in the sample; it captures the relative importance of τ^{kc}_t in affecting firm i's product k export. Thus, $\sum\limits_{c\in C_{it}} (\frac{X^{kc}_{i,initial\_year}}{X^k_{i,initial\_year}})\tau^{kc}_t$ is the time-invariant weighted average of foreign tariffs on product k for firm i. Such a time-invariant weight can avoid the afford-mentioned endogeneity of weighted tariffs.

We then address TFP_{it}. Although many methods can be employed to measure a firm's TFP, or productivity, we adopt the Olley-Pakes (1996) approach to estimate each Chinese firm's TFP (referred to as TFP1). We modify the standard Olley-Pakes approach to better reflect the reality in China. First, following Feenstra et al. (2013), we use deflated output and input prices at the firm-product level to measure TFP. Second, we use real capital depreciation to construct a firm's real investment (the perpetual inventory method).[6] Third, we consider the effect of China's WTO accession in 2001 and the processing behavior of firms in TFP realization. A detailed description of the augmented Olley-Pakes TFP measures is provided in Appendix C. We also employ other measures of TFP to verify the robustness of the results.[7]

2.2 Data

Regression (1) and construction of HT, FT and TFP require extensive information. Thus, we employ three highly disaggregate panel datasets: product-level tariff data of every country, firm-level production data of Chinese firms, and firm and product-level trade data of Chinese firms. A brief description of these datasets is provided below, and detailed discussions are provided in Appendix A.

Tariffs. The WTO official webpage shows the tariffs of all WTO member countries/regions at HS six-digit level.[8] The database includes the following tariff data for each product category: number of ad valorem duties and non ad valorem duties; average, minimum, and maximum ad valorem duties; and percentage of free duty and bound duty. For analysis purpose, average ad valorem duty is considered the most suitable; hence, only this item is included in our dataset.

Firm production data. China's National Bureau of Statistics maintains a rich database derived from annual surveys of large manufacturing enterprises in China. This database, called the Chinese Manufacturing Enterprises (CME) database, includes all state-owned enterprises (SOE) and large non-SOEs whose annual sales are more than RMB five million (or, equivalently, $770,000). Approximately 162,885 firms are included in 2000

[6] Firm-level data only provide the book value of each firm's capital stock. However, the original value of each firm's capital stock must be obtained for TFP estimation. To solve this problem, we assume $A_t = A_o \Pi_{s=o}^{t}(1 + r_s)$, where A_t is the book value of a firm's capital stock in year t, A_o is the original value of the firm's capital stock when it is purchased in year o, and r_s is the estimated province-industry-level growth rate of nominal capital stock in year s obtained from Brandt et al. (2012). If A_t and r_s are known for each firm, the firm's original nominal book value can be determined accordingly. Approximately 40% of observations have missing investment data, but this is not a problem because our estimation results do not change qualitatively when other measures of TFP are employed as shown later.

[7] The Levinsohn and Petrin (2003) approach is also a popular method to construct TFP. In this approach, materials (*i.e.*, intermediate inputs) are used as a proxy variable. Yu (2013) argues that this approach is appropriate for firms that do not utilize a large amount of imported intermediate inputs, and so it is less appropriate for our study because Chinese firms rely substantially on imported intermediate inputs whose prices are significantly different from those of domestic intermediate inputs (Helpern *et al.*, 2011). Nonetheless, our results do not change qualitatively when Levinsohn-Petrin (2003) TFP or System-GMM TFP is employed. Estimates that employ such TFP measures are not reported to save space but are available upon request.

[8] Data can be accessed at http://tariffdata.wto.org/ReportersAndProducts.aspx. The data from Trade Analysis and Information System generally have missing values, particularly data on the tariffs imposed by other countries on Chinese exports. The product-destination-year combinations that have missing tariffs are thus eliminated.

and $301,961$ in 2006.[9] The CME database contains information on more than 100 financial variables obtained from each firm's accounting statement. The database has obvious omissions and errors. Following Feenstra et al. (2013), we clean the database as follows. We eliminate the observations (i.e., firms) wherein some key financial variables (such as total assets, net value of fixed assets, sales, and gross value of industrial output) are missing, or the number of employees is less than eight.[10] According to the basic rules of the generally accepted accounting principles, we also omit the observations wherein (i) liquid assets are larger than total assets, (ii) total fixed assets are larger than total assets, (iii) the net value of fixed assets is larger than the total assets, (iv) the firm's identification number is missing, or (v) the firm's establishment time is invalid.

Export data. China's General Administration of Customs maintains a highly disaggregate trade database wherein each international trade transaction is recorded. The database contains a large variety of information about each trading firm, including each export product's price, quantity, value, and destination. Product information is available at the HS eight-digit level. We use this database to calculate each Chinese firm's export product scope and construct the weights for HT and FT for each firm. Some firms export products that belong to more than one industry. Considering that our focus is on within-industry multiproduct analysis, we assign a firm to an industry at HS 2-digit level, in which the firm has the most number of export products.

Our study requires the merging of the Customs database and CME database. Matching the two is challenging because they use completely different firm-identification systems. As in Yu (2013), by using the firms' Chinese names, zip codes, and telephone numbers, we are able to match 76,946 firms, which account for more than 40% of the manufacturing firms reported in the CME database and approximately 53% of the export value reported in the Customs database.[11] This representation is comparable to that of Bernard et al. (2009) for US data and Wang and Yu (2012) for Chinese data.

The summary statistics are reported in Table 1 which has three sub-tables. Tables 1A and 1B show that export product scope has a very large variation: The minimum of export product scope is 1 (i.e., a single product), whereas the maximum is 527, with the mean equal to 6.49. Approximately 79% of the Chinese firms (in our merged dataset) exported more than a single product from 2000 to 2006 and accounted for 91.4% of the total exports. Moreover, approximately two-thirds of the firms exported less than 5 products, 90% exported less than 15 products, and only 5% exported more than 25 products.

As shown in Table 1C, China's home tariffs (measured at both industry and firm levels) declined by approx-

[9] In fact, the aggregate data for the manufacturing sector in the annual *China's Statistical Yearbook* are compiled from the CME dataset.

[10] The reason for selecting eight workers as the threshold is that firms with less than eight workers fall under a different legal regime, as mentioned by Brandt *et al.* (2012). We adopt this criterion also because a very small company may not have a good accounting/reporting system. However, our results are not sensitive to this critical level.

[11] Our merged dataset has higher mean of sales than the full-sample CME database; this finding indicates that large firms are likely to be matched. The same matching procedure was used by Yu and Tian (2012).

imately 50% from 2000 to 2006, whereas foreign tariffs (measured at the firm level) decreased by only 3%. One possible reason for the slight decline of foreign tariffs is that most important export destinations for Chinese firms are developed countries which typically had already had a low import tariffs in the beginning year (i.e., in 2000) of our sample (See Yu, 2013, for a detailed discussion).

[Table 1]

2.3 Estimates

The estimation results from the same regression model (1) can differ both quantitatively and qualitatively depending on our assumption of the distribution of the dependent variable. We first assume a normal distribution. The OLS regression estimates are shown in Table 2. Both home and foreign tariffs are positively associated with firms' export product scope. This result suggests that firms reduce their export product scope in response to both home and foreign tariff cuts.

[Table 2]

Our data clearly show that most of the firms export a small number of products, and only a few of them export a very large number of products. This observation suggests that the dependent variable does not follow a normal distribution. Thus, the OLS result reported in column (1) of Table 2 could be biased. Because our dependent variable is a non-negative count number, the use of count-data estimates would be more reliable (Cameron and Trivedi, 2005). Given that Poisson distribution is the most popular discrete distribution used to capture the characteristics of various count data, we also calculate the Poisson estimate (with a clustered robust standard error). Specifically, the dependent variable is assumed to have a probability function $f(e, \mu) = \frac{\exp(-\mu)\mu^e}{e!}$, where $\mu = \exp(\mathbf{X}'\boldsymbol{\beta})$ and $\mathbf{X}$ denotes the vector of independent variables. The regression results are shown in column (2) of Table 2. The main results obtained from OLS remain valid qualitatively. Both home and foreign tariffs have positive and significant effects on export product scope.

Although Poisson distribution is the most popular approach for count data, it may not provide the best representation of our sample distribution. If our sample follows a Poisson distribution, then the mean and variance of a firm's export product scope should be identical and equal to μ. However, our data reveal that the variance of the sample ($var(e) = 96.9$) is approximately 15 times larger than its mean ($\bar{e} = 6.5$), which indicates that Poisson distribution does not provide a good representation of our data. Moreover, our test of the goodness of fit for the Poisson model reports an extremely large χ^2 value (607,445), which again confirms the inappropriateness of Poisson distribution for our dependent variable.

We then resort to negative binomial distribution because it allows the sample to exhibit a pattern of over-dispersion. The probability density function of negative binomial distribution has the following form: $f(e, \mu) =$

$\frac{\Gamma(\alpha^{-1}\mu+e)}{\Gamma(\alpha^{-1}\mu)\Gamma(e+1)}(\frac{\alpha^{-1}\mu}{\alpha^{-1}\mu+\mu})^{\frac{1}{\alpha}}\left(\frac{\mu}{\alpha^{-1}\mu+\mu}\right)^e$, where $\mu = \exp(\mathbf{X}'\boldsymbol{\beta})$ and $\Gamma(\cdot)$ is the Gamma function. In fact, when drawing a graph based on the proportion of firms with different export product scope (see Figure 1), we notice that the negative binomial distribution approximates the observed distribution much better than the Poisson distribution. Since around 80% of the exporters have export product scope less than 10, we assume 10 as the maximum value of the discrete level.[12] We report the negative binomial regression results in column (3) of Table 2. We find that the over-dispersion parameter α generated by the likelihood ratio test is significantly different from zero (we obtain $\alpha = .660$ from the regression), indicating that negative binomial distribution is a good probabilistic representative of our data.[13] The coefficients of both home and foreign tariffs are positive and statistically significant. We include year-specific fixed effects in the regressions because several other time-variant variables, such as exchange rate, may affect the firms' optimal export product scope. We also include firm-specific fixed effects to control the effects of firm-invariant variables, such as firm location.[14] The fixed-effect negative binomial estimates are presented in column (4) of Table 2. The coefficients of home and foreign tariffs are again positive and highly significant. When year fixed effect is introduced, another control variable, China's GDP, is dropped out automatically.

[Figure 1]

All estimates in Table 2 show that more-productive firms have a larger export product scope. This finding supports the prediction of existing theoretical studies on multiproduct firms using Chinese data. Gravity models indicate that the GDP of two trading countries has positive effects on bilateral trade flows. We obtain some effects of gravity on export product scope. On the one hand, we find that the GDP of foreign countries increases the export product scope of Chinese firms. To better evaluate the effects of foreign countries' GDP, we construct and use firm-specific GDP in our analysis by using the share of a firm's export to each country as the weight of the corresponding importing country's GDP. On the other hand, the effect of China's GDP on the export product scope of Chinese firms is insignificant (with an erratic sign). This effect is not be emphasized in our analysis because it will be automatically eliminated when firm-specific and year-specific fixed effects are controlled. We also obtain the following observations: (1) a firm's capital-labor ratio has a negative effect on its export product scope; (2) SOEs have larger export product scopes than non-SOE with other things equal; and (3) firms that engage in processing trade have smaller export product scopes than other firms, i.e., those that only engage in ordinary trade.[15]

[12] Changing the maximum number does not change our estimation results.

[13] We also perform regression based on gamma distribution and obtain results very similar to those of negative binomial distribution. Such results are not presented in the table to save space but are available upon request.

[14] Firm-specific fixed effects in the negative binomial model apply to the distribution of the dispersion parameter (Hardin and Hilbe, 2003).

[15] Some firms change their types of ownership and shipment mode (i.e., processing or ordinary exports). Hence, SOE, foreign, and processing indicators are not eliminated from the fixed-effects estimates. The transitional probability matrixes are not reported to

Four important caveats relate to home tariffs. First, two groups of firms are special. Pure domestic firms do not have any exports; thus, their export product scope (zero) is insensitive to changes in home and foreign tariffs. By contrast, pure exporting firms have no domestic sales; thus, home tariffs do not have any effect on their export product scope. We omit these two groups of firms from the sample to obtain better results. The regression results are shown in column (5) of Table 2. All the coefficients are very close to their counterparts in column (4). This result implies that omitting them from the sample does not change our estimation results.

Second, HT_{it} disregards tariffs on intermediate goods. However, changes in the intermediate goods' tariffs will affect the final goods' profits, which then affect the firm's decision on the total product and export product scopes of the final goods. Moreover, trade liberalization in final goods is often accompanied by trade liberalization in intermediate goods. Hence, the cost effects associated with tariff changes on intermediate goods must be controlled. Accordingly, we include "home input tariffs" as an additional independent variable. Processing imports are duty-free in China; hence, even firms that import the same set of inputs may face different effective tariffs. This phenomenon makes it more difficult to construct firm-specific "home input tariffs." Given that a firm can engage in both processing and non-processing imports, we adopt the index of firm-specific input tariffs (FIT_{it}) suggested by Yu (2013) as our "home input tariffs" for firm. The index is

$$FIT_{it} = \sum_{k \in O_i} \frac{m^k_{i,initial\_year}}{\sum_{k \in M_i} m^k_{i,initial\_year}} \tau^k_t, \tag{4}$$

where $m^k_{i,initial\_year}$ is the value of firm i's imports of intermediate good k in the first year the firm appears in the sample, O_i is the set of firm i's non-processing imports, and M_i is the set of the firm's total imports. The set of processing imports does not appear in (4) because processing imports are duty free. FIT_{it} is constructed with time-invariant weights to avoid the afford-mentioned endogeneity of weighted tariffs, measuring the import weight of each product based on data on the firm's first year in the sample. Table 3 shows the negative binomial estimates when "home input tariffs" is included as a control variable. Trade liberalization in intermediate goods imports lowers export product scope. This result is counter-intuitive. However, the result is reversed for less-integrated firms. In any case, the inclusion of such a control variable does not alter the effects and significance of the two key variables, that is, home tariffs and foreign tariffs of the final goods.

[Table 3]

The third caveat is that in constructing HT_{it}, we assume that the share of each product a firm sells in the domestic market is the same as that in the foreign market. This is definitely untrue, but we would not be able to solve the problem directly because of data limitations. We eliminate the pure domestic and pure exporting firms from the sample to address this problem in part because these two types of firms violate the aforementioned

save space but are available upon request.

assumption to the largest degree. We also perform the following auxiliary regressions to verify the robustness of the main results. China holds an important position in global supply chains (GSCs), and different firms engage in GSCs at different degrees (Yu, 2013). As a result, the differences between their sales distribution in the domestic market and that in foreign markets are also different. We classify all two-digit Chinese industries into two groups, namely, less integrated and more integrated, according to their "production depth" of engaging in GSCs, which is measured by the ratio of value-added to gross industrial output (OECD, 2010). The division line is the mean of the production depth ratio across industries. We then run the regressions separately for these two groups and obtain the estimates in columns (2) and (3) of Table 3. These two groups have different degrees of approximation to the "equal share" assumption; however, we find that for both the less-integrated group and more-integrated group, home and foreign tariffs have the same qualitative results (sign and significance) as in the main model. Hence, our main findings are not sensitive to the "equal share" assumption.

The fourth caveat is that HT_{it} does not include tariffs on products that firm i does not produce. When there is a change in the tariffs on products that a firm does not produce but is competing with, the profits of the firm's existing products and those the firm may potentially produce will be affected. Consequently, the firm's decision on its total product and export product scopes may change. The reason is obvious. Suppose that a firm produces products x and y and product z's tariff experiences a large reduction. Producing z then becomes profitable for the firm. However, if the firm produces z, its profit from existing products may decrease (e.g., drawing resources away from production of existing products). Thus, the total product scope may expand or shrink, depending on how the existing products' profits are affected. We adopt an industry-wide, as opposed to firm-specific, tariff to replace HT_{it} to capture this effect. The regression results are presented in column (4) of Table 3. The coefficients of both home and foreign tariffs are positive and significant.

Lastly, tariff changes may induce a new entry. The export product scopes of new entrants may differ significantly from those of the incumbents. In this case, the estimate may not reflect the actual effects of tariff changes on existing firms' export product scope because it also includes the new entrants' export product scope. We run a balanced panel regression to separate these effects and report the results in column (5) of Table 3. The sign and significance of the home tariff effects do not change.

2.4 Role of Firm Heterogeneity in Productivity

The general conclusion from Table 3 is that Chinese firms would reduce their export product scope in response to home and foreign tariff cuts. As Qiu and Zhou (2013) pointed out, existing theoretical studies and empirical findings show that heterogeneous firms with different productivities may or may not respond to trade liberalization in the same manner with regard to their product scope adjustment. This issue is investigated with Chinese data in the present study. We divide all firms into two groups: low-productivity and high-productivity firms *within* each industry. We then combine all low- (high-) productivity firms from all industries as the low (high) productivity category. Table 4 shows the negative binomial estimates for the low productivity category in columns (1) and (2) and the high productivity category in columns (3) and (4). Columns (1) and (3) contain estimates without fixed effects, and columns (2) and (4) contain estimates with two-way fixed effects. The key coefficients, namely, home and foreign tariffs, are positive and significant. That is, the low-productivity and high-productivity Chinese firms adjust their export product scope in the same direction in response to tariff cuts. Firm heterogeneity in productivity does not matter in this regard.

[Table 4]

2.5 Endogeneity Issues

The estimates in Tables 2-4 may encounter the endogeneity issues of reverse causality. When firms are forced to reduce their export product scope because of the tough import competition induced by home tariff cuts, they may lobby the government for imposing temporary trade restrictions (Grossman and Helpman, 1994; 1996; Bown and Crowley, 2013). Thus, export product scope could reversely affect home tariffs (HT_{it}).[16] Evidence for such a phenomenon exists in developing countries, such as Turkey (Gawande and Bandyopadhyay, 2000), and developed countries, such as the U.S. (Goldberg and Maggi, 1999). This phenomenon may not occur in China because of China's special policy regime and strong regulations on labor unions. Nevertheless, we check whether our main results are sensitive to this potential problem. We control for such reverse causality by using an IV approach.

Inspired by Amiti and Konings (2007) and Yu (2013), here we construct a one-year lag of home tariffs as the instrument by replacing τ_t^k in Eq. (2) with $\tau_{t-1.}^k$ The idea is that the government is generally hard to remove the high protection status quo from an industry with high tariffs, perhaps due to the pressure from domestic special interest groups. Thus, compared to other industries, sectors with high tariffs one year ago would still have relatively high tariffs in the current year.

We report the IV Poisson estimates in columns (1)-(3) of Table 5.[17] All variables are measured at their levels but "home tariffs" is treated as an endogenous variable whereas a "one-year lag of home tariffs" serves as the instrument. Column (1) includes the two key variables (i.e., home tariffs and foreign tariffs), the two-digit industry-specific fixed effects, and the year-specific fixed effects. Column (2) adds more control variables such as firm productivity (TFP1), log weighted GDP of importers, foreign indicators, SOE indicators, and processing

[16] However, it is not a worry for the reverse causality of foreign tariffs (FT_{it}) since Chinese firm's export product scope would not reversely affect the import tariffs imposed by *all* trading partners. This is especially true when foreign tariffs are already measured by time-invariant weight.

[17] The IV Poisson estimates implement a generalized method of moments (GMM) estimator of Poisson regression and allow endogenous variables to be instrumented by excluded instruments. Poisson regression assumes $E(e|x) = \exp(\mathbf{X}b)$ to obtain a consistent estimate of b; thus, it is appropriate for a wide variety of models where the dependent variable is non-negative (Mullahy, 1997; Nichols, 2007).

indicators. After controlling for endogeneity, both home tariffs and foreign tariffs are still positive significant, suggesting that both home tariff reductions and foreign tariff cut reduce home firm's export product scope. Column (3) drops pure processing firms out of the sample, which yields similar results.

Finally, column (4) runs the IV Poisson estimate where all variables are in one-period difference.[18] Given that difference estimates wipe out all unobserved firm heterogeneity (Amiti and Konings, 2007), we only include year-specific fixed effects to control the time-variant factors. Inspired by the work of Trefler (2004), we employ two-period differences in firm-level home tariffs as the instrument of firm-level home tariffs. Both home tariffs (HT_{it}) and foreign tariffs (FT_{it}) are again positive and significant. The Cragg-Donald χ^2 statistics is above the critical values suggested by Stock and Yogo (2005). This result indicates that our IV estimates are not weakly identified.

[Table 5]

2.6 Summary and Issues

Two important results are obtained in this preliminary empirical analysis and they deserve further investigation and understanding. First, we find that firms adjust their export product scope *similarly* in response to home and foreign tariff cuts. However, these two types of tariff reduction have opposite effects on the firms. As indicated in literature (e.g., Qiu and Zhou, 2013), bilateral trade liberalization poses both a threat and an opportunity to every firm. A home tariff cut intensifies domestic competition; this situation is not good for the home firms. By contrast, a foreign tariff cut makes the domestic firms' export more profitable. This conventional wisdom does not clarify our finding on Chinese firms' export product scope adjustment.

Second, we find that firms with different levels of productivity adjust their export product scope in the *same* direction in response to tariff cuts. However, recent literature on heterogeneous firms suggests that high-productivity firms normally behave differently from low-productivity firms.

We explore the two issues mentioned above by first developing a theoretical model (in Section 3) and then testing the predictions from the model (in Section 4).

3 Theoretical Model and Analysis

Our model consists of a world with two countries: China and Foreign. Each country has two industries, namely, the numeraire good industry and the differentiated products industry. Differentiated products are produced by a continuum of firms with measure 1, and numeraire good is produced by atomic firms.

[18] We eliminate observations with negative first-difference of export product scope from the sample.

3.1 Technologies

In China, every firm in the differentiated goods industry can produce multiple products. All firms employ the same production technology but have different managerial capabilities.[19] On the production side, we suppose that a firm produces a set of products with measure s. We index the firm's core competency as product 0 and the others in descending productivity in $[0, s]$; this indexing captures the situation wherein products further away from the core competency become less productive. We let the unit cost of producing the ith product be $c_i = c + \theta i$, where $\theta > 0$ captures the decline of productivity. The unit cost of producing the core competency is c. Introducing a product is costly. If a firm introduces s products, a fixed cost equal to ks will exist, where $k > 0$.

On the management side, we assume that each firm in each market incurs a cost of managing sales, called management cost. Management cost is a fixed cost with regard to the sales value/volume, but is increasing with regard to the number of products.[20] This is justified by the fact that a firm needs to have different sales teams for different product lines which have different features, functions and target consumers. Moreover, we further assume that firms are of two types: *efficient* firms that have lower management cost, denoted by m_l per product line per market, and *inefficient* firms that have higher management cost, denoted by m_h per product line per market, with $m_h > m_l$. Let σ denote the fraction of efficient firms in the economy.

Given that our focus is on Chinese firms, we simplify the situation for foreign firms. We assume that a continuum of identical foreign firms produce the differentiated goods. All of them have the same marginal cost of production, which is assumed to be zero. Each firm produces a single product. Managing sales has no cost, and product introduction has no fixed cost. The measure of foreign firms is also assumed to be 1.

3.2 Product Markets

Following Melitz and Ottaviano (2008), we assume that Z identical consumers exist in China, with each having a quasi-linear preference for the numeraire good and all varieties from the differentiated goods industry.

$$U = Q_0 + \alpha \int_{i \in \Omega} q_i di - \frac{1}{2}\beta \left(\int_{i \in \Omega} q_i di \right)^2 - \frac{1}{2}\gamma \int_{i \in \Omega} q_i^2 di,$$

where α, β, and γ are all positive constants; Q_0 is the consumption of the numeraire good; Ω is the set of all varieties sold in the Chinese market; and q_i is the consumption of variety i. A consumer maximizes her utility subject to a budget constraint. As a result, the market demand for variety i by all Z consumers is

[19] We will examine the case of firm heterogeneity in production productivity in Subsection 3.4.

[20] In our earlier version of the paper, we also assume that management cost is increasing in sales. The present assumption is more realistic.

$p_i = \alpha - \frac{\beta}{Z}\int_{j\in\Omega} q_j dj - \frac{\gamma}{Z}q_i$, from which we obtain the demand function for variety i as

$$p_i = A - bq_i, \text{ where } A = \frac{\alpha\gamma + \beta P}{\beta M + \gamma} \text{ and } b = \frac{\gamma}{Z}. \tag{5}$$

In the above demand function, p_i is the price of variety i, M is the measure of Ω, and $P = \int_{i\in\Omega} p_i di$ is the aggregate price of all varieties. Slope b is exogenous, but the intercept A is endogenous, depending on the degree of product substitution (β) and the degree of product market competition (captured by the endogenous P and M).

The set of varieties, Ω, is large; thus, the seller of variety i regards himself as a small monopolist of variety i whose decision has no direct effect on other products.[21] Competition in the market is captured completely by the vertical intercept of the demand function (A).

The foreign country also has Z consumers and the same demand structure as China. In particular, the demand function for variety i is

$$p_i = A^* - bq_i, \text{ where } A^* = \frac{\alpha\gamma + \beta P^*}{\beta M^* + \gamma}. \tag{6}$$

In this demand function, M^* is the measure of the set of varieties sold in the foreign market, which is denoted by Ω_F, and $P^* = \int_{i\in\Omega_F} p_i di$ is the aggregate price of all varieties in the foreign market.

We assume that tariffs take the form of iceberg transport cost. We let t (> 1) and $t^*(> 1)$ denote China's tariff and the foreign country's tariff. Then, t units of a product must be produced by a foreign firm to sell one unit in the Chinese market, and t^* units of a product must be produced by a Chinese firm to sell one unit in the foreign market. Free trade exists in the numeraire good industry.

3.3 Firms' Decision

We first analyze the Chinese firms' decisions. Each firm takes A and A^* as given when making its decisions. Because all Chinese firms have the same production productivity, without loss of generality, we set $c = 0$ to reduce notation. Suppose that firm j ($j = l$ for efficient firm and $j = h$ for inefficient firm) decides to introduce a range of products, $[0, s_j]$, which is called the firm's *total product scope*, and export a range of products $[0, e_j]$, which is called the firm's *export product scope*.[22] With consumer preference and market size (Z) in the two markets being the same, Chinese firms have a disadvantage in the foreign market because they face trade protection in the foreign market. Hence, in equilibrium, a Chinese firm will not introduce a product that is exported to the foreign market but not sold to the domestic market, that is, $e_j \leq s_j$. If $e_j < s_j$, then some

[21] Following most studies in the literature, we do not consider carniberlization, which is about strategic competition among varieties of the same firm.

[22] If a firm produces product $i \in [0, s]$, it will produce all products $i' < i$ because of the decreasing efficiency in $[0, s]$. If it exports product $i \in [0, e]$, it will export all products $i' < i$.

products ($i \in (e_j, s_j]$) are sold in the domestic market but are not exported; the firm's export products are a subset of its total products. This is the case when the fixed cost of product introduction (k) is not too large. Under this circumstance, the firm's decision in the home market is expressed as

$$\max_{s_j, q_i} \int_0^{s_j} [(A - bq_i)q_i - \theta i q_i]\, di - m_j s_j - k s_j. \tag{7}$$

It is easy to derive the set of first order conditions, from which we obtain the optimal total product scope

$$s_j = \frac{A - 2\sqrt{b(m_j + k)}}{\theta}. \tag{8}$$

The total product scope is larger with stronger market demand (A), lower management cost, lower cost of product introduction (k), and slower decline of productivity (θ). The optimal quantity, price, and profit of each product are, respectively,

$$q_{ji} = \frac{A - \theta i}{2b}, \;\; p_{ji} = \frac{A + \theta i}{2}, \;\; \text{and} \;\; \pi_{ji} = \frac{1}{4b}\left(A - \theta i\right)^2, \;\; \text{for all } i \in [0, s_j]. \tag{9}$$

A stronger demand (i.e., a larger A) leads to a larger output, a higher price and a larger profit.

Given $e_j < s_j$, the firm's optimal decision in the foreign market is provided by

$$\max_{e_j, q_i} \int_0^{e_j} [(A^* - bq_i)q_i - t^* \theta i q_i] di - m_j e_j.$$

It is easy to derive the set of first order conditions, from which we obtain the optimal export product scope

$$e_j = \frac{A^* - 2\sqrt{bm_j}}{\theta t^*}. \tag{10}$$

The optimal quantity, price and profit of each export product for $i \in [0, e_j]$ are

$$q^*_{ji} = \frac{A^* - \theta i t^*}{2b}, \;\; p^*_{ji} = \frac{A^* + \theta i t^*}{2}, \quad \text{and} \;\; \pi^*_{ji} = \frac{1}{4b}\left(A^* - \theta i t^*\right)^2.$$

The export product scope is larger with stronger market demand (A^*), lower management cost (m_j), slower decline in productivity (θ), and lower foreign tariff (t^*). A decrease in foreign tariff increases output and profit, but reduces price. Tougher competition (smaller A^*) reduces output, price and profit.

It is easy to obtain

$$\frac{\partial \pi^*_{ji}}{\partial t^*} < 0 \quad \text{and} \quad \frac{\partial^2 \pi^*_{ji}}{\partial i \partial t^*} < 0. \tag{11}$$

That is, every product benefits from foreign country's tariff cut, and due to the iceberg-transportation nature of tariff, products with higher i benefit more from the foreign country's tariff cut.

We now analyze the foreign firms. In the Chinese market, a foreign firm chooses its quantity to maximize its profit $(A - bq_{fc})q_{fc} - tq_{fc}$, where subscript fc stands for a foreign firm in the Chinese market. Thus, the optimal quantity, price, and profit of a foreign firm in the Chinese market are, respectively,

$$q_{fc} = \frac{A - t}{2b}, \;\; p_{fc} = \frac{A + t}{2}, \;\; \text{and} \;\; \pi_{fc} = \frac{1}{4b}(A - t)^2. \tag{12}$$

In the foreign market, the foreign firm chooses its output to maximize its profit $(A^* - bq_{ff})q_{ff}$, where subscript ff stands for a foreign firm in the foreign market. The optimal quantity, price, and profit of a foreign firm in the foreign market are, respectively,

$$q_{ff} = \frac{A^*}{2b}, \;\; p_{ff} = \frac{A^*}{2}, \;\; \text{and} \;\; \pi_{ff} = \frac{1}{4b}A^{*2}. \tag{13}$$

3.4 Market Equilibrium

Lastly, we determine equilibrium A and A^*.

Given that $A = \frac{\alpha\gamma+\beta P}{\beta M+\gamma}$, we first calculate M and P. $M = s_l\sigma + s_h(1-\sigma) + 1$. From (9), we obtain the aggregate price of firm j in the Chinese market as follows:

$$p_j = \int_0^{s_j} p_{ji}di = \frac{1}{2}As_j + \frac{1}{4}\theta s_j^2.$$

Each foreign firm's price in the Chinese market is given in (12). Thus, the aggregate price in the Chinese market is

$$P = \frac{1}{4}\left[2A\sigma s_l + \theta\sigma s_l^2 + 2A(1-\sigma)s_h + \theta(1-\sigma)s_h^2 + 2(A+t)\right].$$

To simplify the notation, we let $\delta = \frac{2\gamma}{\beta}$. Using the results in $A = \frac{\alpha\gamma+\beta P}{\beta M+\gamma}$ yields

$$A = \frac{2\alpha\delta + \theta[\sigma s_l^2 + (1-\sigma)s_h^2] + 2t}{2[\sigma s_l + (1-\sigma)s_h + 1 + \delta]}. \tag{14}$$

In the foreign market, the total number of products sold is $M^* = \sigma e_l + (1-\sigma)e_h + 1$. The aggregate price of Chinese exporter j is

$$p_j^* = \int_0^{e_j} p_{li}^* di = \frac{1}{2}A^*e_l + \frac{1}{4}t^*\theta e_j^2.$$

Each foreign firm's price is provided in (13). Thus, the aggregate price in the foreign market is

$$P^* = \frac{1}{4}\left[2A^*\sigma e_l + t^*\theta\sigma e_l^2 + 2A^*(1-\sigma)e_h + \; t^*\theta(1-\sigma)e_h^2 + 2A^*\right].$$

Using the results in $A^* = \frac{\alpha\gamma+\beta P^*}{\beta M^*+\gamma}$ yields

$$A^* = \frac{2\alpha\delta + \theta t^*[\sigma e_l^2 + (1-\sigma)e_h^2]}{2[\sigma e_l + (1-\sigma)e_h + 1 + \delta]}. \tag{15}$$

Substituting A in (8), we obtain two equations jointly determining the optimal total product scopes s_l and s_h, which are functions of t. Substituting A^* in (10), we obtain two equations jointly determining the optimal export product scopes e_l and e_h, which are functions of t^*.

3.5 Trade Liberalization

We analyze the respective effects of two types of trade liberalization on the export product scope of Chinese firms. The first type of liberalization is tariff reduction in China (t), and the second type is tariff reduction in the foreign country (t^*).

We first examine $\frac{de_l}{dt}$ and $\frac{de_h}{dt}$. Based on the expression of e_j from (10) and A^* from (15), we immediately know that t does not have any direct effect on e_l and e_h. However, the optimal export product scope given in (10) is obtained under the condition that $e_l < s_l$ and $e_h < s_h$. The Chinese tariff cut may eventually result in the violation of this condition. We prove in Appendix B that $\frac{ds_l}{dt} > 0$ and $\frac{ds_h}{dt} > 0$. Hence, when a tariff cut is implemented in China, Chinese firms reduce their total product scope (s_l and s_h). When tariff cuts are implemented continuously, the total product scope is eventually reduced to the level of the export product scope (e_l and e_h). Once $e_l = s_l$, the optimal export product scope of efficient Chinese firms is no longer given in (10), and once $e_h = s_h$, the optimal export product scope of inefficient Chinese firms is no longer given in (10). Then, we have $\frac{de_j}{dt} = \frac{ds_j}{dt} > 0$.

We then discuss the effect of foreign tariff cuts on Chinese firms' export product scope. We prove in Appendix B that

$$\text{(i) } \frac{de_l}{dt^*} < 0, \text{ and (ii) } \frac{de_h}{dt^*} > 0 \text{ iff } m_h \text{ is sufficiently large.} \tag{16}$$

The above analysis allows us to establish the following proposition.

Proposition 1. *(i) Suppose that there is a drastic cut of import tariffs in China. Then a further tariff cut reduces all Chinese firms' export product scope.*

(ii) In response to a tariff cut by the foreign country, Chinese firms with high managerial efficiency expand their export product scope, whereas those with low managerial efficiency reduce their export product scope if and only if their management cost is sufficiently high (i.e., m_h is sufficiently large).

The results of the proposition are surprising. On the one hand, one may ask why a domestic tariff cut affects export product scope. On the other hand, one may ask why some exporters are negatively affected by a foreign tariff cut such that they have to reduce their export product scope. The explanation is as follows. With regard to domestic tariff cut, each firm incurs a cost of introducing (or maintaining) every product it produces. By retaining a product, a firm obtains profit from the market; however, discontinuing a product results in saving from the fixed cost of production introduction (k) and the fixed cost of sales (m_j). When the domestic market is very profitable, the profit from the domestic market alone can cover the fixed costs. In that case, $e_l < s_l$ and lowering the Chinese tariff reduces a Chinese firm's domestic market profit, which results in a reduction in total product scope but not in export product scope because the latter is only affected by foreign market profitability. However, when a drastic tariff cut is implemented, the firm reduces its product scope to a large extent that the set of products available for export is likewise reduced. This is how domestic trade liberalization affects exports.

A foreign tariff cut has a direct and an indirect effect on Chinese exporters. Every firm's marginal product earns zero profit from the foreign market. On the one hand, the foreign tariff cut lowers the cost of every exported product and thus increases profits. The latter induces all firms to expand their export product scope. This phenomenon is the cost effect, which is positive and direct. On the other hand, a low cost causes every firm to reduce the prices of all its products, which increases competition (lowering A^*). This competition effect, which is negative and indirect, reduces the profits of all products (including the marginal products) and tends to reduce every firm's export product scope. The export product scope of a firm is reduced or expanded depending on the net effect on its marginal product. The competition effect is the same for all products as it shifts down the demand intercept (A^*). However, the cost effect is different for the efficient firms and the inefficient firms. An efficient firm's marginal product has a higher marginal cost of production ($e_l\theta$) than that of an inefficient firm ($e_h\theta$) because the marginal products of all firms earn zero profit and the cost of a product is the sum of its management and production costs. As discussed earlier right below (11), a reduction in foreign tariff (in the form of iceberg transport cost) reduces all products' cost of production by the same percentage; thus, an efficient firm benefits more than an inefficient firm because the former enjoys a larger cost reduction in the absolute term. This is why under certain conditions, the net effect is positive for efficient firms (the cost effect is larger than the competition effect) but negative for inefficient firms (the competition effect is larger than the cost effect).

3.6 Firm Heterogeneity in Production Productivity

The most interesting message from Proposition 1 is that when a tariff cut is implemented in the foreign country, Chinese firms with different managerial efficiency levels respond in opposite directions. In this section, we examine whether the heterogeneous response to foreign tariff cuts by firms with different managerial efficiency levels can be reinterpreted as by firms with different production productivity levels, namely, the usual Melitz (2003) type of firm heterogeneity. We make a few modifications to the main model. First, we assume that Chinese firms are homogeneous in managerial efficiency to obtain a clean result; for simplicity, we let $m_l = m_h = 0$. Second, Chinese firms differ in production productivity. We assume that the cost of core competency c is uniformly distributed in $[0, 1]$. Third, we merely focus on equilibrium analysis in the foreign market.

The derivation of optimal export product scope is similar to that in the main model except for one difference: all equilibrium variables are functions of c. Suppose that a firm has cost of core competence equal to c, called firm c. Then, firm c's optimal export product scope is

$$e(c) = \frac{A^* - \ ct^*}{\theta t^*} = \frac{A^*}{\theta t^*} - \frac{c}{\theta}. \tag{17}$$

We assume that the foreign tariff is not too high or the foreign demand is sufficiently strong such that all Chinese firms export to further simplify the analysis. This condition requires $A^* > t^*$ which we assume to hold below. The export quantity, price, and profit of firm c's ith product are

$$q_i^*(c) = \frac{A^* - (c+\theta i)t^*}{2b}, \quad p_i^*(c) = \frac{A^* + (c+\theta i)t^*}{2}, \quad \text{and} \quad \pi_i^*(c) = \frac{1}{4b}[A^* - (c+\theta i)t^*]^2.$$

Thus, the aggregate price of firm c is given by

$$\begin{aligned} p^*(c) &= \int_0^{e(c)} p_i^*(c)di = \frac{1}{2}(\ A^* + ct^*)e(c) + \frac{1}{4}t^*\theta e(c)^2 \\ &= \frac{(A^* - ct^*)}{4\theta t^*}(3A^* + ct^*). \end{aligned}$$

The aggregate price in the foreign market is given by

$$P^* = \int_0^1 p^*(c)dc + \frac{1}{2}A^* = \frac{9A^{*2} - 3A^*t^* + t^*}{12\theta t^*} + \frac{1}{2}A^*.$$

The number of products in the foreign market is given by

$$M^* = \int_0^1 \frac{A^* - \ ct^*}{\theta t^*}dc + 1 = \frac{2A^* - t^*}{2\theta t^{*2}} + 1$$

The above expressions of P^* and M^*, together with $A^* = \frac{\alpha\gamma + \beta P^*}{\beta M^* + \gamma}$, allow us to solve for the equilibrium A^* as a function of t^*, expressed as $A^*(t^*)$. Substituting equilibrium A^* into the expression of optimal product scope (17), we obtain

$$e(t^*, c) = \frac{A^*(t^*)}{\theta t^*} - \frac{c}{\theta}.$$

$\frac{de(t^*,c)}{dt^*}$ is independent of c. That is, all firms respond to the foreign tariff cut in the same direction. Our numerical example shows that $\frac{de(t^*,c)}{dt^*} < 0$. That is, in response to the foreign tariff cut, all Chinese firms expand their export product scope.

One may ask why the result is different from Proposition 1, which is derived from the model with firm heterogeneity in managerial efficiency. In the main model, the two types of firms have different production productivity levels for their marginal products; thus, foreign tariff reduction affects them differently. However, with homogeneity in managerial efficiency and heterogeneity in production productivity, all firms have the same production productivity for their marginal products. This condition can be seen by substituting (17) into the cost of a firm's marginal product: $c + \theta e(c) = \frac{A^*(t^*)}{t^*}$, which is independent of c. Thus, all firms' marginal products will be affected similarly.

4 Further Empirical Analysis: The Role of Managerial Efficiency

Guided by our theoretical analysis, we conduct an empirical investigation with emphasis on the responses of heterogenous firms to foreign tariff cuts.

We first construct a measure of managerial efficiency. We follow management science literature (e.g., Miller and Vollmann, 1985; Cooper and Kaplan, 1991; Fisher and Ittner, 1999) and use a firm's overhead expenses to proxy for management costs. Specifically, we construct two indicators of managerial efficiency for each firm: high overhead indicator (representing low managerial efficiency) and low overhead indicator (representing high managerial efficiency). We rank all firms in *each* industry according to their overhead expenses (in logarithm). When a firm's overhead expenses is higher than the top 25^{th} quantile, the firm has low managerial efficiency; its high overhead indicator takes the value one, and its low overhead indicator takes the value zero. Similarly, when a firm's overhead expenses is lower than the bottom 25^{th} quantile, the firm has high managerial efficiency; its high overhead indicator takes the value zero, and its low overhead indicator takes the value one. The low and high overhead indicators of firms with overhead expenses between the 25^{th} and 75^{th} quantile are zero. We then pool firms from all industries while maintaining the value of their indicators.

After introducing managerial efficiency and distinguishing it from production productivity, we realize a problem in the TFP measure. The conventional measure of TFP, including our TFP1, is a Solow residual that includes both managerial efficiency and production productivity. To clarify this, consider the following standard Cobb-Douglas gross production function

$$\ln Y_{it} = \alpha_k \ln K_{it} + \alpha_l \ln L_{it} + \alpha_m \ln M_{it} + x_{it} + \varepsilon_{it}, \tag{18}$$

where Y_{it}, K_{it}, L_{it}, M_{it}, and x_{it} are firm i's sales, capital, labor, intermediate inputs, and productivity in year t, respectively.[23] The conventional Olley-Pakes measure of productivity involves obtaining the difference between log output and log factor inputs times their estimated coefficients as follows:

$$TFP1_{it} \equiv x_{it} = \ln Y_{it} - \hat{\alpha}_k \ln K_{it} - \hat{\alpha}_l \ln L_{it} - \hat{\alpha}_m \ln M_{it}. \tag{19}$$

In this approach, firm productivity (TFP1) is clearly correlated with the *ex-post* productivity shock (ε_{it}), such as managerial efficiency.

We follow Feenstra et al. (2013) and construct an *ex-ante* productivity measure called TFP2 to exclude managerial efficiency from our TFP measure. Suppose that investment V_{it} in the Olley-Pakes approach depends on *anticipated* productivity $TFP2_{it}$ of the firm according to the following functional relation: $V_{it} = g_1(x_{it}, \ln K_{it}, EX_{it}, PE_{it}, WTO_t)$, where EX_{it} (PE_{it}) is the export (processing export) indicator that measures whether firm i exports (engages in processing exports) in year t, and WTO_t is an indicator that

[23] Note that Feenstra et al. (2013) worked on a value-added production function instead.

equals one for every year after 2001 and zero before 2001 as China became a WTO member in 2001. Inverting this relation, anticipated productivity can be obtained as

$$TFP2_{it} = g_1^{-1}(V_{it}, \ln K_{it}, EX_{it}, PE_{it}, WTO_t). \tag{20}$$

Appendix C provides a more detailed discussion on our TFP1 and TFP2 construction. Table A2 in the Appendix provides the industry-level estimates of the firms' TFP1 and TFP2 in each industry, together with the associated coefficients of labor, capital, and materials.

With the newly constructed TFP2, we consider the following specification to include firm heterogeneity in managerial efficiency.

$$e_{it} = \beta_0 + \beta_1 TFP2_{it} + \beta_2 HT_{it} + \beta_3 FT_{it} + \beta_4 FT_{it} \times HO_{it} + \beta_5 FT_{it} \times LO_{it} + \boldsymbol{\theta\Psi}_{it} + \epsilon_{it}, \tag{21}$$

where foreign tariffs appear three times in the equation: the foreign tariffs itself, its interaction with the high overhead indicator (HO_{it}), and its interaction with the low overhead indicator (LO_{it}). Our theory predicts that $\hat{\beta}_3 + \hat{\beta}_4 > 0$ and $\hat{\beta}_3 + \hat{\beta}_5 < 0$ because high (low) management cost firms reduces (increases) their export product scope in response to foreign tariff cuts. The regression results are given in Table 6.

[Table 6]

As shown in column (1) of Table 6, high-productivity firms have larger export product scopes. Again, we find that both home and foreign tariff variables have positive and statistically significant coefficients. More importantly, the interaction between foreign tariffs and the high managerial efficiency (i.e., low overhead) dummy is negative and significant, with a much larger economic magnitude than the own coefficient of foreign tariffs. This finding indicates that the effect of foreign tariffs on export product scope is negative (i.e., $0.002-0.005 < 0$). Thus, a foreign tariff reduction increases the export product scope of high managerial efficiency firms. By contrast, the coefficient of the interaction between foreign tariffs and the low managerial efficiency (i.e., high overhead) indicator is positive and significant. Given that $0.002 + 0.003 > 0$, a foreign tariff reduction reduces the export product scope of low managerial efficiency firms. Middle managerial efficiency firms also reduce their export product scope (as indicated by the coefficient value 0.002).

Since home tariffs measure may face some potential pitfalls due to our data limitations, it is interesting to see whether our results are driven by such a measured home tariffs. Hence, we replace firm-specific time-invariant home tariffs with simple industry-level home tariffs in column (2) of Table 6, we find that all results remain robust. However, the coefficients of firm's true production efficiency (TFP2) are no longer significant, though still positive, in both column (1) and (2). We suspect this is due to the inclusion of pure processing firms which, by definition, sell all of their products to other countries. Such firms are found to be less productive than non-pure processing firms (Dai *et al.*, 2013). To make sure that our results are not driven by the pure processing firms, we drop them in column (3). We still find that both time-invariant home tariffs and time-invariant foreign tariffs are positive and significant, and the interaction terms with foreign tariffs exhibit a similar pattern as discussed above. Finally, it is reasonable to ask how sensible our results are to the 25^{th} quantile overhead expenses threshold. In column (4) we take a more parsimonious number and re-define high managerial-efficiency firms as those with overhead expenses lower than the bottom 10^{th} quantile and low managerial-efficiency firms as those with overhead expenses higher than the 90^{th} quantile. We find that our results are insensitive to such an alternative threshold.

[Table 7]

Generally speaking, larger firms also have higher overhead expenses, other things equal (especially for equal managerial efficiency). This raises a concern about the appropriateness of "total overhead expenses" as a measure of managerial efficiency. We address this concern in two ways. First, we include log of firm sales as an additional regressor. Second and more importantly, we use overhead-profit ratio, defined as a firm's total overhead expenses divided by its profit, to define managerial efficiency.[24] We, again, use top and bottom 25^{th} quantiles of firm's overhead-profit ratio as thresholds to define the low and high overhead indicators in each industry. Finally, we perform the Wald test of equality of coefficients $\hat{\beta}_3$ and $\hat{\beta}_5$ for each specifications. The low p-values in each column confirm a strong significant difference in the two coefficients between foreign tariffs and its interaction with the low overhead indicators.

Column (1) of Table 7 reports the negative binomial estimation results. The coefficients of home tariffs, foreign tariffs and its interactions with high (low) overhead indicator all have the anticipated signs. However, the magnitude of the interaction term between foreign tariffs and low overhead indicator is too small to dominate the own coefficient of the foreign tariffs. We suspect that this is due to the lack of control for endogeneity of home tariffs. Hence, we run the IV Poisson estimates in columns (2)-(4) by treating home tariffs as endogenous. By using previous year's home tariffs (with initial weight) as the instrument, the IV Poisson estimation in column (2) shows that the coefficients of home tariffs, foreign tariffs and the interactions with overhead indicators are significant and have the anticipated signs; and more importantly, the magnitude of the interaction term between foreign tariffs and low overhead indicator is larger than that of the foreign tariffs. Since the measure of time-invariant home tariffs cannot apply to the sample of pure domestic firms and pure exporters, as discussed above, we hence drop the two types of firms in column (3) and find very robust results. The last column of Table 7 further drops pure processing firms and still exhibits similar results as those in column (3). Thus, all our findings are robust.

[24] We use log value for total overhead expenses, but actual value for overhead-profit ratio to make the estimate values comparable in terms of size.

5 Concluding Remarks

In this study, we conduct theoretical and empirical analyses on the effects of unilateral tariff cuts on firms' export product scope. The preliminary empirical analysis based on Chinese data shows that Chinese firms reduce their export product scope in response to a domestic tariff cut and a foreign tariff cut. Low-productivity and high-productivity firms behave similarly. We build a theoretical model to fully understand this phenomenon. The novelty of our theoretical model is that it explicitly incorporates a new dimension of firm heterogeneity, namely, managerial efficiency. Our model predicts that the home country's tariff cut reduces all home firms' export product scope; however, in response to a foreign country's tariff cut, a home firm's export product scope expands (shrinks) when the firm's management cost is low (high). We then conduct another empirical analysis and obtain strong evidence to support our theoretical predictions.

Firm heterogeneity in managerial efficiency is the new element in our theoretical and empirical models. We verify the generality of our results based on our specifications of managerial efficiency. In our theoretical model, we model a firm's management cost as a linear function of its total sales. After checking, we find that the results also hold if a firm's management cost is assumed as a quadratic function of total sales. It will be more convincing if we obtain the same results using a more general function of managerial efficiency. Similarly, in our empirical analysis, we use a firm's total overhead expenses and overhead-profit ratio, respectively, as a proxy for management cost. Although these are common measures of management cost in literature, it would be interesting to explore other measures to confirm the robustness of our results.

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Table 1A: Distribution of Firms' Export Product Scope

Export Product Scope	Number of Obs.		Export Value	
	Percent	Cumulative	Percent	Cumulative
1	21.06	21.06	8.64	8.64
2	15.66	36.72	8.65	17.29
3	11.54	48.25	7.80	25.10
4	8.91	57.16	7.60	32.70
5	6.90	64.07	5.85	38.54
6-15	25.82	89.89	31.35	69.89
16-25	6.01	95.90	10.99	80.88
26-527	4.10	100.0	19.12	100.0

Table 1B: Summary Statistics (2000-2006)

Variable	Mean	Std. Dev.
Export Product Scope	6.49	9.84
Firm Sales (RMB1,000)	150,053	1,061,312
Number of Employees	479	1,687
Home Tariffs (Firm Level)	8.52	7.70
Home Tariffs (Industry Level)	11.72	5.59
Foreign Tariffs (Firm Level)	7.47	7.10
Home Input Tariffs (Firm Level)	2.12	3.88
Log China's GDP	28.29	.265
Log Importers' Weighted GDP	28.70	2.43
Overhead-Profit Ratio	8.46	234
Log of Overhead Expenses	6.83	2.18
SOE Indicator	.021	.141
Foreign Indicator	.589	.491
Processing Indicator	.286	.452

Notes: Value is in Chinese yuan. US$1 was equivalent to approximately 8.20 yuan for most of the time in 2000-2006.

Table 1C: Tariff Reductions

Year	Ind. Home Tariffs		Firm Home Tariffs		Firm Foreign Tariffs		Firm Input Tariffs	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
2000	20.34	8.44	15.62	4.13	7.72	8.77	2.69	5.22
2006	10.11	4.15	7.69	1.60	7.61	8.35	1.70	3.47
Change (%)	50.31	–	50.77	–	2.43	–	36.80	–

Notes: Columns (1)-(2) report the mean and standard deviation of 3-digit industry-level home import tariffs whereas columns (3)-(4) report firm-level home import tariffs as described in Eq. (2). Columns (5)-(6) report the mean and standard deviation of firm-level foreign tariffs as described in Eq.(3). The last two columns report the mean and standard deviation of firm input tariffs as described in Eq. (4) in the text.

Table 2: Baseline Estimates

Econometric Methods:	OLS	Poisson	Negative Binomial		
Regressand: Export Product Scope	(1)	(2)	(3)	(4)	(5)
Home Tariffs (Firm-Level)	0.134***	0.015***	0.016***	0.007***	0.008***
	(29.77)	(21.45)	(37.43)	(10.91)	(10.55)
Foreign Tariffs	0.103***	0.013***	0.013***	0.003***	0.003***
	(21.58)	(25.27)	(27.17)	(9.21)	(6.68)
Log Firm TFP (TFP1)	2.781***	0.273***	0.344***	0.035***	0.051***
	(22.92)	(19.85)	(40.59)	(4.19)	(4.78)
Log China's GDP	0.630***	0.093***	0.076***		
	(4.21)	(4.25)	(5.91)		
Log Weighted GDP of Importers	1.367***	0.223***	0.155***	0.123***	0.130***
	(60.91)	(43.74)	(131.14)	(54.57)	(46.25)
Log Capital-Labor Ratio	0.028	0.007	-0.011***	-0.001	0.002
	(1.01)	(1.29)	(-4.69)	(-0.28)	(0.29)
Foreign Indicator	0.443***	0.015	0.082***	0.113***	0.109***
	(5.39)	(0.77)	(12.91)	(5.11)	(4.11)
SOE Indicator	1.062***	0.158***	0.118***	-0.059	-0.081*
	(3.28)	(2.64)	(5.03)	(-1.50)	(-1.91)
Firm-specific Fixed Effects	No	No	No	Yes	Yes
Year-specific Fixed Effects	No	No	No	Yes	Yes
Pure Domestic Firms Dropped	No	No	No	No	Yes
Pure Exporting Firms Dropped	No	No	No	No	Yes
Prob.$>\chi^2$	.000	.000	.000	.000	.000
Observations	87,763	87,763	87,763	63,844	43,191

Note: Robust t-values corrected for clustering at the firm level in parentheses. *(**) indicates significance at the 10% (5%) level. 23,919 observations are dropped in Columns (4) and (5) because of only one observation per group.

Table 3: Negative Binomial Estimates

Regressand: Export Product Scope	All Sample	GSCs Integrated		All Sample	
		Less	More		
	(1)	(2)	(3)	(4)	(5)
Home Tariffs (Firm-Level)	0.009***	0.008***	0.009***		0.024***
	(9.11)	(5.81)	(6.75)		(8.06)
Home Tariffs (Industry-Level)				0.010***	
				(17.13)	
Foreign Tariffs	0.002***	0.001	0.002***	0.004***	0.027***
	(3.01)	(1.62)	(2.96)	(16.49)	(7.72)
Home Input Tariffs	0.084	0.170	0.126		-0.632
	(0.62)	(0.71)	(0.75)		(-1.05)
Log Firm TFP (TFP1)	0.032**	0.046**	0.030	0.125***	0.186***
	(2.53)	(2.18)	(1.60)	(19.46)	(3.87)
Log Weighted GDP of Importers	0.128***	0.118***	0.131***	0.119***	0.154***
	(33.27)	(18.65)	(26.31)	(89.72)	(13.40)
Log Capital-Labor Ratio	0.003	0.011	-0.002	-0.008***	-0.022
	(0.41)	(0.97)	(-0.23)	(-3.08)	(-1.29)
Foreign Indicator	0.147***	0.054	0.192***	0.128***	-0.272***
	(3.99)	(0.92)	(3.89)	(13.66)	(-4.15)
SOE Indicator	-0.108**	-0.073	-0.119*	0.061**	0.061
	(-2.01)	(-0.67)	(-1.93)	(2.37)	(0.36)
Firm-specific Fixed Effects	Yes	Yes	Yes	Yes	Yes
Year-specific Fixed Effects	Yes	Yes	Yes	Yes	Yes
Pure Domestic Firms Dropped	Yes	Yes	Yes	No	Yes
Pure Exporting Firms Dropped	Yes	Yes	Yes	No	Yes
Balanced Panel Considered	No	No	No	No	Yes
Prob.$>\chi^2$	.000	.000	.000	.000	.000
Observations	22,291	7,738	14,090	81,081	1,821

Note: T-values corrected for clustering at the firm level in parentheses. *(**) indicates significance at the 10% (5%) level. 19 industries out of 30 are classified as more global supply chain (GSC) integrated. Refer to the text for details.

Table 4: Negative Binomial Estimates with Heterogeneous Productivity

Productivity Category	Low Productive		High Productive	
Regressand: Exporter Scope	(1)	(2)	(3)	(4)
Home Tariffs (Firm-level)	0.013***	0.011***	0.019***	0.013***
	(23.83)	(17.73)	(28.81)	(20.23)
Foreign Tariffs	0.013***	0.005***	0.012***	0.007***
	(20.98)	(12.58)	(17.21)	(13.90)
Log Firm's TFP	0.363***	0.327***	0.220***	0.080***
	(24.24)	(19.51)	(18.16)	(8.40)
Log China's GDP	0.056***		0.092***	
	(3.30)		(4.65)	
Log Weighted GDP of Importers	0.142***	0.120***	0.167***	0.168***
	(88.88)	(59.60)	(95.97)	(75.74)
Log Capital-Labor Ratio	-0.018***	-0.016***	-0.005	-0.011***
	(-5.50)	(-4.11)	(-1.48)	(-3.26)
Foreign Indicator	0.112***	0.155***	0.040***	0.111***
	(13.51)	(12.92)	(4.07)	(9.78)
SOE Indicator	0.154***	0.052	0.088**	0.091**
	(5.08)	(1.36)	(2.39)	(2.40)
Firm-specific Fixed Effects	No	Yes	No	Yes
Year-specific Fixed Effects	No	Yes	No	Yes
Prob.$>\chi^2$	.000	.0,00	.000	.000
Number of Observations	48,441	48,441	39,322	39,322

Notes: Robust t-values corrected for clustering at the firm level in parentheses.*(**) indicates significance at the 10% (5%) level.

Table 5: IV Poisson Estimates

Measures of Tariffs	Level			First-Difference
Regressand: Export Product Scope	(1)	(2)	(3)	(4)
Home Tariffs (Firm-Level)	0.004***	0.005***	0.003**	0.065***
	(2.65)	(4.06)	(2.56)	(5.10)
Foreign Tariffs	0.005***	0.007***	0.007***	0.004**
	(3.45)	(4.40)	(4.01)	(2.11)
Log Firm TFP (TFP1)		0.459***	0.466***	0.019
		(13.24)	(12.74)	(0.41)
Log Weighted GDP of Importers		0.152***	0.155***	0.126***
		(39.21)	(37.33)	(6.26)
Foreign Indicator		0.025	0.045***	0.292*
		(1.64)	(2.80)	(1.81)
SOE Indicator		0.101*	0.105*	-0.342
		(1.74)	(1.78)	(-1.04)
Industry-specific Fixed Effects	Yes	Yes	Yes	Yes
Year-specific Fixed Effects	Yes	Yes	Yes	No
Pure Processing Firms Dropped	No	No	Yes	Yes
Observations	25,457	24,718	22,735	9,679

Note: T-values in parentheses. *,**,*** indicates significance at the 10%, 5%, and 1% level, respectively. Pure processing firms are dropped in columns (3) and (4). Columns (1)-(3) are IV Poisson estimates in which the endogenous variable is home tariff with initial year weight and the instrument is home previous year's tariffs with initial year weight. Column (4) is the first-difference IV Poisson estimate where the regressand and regressors are in first-difference level. The second-difference firm-level home tariff is used as the instrument for first-difference firm-level home tariff with initial year weights.

Table 6: Managerial Efficiency and Export Product Scope

Cutoffs for Overhead Indicators	25^{th}	25^{th}	25^{th}	10^{th}
Regressand: Export Product Scope	(1)	(2)	(3)	(4)
Home Tariffs (Firm-Level: $\hat{\beta}_1$)	0.011***		0.010***	0.013***
	(32.27)		(30.12)	(23.66)
Home Tariffs (Industry-Level: $\hat{\beta}_1$)		0.008***		
		(13.09)		
Foreign Tariffs ($\hat{\beta}_3$)	0.002***	0.002***	0.002***	0.004***
	(7.35)	(4.14)	(9.28)	(9.35)
Foreign Tariffs	0.003***	0.004***	0.002***	0.008***
× High Overhead Indicator ($\hat{\beta}_4$)	(8.29)	(8.52)	(7.23)	(12.01)
Foreign Tariffs	-0.005***	-0.005***	-0.006***	-0.010***
× Low Overhead Indicator ($\hat{\beta}_5$)	(-7.58)	(-5.49)	(-9.26)	(-3.72)
Log Firm TFP (TFP2: $\hat{\beta}_2$)	0.007	0.016	0.015**	0.051***
	(0.93)	(1.47)	(2.07)	(3.92)
Log Weighted GDP of Importers	0.115***	0.122***	0.118***	0.162***
	(109.59)	(84.86)	(111.88)	(88.92)
Foreign Indicator	0.086***	0.107***	0.095***	0.125***
	(9.60)	(10.14)	(10.44)	(13.36)
SOE Indicator	0.016	0.015	0.032*	0.026
	(0.83)	(0.57)	(1.76)	(0.91)
P-value of Diffference between $\hat{\beta}_3$ and $\hat{\beta}_5$	[.000]	[.000]	[.000]	[.000]
Firm-specific Fixed Effects	Yes	Yes	Yes	Yes
Year-specific Fixed Effects	Yes	Yes	Yes	Yes
Pure Processing Firms Dropped	No	No	Yes	Yes
Observations	62,375	57,651	57,497	57,497

Note: T-values in parentheses. * (**) indicates significance at the 10% (5%) level. Columns (1)-(3) use top and bottom 25^{th} quantiles of firm's overhead expenses within its industry as cutoffs to define the low(high) overhead indicators whereas column (4) uses the top and bottom 10^{th} quantiles as cutoffs. All pure domestic firms and pure exporters are dropped in all estimates. Pure processing firms are dropped in columns (2)-(4).

Table 7: IV Poisson Estimates with Alternative Measure of Managerial Efficiency

Econometric Methods:	Neg. Binomial	IV Poisson		
Regressand: Export Product Scope	(1)	(2)	(3)	(4)
Home Tariffs (Firm-Level: $\hat{\beta}_1$)	0.011***	0.023***	0.027***	0.026***
	(27.01)	(21.57)	(21.71)	(19.98)
Foreign Tariffs ($\hat{\beta}_3$)	0.006***	0.003**	0.003**	0.003**
	(15.41)	(2.26)	(2.02)	(2.04)
Foreign Tariffs	0.002***	0.006***	0.005***	0.006***
×High Overhead Indicator ($\hat{\beta}_4$)	(4.43)	(4.19)	(3.17)	(3.21)
Foreign Tariffs	-0.001***	-0.004**	-0.004**	-0.005***
×Low Overhead Indicator ($\hat{\beta}_5$)	(-2.66)	(-2.47)	(-2.55)	(-2.60)
Log Firm TFP (TFP2: $\hat{\beta}_2$)	0.173***	0.311***	0.226***	0.210***
	(16.05)	(15.03)	(9.65)	(8.70)
Log Weighted GDP of Importers	0.152***	0.146***	0.146***	0.148***
	(104.67)	(45.55)	(39.95)	(38.31)
Foreign Indicator	0.161***	0.106***	0.088***	0.096***
	(20.54)	(8.33)	(6.23)	(6.64)
SOE Indicator	-0.042*	-0.038	-0.051	-0.051
	(-1.65)	(-0.74)	(-0.94)	(-0.93)
Log Firm Sales	0.139***	0.187***	0.191***	0.191***
	(50.24)	(37.99)	(35.14)	(33.77)
P-value of Diffference between $\hat{\beta}_3$ and $\hat{\beta}_5$	[.000]	[.001]	[.001]	[.001]
Firm-specific Fixed Effects	Yes	Yes	Yes	Yes
Year-specific Fixed Effects	Yes	Yes	Yes	Yes
Pure Domestic Firms Dropped	No	Yes	No	Yes
Pure Exporting Firms Dropped	No	No	Yes	Yes
Pure Processing Firms Dropped	No	No	No	Yes
Observations	87,817	35,565	27,083	25,353

Note: T-values in parentheses. * (**) indicates significance at the 10% (5%) level. All columns use top and bottom 25^{th} quantiles of firm's overhead-profit ratio as cutoffs to define the low(high) overhead indicators in *each* industry. Column (1) is negative binomial estimate. Columns (2)-(4) are IV Poisson estimates in which the endogenous variable is home tariff with initial year weight and the instrument is home previous year's tariffs with initial year weight.

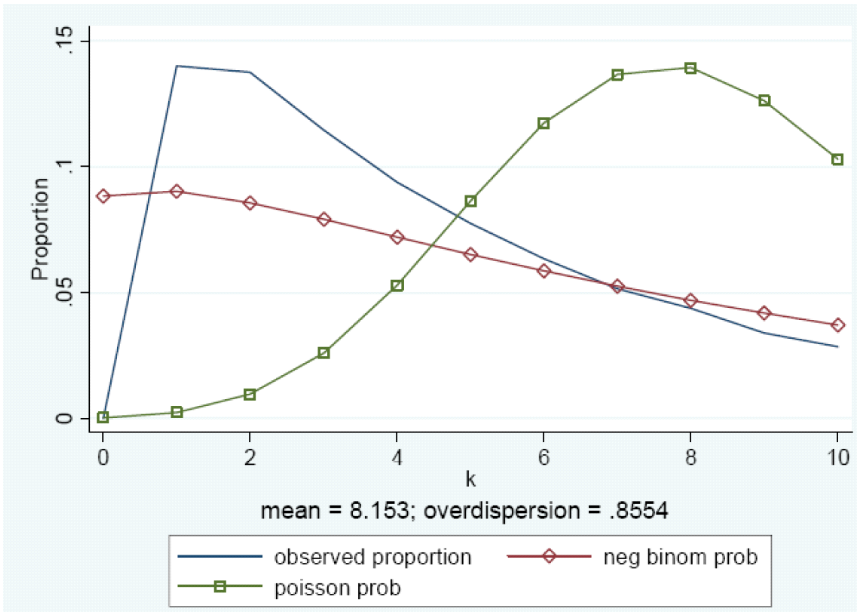

Figure 1: Distribution of Chinese Firms' Export Product Scope

Appendix A: Matching Transaction-Level Trade Data and Firm-Level Production Data

A.1. Transaction-Level Trade Dataset

The extremely disaggregated transaction-level monthly trade data during 2000-2006 are obtained from China's General Administration of Custom. Each transaction is described at the HS 8-digit level. The number of monthly observations increases from around 78 thousand in January 2000 to more than 230 thousand in December 2006. As shown in Column (1) of Table A1, the annual number of observations is more than 10 million in 2000 and 16 million in 2006, with more than 118 million in total for seven years. Column (2) of Table A1 exhibits that there are 286,819 firms that ever engage in international trade during this period.

For each transaction, the dataset consists of three types of information: (1) 5 variables on basic trade information. They are value (in current US dollar), trade status (export or import), quantity, trade unit, value per unit (i.e., value divided by quantity). (2) 6 variables on trade mode and pattern. These include country of destination for exports, country of origin for imports, routing (i.e., whether the product is shipped through an intermediate country/regime), customs regime (e.g., processing trade or ordinary trade), trade mode (i.e., by sea, by truck, by air, or by post), customs port (i.e., where the product departs or arrives). (3) Firms' information associated with each transaction. In particular, it includes 7 variables such as firm's name, identification number set by the customs, city where the firm is located, telephone, zip code, name of the manager/CEO, ownership type of firm (e.g., foreign affiliate, private, or state-own-enterprises).

A.2. Firm-Level Production Dataset

The firm-level panel dataset covers around an average 230,000 manufacturing firms per year in 2000-2006. The number of firms doubled from 162,885 in 2000 to 301,961 in 2006. The data are collected and maintained by China's National Bureau of Statistics in an annual survey of manufacturing enterprises. It contains all information of three accounting sheets (i.e., Balance Sheet, Loss & Benefit Sheet, and Cash Flow Sheet). On average, the total value of industrial production covered in such a dataset accounts for around 95% of China's total industrial production in each year. In fact, the aggregated data on the industrial sector in China's Statistical Yearbook published by the Natural Bureau of Statistics (NBS) are compiled from this dataset. The dataset includes more than 100 financial variables listed in the main accounting sheets of all these firms. It covers two types of manufacturing firms: (1) all SOEs; (2) non-SOEs whose annual sales are more than five million RMB. The number of firms increased from more than 160 thousand in 2000 to 301 thousand in 2006. As shown in column (3) of Table A1, the total number of firms that ever appear in the dataset during 2000-2006 is 615,951.

The raw production dataset is still quite noisy given that many unqualified firms are included, largely because of mis-reporting by some firms. For example, information on some family-based firms, which usually have no formal accounting system in place, is based on a unit of one RMB, whereas the official requirement is a unit of 1000 RMB. We hence filter the raw production data as introduced in the text. Accordingly, the total number of firms covered in the dataset is reduced to 438,165, around 1/3 of firms are dropped from the sample after such a filter process. As shown in column (4) of Table A1, such a filter ratio is even higher in the initial years: around 1/2 of firms are dropped in 2000.

A.3. Matching Method

Although these two datasets have rich information on production and trade, it is challenging to match them. Although both datasets contain a variable of each firm's identification number, their coding systems are completely different and share no common characteristics. For example, the lengths of the firm's ID variable in transaction-level dataset are 10 digits whereas those in firm-levels only have 9 digits. China's customs administration just constructs a complete coding system different from the one adopted by the National Bureau of Statistics.

To address this challenge, we take two approaches to match transaction-level trade data and firm-level production data. First, we match the two datasets by firm's name and year. That is, if a firm from one dataset has exactly the same Chinese name as a firm in another dataset in a particular year, they must be the same firm. The year variable is necessary to use for an auxiliary identification variable since some firms could change their name in different years and new comers could possibly take other firms' original names. As a result, the number of matched firms is 83,679 in total by using the raw production dataset, and reduced to 69,623 in total by using the more accurate filtered production dataset.

Second, we rely on two other common variables to further identify firms, namely, zip code and the last seven digits of a firm's phone number. The rationale is that firms should have different and unique phone numbers within a postal district. Although this method seems straightforward, subtle technical and practical difficulties still remain. For example, the phone numbers in the product-level trade data include both area phone codes and a hyphen, whereas those in the firm-level production data do not. We use the last seven digits of the phone number to serve a proxy for firm identification for two reasons. The first reason is that during 2000–2006, some large Chinese cities changed their phone number digits from seven to eight, which usually added one more digit at the beginning of the number. Therefore, sticking to the last seven digits of the number would not confuse the firm's identification. The second reason is that in the original dataset, phone number is defined as a string of characters with the phone zip code. However, it is inappropriate to de-string such characters to numerals since a hyphen bar is used to connect the zip code and phone number. Using the last seven-digit substring solves this problem neatly.

A firm could miss its name information in either trade or production dataset. Similarly, a firm could lose information on phone and/or zip code. To secure that our matched dataset can cover common firms as many as possible, we include the observations in the matched dataset if a firm appears in either one of the two approaches just described above. As a result, the number of matched firms increases to 90,558 when the raw production dataset is used, as shown in column (7) of Table A1. By way of comparison, such a matching performance is in the same magnitude to (or even better than) other similar studies (See Yu (2013) for detailed discussions).

Appendix B: Proof of Proposition 1.

(i). Rewrite (8) and (14) as

$$A - \theta s_l - 2\sqrt{b(m_l + k)} = 0,$$

$$A - \theta s_h - 2\sqrt{b(m_h + k)} = 0,$$

$$2[\sigma s_l + (1-\sigma)s_h + 1 + \delta]A - \theta[\sigma s_l^2 + (1-\sigma)s_h^2] - 2\alpha\delta - 2t = 0.$$

Differentiating the three equations with respect to t and doing some manipulation yields

$$\frac{ds_l}{dt} = \frac{ds_h}{dt} = \frac{1}{A + 1 + \delta} > 0.$$

(ii). We now turn to foreign tariff cuts. Rewrite (10) and (15) as

$$A^* - \theta t^* e_l - 2\sqrt{bm_l} = 0, \tag{A1}$$

$$A^* - \theta t^* e_h - 2\sqrt{bm_h} = 0, \tag{A2}$$

$$2[\sigma e_l + (1-\sigma)e_h + 1 + \delta]A^* - \theta t^*[\sigma e_l^2 + (1-\sigma)e_h^2] - 2\alpha\delta = 0. \tag{A3}$$

Differentiating (A1) and (A2), respectively, with respect to t^* yields

$$\frac{de_h}{dt^*} = \frac{de_l}{dt^*} + \frac{e_l - e_h}{t^*}. \tag{A4}$$

Hence, $\frac{de_h}{dt^*} > \frac{de_l}{dt^*}$ because $e_h < e_l$.

Differentiating (A3) with respect to t^* and using (A4) to substitute $\frac{de_h}{dt^*}$, we obtain

$$\frac{de_l}{dt^*} = \frac{K_l}{2(1+\delta)\theta t^* + 2A^*} < 0,$$

where $K_l = -2\sigma(e_l - e_h)A^*/t^* - 2\theta(1+\delta)e_l - \theta[\sigma e_l^2 + (1-\sigma)e_h^2] < 0$. Note that $e_l > e_h$; thus, $K_l < 0$ and hence the above inequality holds.

Similarly, we can also obtain

$$\frac{de_h}{dt^*} = \frac{K_h}{2(1+\delta)\theta t^* + 2A^*},$$

where $K_h = -2\sigma(e_h - e_l)A^*/t^* - 2\theta(1+\delta)e_h - \theta[\sigma e_l^2 + (1-\sigma)e_h^2]$. Using (A2) to substitute A^*, we can simplify

$$K_h = \sigma(e_l - e_h)\left[\frac{4\sqrt{bm_h}}{t^*} - \theta(e_l - e_h)\right] - 2\theta(1+\delta)e_h - \theta e_h^2.$$

From (A1) and (A2), we also obtain

$$e_l - e_h = \frac{2\sqrt{b}(\sqrt{m_h} - \sqrt{m_l})}{\theta t^*}.$$

Substituting the above in K_h to reduce to

$$K_h = \frac{4\sigma b(m_h - m_l)}{\theta t^{*2}} - 2\theta(1+\delta)e_h - \theta e_h^2.$$

As $\frac{\partial e_h}{\partial m_h} < 0$, it is clear that $K_h > 0$ for sufficiently large m_h, and so under the same condition, $\frac{de_h}{dt^*} > 0$. Q.E.D.

Appendix C: Measuring Ex-ante TFP (TFP2)

This section discusses how we construct and measure TFP using two different approaches: *ex-post* TFP (TFP1) and *ex-ante* TFP (TFP2) inspired by Feenstra et al. (2013).

We extend the Olley–Pakes (1996) approach to fit with China's reality in the following ways. Firstly, given that the measure of TFP requires real terms of firm's inputs (labor and capital) and output, we adopt different price deflators for inputs and outputs from Brandt *et al.* (2012) in which the output deflators are constructed using "reference price" information from *China's Statistical Yearbooks* whereas input deflators are constructed based on output deflators and China's national input-output table (2002).

Secondly, we take China's WTO accession in 2001 into account since such a positive demand shock would push Chinese firms to expand their economic scales, which in turn can exaggerate the simultaneous bias of their measured TFP. Thirdly, it is essential to construct the real investment variable when using the Olley-Pakes (1996) approach. As usual, we adopt the perpetual inventory method to investigate the law of motion for real capital and real investment. Different from assigning an arbitrary number for the depreciation ratio, we use the exact firm's real depreciation provided by the Chinese firm-level data set.

Finally, we also consider firm's processing behavior in the TFP realization by constructing a processing export indicator (one denotes processing export and zero otherwise). The idea is that processing firms may use different technology than non-processing firms (Feenstra and Hanson, 2005).

Thus, a firm's investment function is $V_{it} = g_1(x_{it}, \ln K_{it}, EX_{it}, PE_{it}, WTO_t)$ where EX_{it} (PE_{it}) is the export (processing export) indicator to measure whether firm i exports (engages in processing exports) in year

t, and WTO_t is an indicator that equals one if the WTO agreement has occurred after 2001 and zero before that. Therefore, inverting the investment function with respect to its first argument we obtain:[25]

$$x_{it} = g_1^{-1}(V_{it}, \ln K_{it}, EX_{it}, PE_{it}, WTO_t). \tag{22}$$

Given the gross production function

$$\ln Y_{it} = \alpha_k \ln K_{it} + \alpha_l \ln L_{it} + \alpha_m \ln M_{it} + x_{it} + \varepsilon_{it} \tag{23}$$

and defining the function $g_2(\cdot)$ as $\alpha_k \ln K_{jt} + g_1^{-1}(V_{it}, \ln K_{it}, EX_{it}, PE_{it}, WTO_t)$, the estimation of the labor (materials) coefficients $\alpha_l(\alpha_m)$ are obtained as:

$$\ln Y_{it} = \alpha_l \ln L_{it} + \alpha_m \ln M_{it} + g_2(V_{it}, \ln K_{it}, EX_{it}, PE_{it}, WTO_t) + \varepsilon_{it}. \tag{24}$$

The next step is to obtain an unbiased estimated coefficient of α_k. Olley-Pakes (1996) use the following specification:

$$\ln Y_{it} - \hat{\alpha}_l \ln L_{it} - \hat{\alpha}_m \ln M_{it} = \alpha_k \ln K_{it} + E(x_{it}|x_{it-1}, pr_{it}) + [x_{it} - E(x_{it}|x_{it-1}, pr_{it})] + \varepsilon_{it}, \tag{25}$$

where the estimated values of the labor coefficient and materials coefficient are used on the left. The expectation of productivity appearing in (25) is modeled as a forth-order polynomial function of lagged productivity, which can be obtained as $(g_{2i,t-1} - \alpha_k \ln K_{i,t-1})$, and also the predicted probability of the firm's survival into the year t, pr_{it}, based on year $t-1$ information. The predicted probability is obtained from Probit estimation.[26] The term $[x_{it} - E(x_{it}|x_{it-1}, pr_{it})]$ is the productivity shock for surviving firms, but does not affect the investment or exit choice so it is treated as an error.

Once the coefficient of capital $\hat{\alpha}_k$ is estimated in Eq. (25), it is ready to obtain the standard ex-post TFP:

$$TFP1_{it} \equiv x_{it} = \ln Y_{it} - \hat{\alpha}_k \ln K_{it} - \hat{\alpha}_l \ln L_{it} - \hat{\alpha}_m \ln M_{it}.$$

In this way, TFP1 includes both true production productivity and managerial efficiency. By contrast, the *ex-ante* productivity (TFP2) which only capture true production productivity is given by

$$TFP2_{it} = g_1^{-1}(V_{it}, \ln K_{it}, EX_{it}, PE_{it}, WTO_t).$$

[25] Olley and Pakes (1996) show that the investment demand function is monotonically increasing in the productivity shock x_{jt}, by making some mild assumptions about the firm's production technology.

[26] Note that here the non-linear least squares approach is adopted to estimate (25) since it requires the estimated coefficients of the log-capital in the first and second term to be identical (Pavcnik, 2002).

Table A1: Matched Statistics

Year	Trade Data		Production Data		Matched Data			
# of	Transactions	Firms	Raw Firms	Filtered Firms	w/ Raw Firms	w/ Filtered Firms	w/ Raw Firms	w/ Filtered Firms
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
2000	10,586,696	80,232	162,883	83,628	18,580	12,842	21,665	15,748
2001	12,667,685	87,404	169,031	100,100	21,583	15,645	25,282	19,091
2002	14,032,675	95,579	181,557	110,530	24,696	18,140	29,144	22,291
2003	18,069,404	113,147	196,222	129,508	28,898	21,837	34,386	26,930
2004	21,402,355	134,895	277,004	199,927	44,338	35,007	50,798	40,711
2005	24,889,639	136,604	271,835	198,302	44,387	34,958	50,426	40,387
2006	26,685,377	197,806	301,960	224,854	53,748	42,833	59,133	47,591
All Year	128,333,831	286819	615,951	438,165	83,679	69,623	90,558	76,946

Notes: Column (1) reports the number of observations of HS eight-digit monthly transaction-level trade data from China's General Administration of Customs by year. Column (2) reports the number of firms covered in the transaction-level trade data by year. Column (3) reports the number of firms covered in the firm-level production dataset compiled by China's National Bureau of Statistics without any filter and cleaning. By contrast, column (4) presents the number of firms covered in the firm-level production dataset with careful filter according to the requirement of GAAP. Accordingly, column (5) reports the number of matched firms using exactly identical company's names in both trade dataset and raw production dataset. By contrast, column (6) reports the number of matched firms using exactly identical company's names in both trade dataset and filtered production dataset. Finally, column (7) reports number of matched firms using exactly identical company's name, zip code and phone number in both the trade dataset and the raw production dataset. By contrast, column (8) reports number of matched firms using exactly identical company's name, zip code and phone number in both trade dataset and filtered production dataset.

Table A2: Production Productivity and Overhead Expenses

Industry	Labor	Capital	Materials	TFP1	TFP2	Log of Overhead	Overhead-Profit Ratio
13	0.077	0.060	0.814	1.191	1.231	7.018	3.165
14	0.055	0.071	0.857	0.799	0.838	7.436	3.497
15	0.094	0.113	0.799	0.817	0.830	8.134	1.453
16	0.020	0.270	0.783	0.287	0.185	9.929	1.100
17	0.066	0.044	0.868	0.802	0.857	7.458	13.153
18	0.110	0.039	0.798	1.344	1.403	7.154	6.357
19	0.084	0.041	0.857	0.872	0.902	7.195	5.173
20	0.099	0.071	0.841	0.686	0.717	6.793	5.633
21	0.103	0.055	0.814	1.113	1.124	7.179	2.323
22	0.063	0.053	0.867	0.781	0.792	8.159	6.236
23	0.065	0.068	0.815	1.199	1.290	7.735	4.484
24	0.091	0.039	0.823	1.181	1.219	7.262	4.000
25	0.014	0.069	0.865	0.663	0.642	9.101	3.205
26	0.063	0.058	0.820	1.187	1.218	8.091	7.118
27	0.062	0.064	0.790	1.555	1.643	8.440	5.049
28	0.040	0.060	0.889	0.517	0.584	8.239	9.786
29	0.087	0.081	0.769	1.404	1.469	7.702	9.464
30	0.069	0.046	0.836	1.094	1.155	7.381	3.605
31	0.046	0.059	0.844	1.054	1.129	7.439	6.945
32	0.061	0.029	0.891	0.682	0.766	8.727	6.167
33	0.080	0.079	0.850	0.451	0.497	8.198	3.143
34	0.062	0.037	0.841	1.150	1.147	7.402	9.275
35	0.061	0.055	0.837	1.086	1.176	7.768	16.228
36	0.053	0.049	0.841	1.152	1.191	8.082	22.114
37	0.063	0.045	0.835	1.290	1.394	8.274	5.947
39	0.077	0.066	0.836	0.900	0.913	7.865	10.409
40	0.109	0.075	0.806	1.175	1.243	8.136	5.269
41	0.049	0.054	0.806	1.639	1.703	8.041	14.045
42	0.091	0.039	0.857	0.834	0.839	7.044	4.713

Notes: The Chinese industries and associated codes are classified as follows: Processing of foods (13), Manufacture of foods (14), Beverages (15), Textile (17), Apparel (18), Leather (19), Timber (20), Furniture (21), Paper (22), Printing(23), Articles for cultures and sports (24), Petroleum (25), Raw Chemicals (26), Medicines (27), Chemical Fibers (28), Rubber (29), Plastics (30), Non-metallic Mineral (31), Smelting of ferrous metals (32), Smelting of non-ferrous metals (33), Metal (34), General machinery (35), Special machinery (36), Transport equipment (37), Electrical machinery (39), Communication equipment (40), Measuring instrument (41), and Manufacture of artwork (42). We do not report standard errors for each coefficient to save space though available upon request. The logarithm of firm productivity for Chinese firms (TFP1 and TFP2) is estimated by industry using the augmented Olley-Pakes approach introduced in the text. Coefficients of labor, capital, and materials are calculated at the sectoral average whereas TFP1 and TFP2 is measured at firm-level using firm-level output, capital, labor, and materials, respectively. The last two columns report log of firm's overhead expenses and overhead-profit ratio.