Trade Liberalization and Domestic Vertical Integration: Evidence from China

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Abstract

In this study we examine the effects of trade liberalization on domestic mergers and acquisitions (M&As) in China. In particular, we focus on domestic backward vertical integrations in which a domestic upstream firm (target) is acquired by a domestic downstream firm. Our analysis takes China's accession to the WTO (2001) as a quasi-natural experiment for trade liberalization. We find that a decrease in tariffs on the target industry's outputs reduces vertical integrations, but a decrease in tariffs on the target industry's inputs increases vertical integrations. The result is obtained using the difference-in-differences technique and is robust to various specifications of the model and measurement. We build a hold-up model with an upstream supplier and a downstream buyer to provide insights to the empirical finding that the existence of underinvestment is the key to understanding the effects of tariff reductions on firms' organizational choices.

Keywords: Trade liberalization; Vertical integration; Outsourcing; Offshoring.

JEL Codes: F13, F15, L14, L22.

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1 Introduction

How do firms organize their production? Is it through market (outsourcing) or within firms (vertical integration)? This is a classic question in economics. This important question has also been asked in the field of international trade and foreign direct investment (FDI). How do firms organize their production *across countries*, through market (offshoring) or within firms (FDI)? On the one hand, the advancement of information and communication technology has changed the incentive for vertical integration. On the other hand, the decrease in transportation costs and reduction in trade barriers have altered firms' decisions on allocating their production across national boundaries. Theories of firm boundaries (especially the transaction cost and property right theories) have been introduced to address this issue. Most studies in this trade-FDI-organization literature focus on the effects of globalization on multinational corporations' (MNCs) decisions on offshoring and global vertical integration.[1] In contrast to that focus, the present paper explores how globalization affects outsourcing and vertical integration *within* a country's boundary, that is, by *domestic* firms, as opposed to MNCs. It provides an empirical analysis to help address the concern of Acemoglu et al., (2010, p889) who conclude that "*[d]espite a large theoretical literature on the determinants of vertical integration, the economics profession is far from a consensus on the empirical determinants of vertical integration in general.*"

Our empirical analysis is based on China's experiences. The China focus has two advantages. First, China implemented drastic trade liberalization when it was accepted as a member of the World Trade Organization (WTO) in 2001. The timing of China's accession to the WTO is commonly viewed as a shock. Thus, we can use China's WTO accession as a quasi-natural experiment to identify the causal effects of trade liberalization on domestic vertical integrations. Second, reorganization or restructuring of firms *within* China became very active and important since the end of the last century. Figure 1 plots the time trend of three types of mergers and acquisitions (M&As) related with China. During 1998-2014, a total of 18,220 M&As involving Chinese firms were completed. Among those M&As, 67.9% or 12,371, are pure domestic M&As, i.e., both targets and acquirers are Chinese firms. The total value of all reported transactions is USD 741.2 billion and that of the pure domestic M&As

[1] See literature reviews by Antras and Rossi-Hansberg (2009) and Antras (2016).

is USD 411.4 billion, accounting for 55.5% of the total value.[2] As Figure 1 shows, domestic M&As experience a sharp increase after 2001, while the increases of cross-border M&As are less significant.

<Insert Figures 1 here>

We conduct our empirical analysis based on data from 1998 to 2007, with China's WTO entry around the middle of the period. We observe a very large variation in tariff reductions across industries, which allows us to employ the difference-in-differences (DID) method in our analysis. By definition, every vertical integration involves an upstream firm (for example, an engine producer) and a downstream firm (for example, a car maker). Every vertical integration executed via an M&A has a target firm and an acquiring firm. Our analysis focuses on *backward* vertical integrations in which the acquirer (car maker) is from downstream and the target (engine producer) is from upstream.[3] We consider two types of tariff reductions. One is related to tariffs on the inputs that the target (engine producer) uses in its production (for example, iron and steel), which we refer to as *input tariff*. The other type relates to tariffs on the output of the target (that is, engine), which we refer to as *output tariff*. We investigate how a cut in input tariffs (tariffs on iron and steel) and a cut in output tariffs (tariffs on engine) affect the incentive of backward vertical integration (the carmaker acquires the engine producer), respectively.

Our empirical results show that input and output tariff liberalizations have exactly the opposite effects on (domestic backward) vertical integrations: output tariff liberalization *reduces* the number of vertical integrations, while input tariff liberalization *increases* the number of vertical integrations. The finding is obtained based on our main regression model in which we control for a set of industry-level characteristics (the upstream industry) including the average age of firms, total size, degree of market competition, and time-varying international shocks. The finding is robust to various specifications of the model. We propose a theoretical model to help explain the empirical findings. In the model, a domestic firm in the upstream industry makes relationship-specific investment that benefits a domestic firm in the downstream. Underinvestment is an outcome of the hold-up problem associated with the incapability of writing a complete contract. Vertical integration helps solve the underinvestment

[2] Not all M&As report their transaction value and thus, the reported value is only a fraction of the actual total value.

[3] As pointed out by Acemoglu et al. (2010) and other prior empirical work, backward vertical integration is the most important alternative to non-integration. See their paper for a brief discussion. The case is the same in China: during our sample period 1998-2007, the total value of backward vertical integration is USD 19.3 billion, accounting for 41.2% of the total value of all completed M&As; while forward vertical integration only accounts for 22.1%.

problem but the benefit of vertical integration is affected by the outside option, which comes from the import of the upstream products. With an output tariff reduction, the downstream firm under outsourcing benefits more from substituting its supplier with imported input, making vertical integration relatively less attractive as a means of solving the underinvestment problem. In contrast, an input tariff reduction amplifies the benefits from vertical integration, thereby making outsourcing relatively less desirable.

Although considerable empirical literature on the determination of vertical integration exists, empirical studies on the effects of tariffs on vertical integration are relatively new and still scant. As pointed out by Ornelas and Turner (2012, p31), "*the relationship between tariffs and industrial structure has received very little empirical scrutiny*". The present paper contributes to this part of the literature, which includes Alfaro et al. (2016) as the only existing study, to the best of our knowledge.[4] Alfaro et al. (2016) build a simple model in which vertical integration increases productivity but is costly. Their model predicts that higher prices of final goods (the *downstream* firms' output) will make the upstream and downstream firms benefit more from vertical integration. They utilize tariff reductions as an exogenous shock to prices and use cross country data in their empirical analysis to test their theoretical prediction. Unlike (or as a complement to) Alfaro et al. (2016), we examine the effects on vertical integration by changes in the downstream firms' production costs, due to changes in the *upstream* industry's input and output tariffs. Moreover, our empirical findings can be explained using a model of relationship-specific investment and trade, which is built based on Ornelas and Turner (2008, 2012). Our paper provides an indirect test on some of the theoretical predictions of Ornelas and Turner (2008, 2012).

Our paper is also related to existing studies on firm-level adjustments and performances in response to trade liberalization. Firm-level adjustments have many dimensions, including employment (Autor et al., 2013), total factor productivity (TFP) (Topalova and Khandelwal, 2011; Brandt et al., forthcoming), quality upgrading (Amiti and Khandelwal, 2013; Fernandes and Paunov, 2013; Martin and Mejean, 2014), growth (Baldwin and Gu, 2009), innovation and R&D (Bloom et al., 2016; Liu and Qiu, 2016), product scope (Baldwin and Gu, 2009; Qiu and Wen, 2013), and product mix (Mayer et al., 2014). These types of adjustments are *within-firm* adjustments. Our paper is about *inter-firm*

[4] In an empirical study, Breinlich (2008) shows that trade liberalization between Canada and the US has increased the domestic M&As in Canada. That paper, however, is not specific about vertical integrations.

adjustment (outsourcing or vertical integration), and hence, is also related to the literature reviewed by Antras (2016).

Some recent studies emphasize the importance of liberalization in intermediate input tariffs, as opposed to output tariffs. Those studies focus on the effects of intermediate input tariff reductions on firm productivity (Amiti and Konings, 2007; Topalova and Khandelwal, 2011), product scope (Goldberg et al., 2010), product quality (Fernandes and Paunov, 2013; Fan et al., 2015), and innovation (Liu and Qiu, 2016). Our paper adds a new dimension to this list: intermediate input tariff reductions affect domestic firms' organizational choice.

The paper is organized as follows. Section 2 provides a background of the laws, regulations and institutions in China. Section 3 introduces the econometric specification of the main model and describes the data. Section 4 reports and discusses the basic regression results and checks their validity and robustness. In Section 5, we present a conceptual framework to help understand the empirical findings, and conduct further tests on the model. Concluding remarks are provided in the final section.

2 Institutional Background

2.1 China's Accession to the WTO and Trade Liberalization

China began to apply for WTO entry in the late 1980s. After many rounds of negotiations, China finally joined in December 2001 and carried out a large cut in tariffs. Figure 2 exhibits the tariff changes during the period of 1998-2007. We use the International Standard Industrial Classification (ISIC) to classify industries at four-digit level and calculate each industry's input and output tariffs. Output tariffs are directly available from the country's Effectively Applied Tariffs, called AHS tariffs, and input tariffs are calculated using output tariffs and the Chinese Input-Output Table (2002) (see details in subsection 3.2). The left panel of Figure 2 shows the means and standard deviations of the simple average output tariffs while the right panel shows those of the input tariffs. It is evident that during the pre-WTO period, 1998-2001, tariffs did not change much, staying at high levels, around 20% for output tariffs and 9% for input tariffs. In 2002, the first year of WTO entry, output tariffs dropped significantly from 18.67% to 14.10%, and so did input tariffs from 8.88% to 6.36%. Subsequently, both output and input tariffs continued to decrease and then remained stable after 2005 at around 10.42% for output tariffs and 4.86% for input tariffs.

Substantial variations in tariff levels and reductions across industries can be observed. The standard deviations of output tariffs are around 60% of the means while those of input tariffs are around 30% in the entire period. Figure 3 plots the tariff reductions of all industries during the post-WTO period, i.e., 2002 to 2007, against the corresponding industries' initial tariff levels in 2001. We can see strong positive correlations for both input and output tariffs: industries with higher initial tariff levels experienced larger tariff reductions in the post-WTO entry period.

<Insert Figures 2 & 3 here>

In summary, the two figures present four features of tariff changes in China during 1998-2007. First, a sudden and drastic reduction in tariffs took place in 2002. Second, substantial variations of tariff reductions occurred across industries. Third, across all industries, a strong and positive correlation between the initial tariff levels (in 2001) and the subsequent tariff reductions exists. Fourth, tariffs in the pre-WTO period were more or less constant. We can take the advantage of these four characteristics to examine the effects of trade liberalization on domestic firms' vertical integrations.

Specifically, the above features of tariff changes enable us to use the tariff levels of each industry in 2001 to proxy the degrees of tariff reductions. The validity of our identification strategy relies on the exogeneity of the key explanatory variable, i.e., the tariff levels in 2001. Following Fan et al. (2015), Bloom et al. (2016), and Liu and Qiu (2016), we argue that the nature of China's accession to the WTO provides a quasi-natural experiment for such an identification. The sudden and drastic drop of tariffs in 2002 reflects the pure policy change because of China's accession to the WTO. The change is unlikely to be driven by other confounding factors associated with vertical integrations.

2.2 M&As and Related Regulations

M&As were not active in China until the late 1990s. Table 1 reports the number of completed domestic M&As in China during 1986-2007. According to Reuters' M&A database, the first domestic M&A in China was completed in 1987. In the early years, only a small number of M&As occurred, one in 1990, two in 1991 and five in 1992. Since then, M&A activities had continued to grow and became very active in the late 1990s. In 1998, the number of completed domestic M&As reached 100 in a year for the first time. The number increased dramatically after China's accession to the WTO, reaching its peak at 969 in 2007.

<Insert Table 1 here>

The first law on M&As promulgated in China is the *Interim Provisions on Enterprises Mergers and Acquisitions* (1989). The law officially clarifies the definition of M&A for the first time in China: the purchase of one firm by another firm which induces the end or change of the target's legal corporation. The law also provides guidelines and legal basis for conducting M&As in China. Subsequently, the government introduced a series of laws, provisions, regulations, guidance, and policies, some of which regulate M&A in general while some are specific to certain types of M&As.

As for the general type of M&A laws and regulations, the *Anti-Monopoly Law of People's Republic of China* (2008) is the most comprehensive law on anti-monopoly in China. The first draft of the *Anti-Monopoly Law* was officially launched in 1994, when it was listed on the legislative agenda by the Standing Committee of National People's Congress. The final draft was submitted to the National People's Congress in June 2006 for deliberation, and finally passed and adopted in the 29th Meeting of the Standing Committee of the Tenth National People's Congress on August 30, 2007. The *Anti-Monopoly Law* came into effect on August 1, 2008. It is enacted to "prevent and prohibit monopolistic conduct, protect fair competition, improve the efficiency of operation, safeguard consumer and public interests, and promote the healthy development of the socialist market economy." Although M&As, including vertical integrations, are regulated directly by this law, our analysis is not affected because our data are from the sample period which ends in 2007, prior to the introduction of this law.

Other policies and regulations that are specific to certain types of M&As also exist. The first type is M&A policies on foreign invested enterprises (FIEs) in China. Laws and policies in this group, which were introduced during the sample period of the present study, include *Interim Provisions on Purchase of SOEs by Foreign Investors* (1999), *Provisions on Mergers and Divisions of FIEs* (1999), *Catalogues Guiding Foreign Investment in Industry* (2002), and *Interim Provisions on Mergers with and Acquisitions of Domestic Enterprises by Foreign Investors* (2003). These policies, however, do not have direct effects on the *pure domestic* M&As, which are the focus of the present study.

Another type of specific policies relates to state-owned enterprises (SOEs). China carried out SOE reforms mainly in the late 1990s and early 2000s. Reforms include privatization, M&As, and bankruptcy. Specific policies are *Notice on Several Issues in Trial of Merger and Acquisition and Bankruptcy of SOEs* (1996), *Notice on Relevant Issues Regarding the Selling of Small SOEs* (1999), *Interim Provisions on Purchase of SOEs by Foreign Investors* (1999), and *Interim Provisions on Restructuring SOEs Using Foreign Investment* (2002). These regulations may affect the incentives and outcomes of M&As involving SOEs. To insulate the effects of these regulations, we control for factors related to SOEs in our robustness checks.

The *Administration of the Takeover of Listed Companies Procedures* (2002) is specific to listed firms. This is the first regulation on takeovers targeted at listed companies. Although the introduction of this regulation could affect takeover of listed companies differently from other types of takeovers, our identification strategy remains valid as long as the effects of this regulation across industries do not systematically coincide with the effects of trade liberalization. Nonetheless, we will check with a subsample of unlisted firms in our robustness regressions to control for possible effects of this regulation.

3 Econometric Specification and Data

3.1 Empirical Model

Vertical integration occurs when a downstream firm acquires an upstream firm, called backward vertical integration, or an upstream firm acquires a downstream firm, called forward vertical integration. The present study focuses on domestic *backward* vertical integration. We will use the term "vertical integration" for "backward vertical integration" throughout the paper for succinctness without causing misunderstanding. To identify the causal impact of trade liberalization on vertical integration, we exploit the quasi-natural experiment based on China's accession to the WTO in 2001 to conduct a DID analysis. As pointed out earlier, our data cover the period 1998-2007, which includes both the pre-WTO (1998-2001) and post-WTO period (2002-2007), and China's WTO accession resulted in a large scale tariff reductions across all industries, but with a significant degree of variations. This feature enables us to conduct a DID estimation that examines the difference between the changes in vertical integration activities in industries with larger tariff reductions (the treatment group) and the corresponding changes in industries with smaller tariff reductions (the control group).

Accordingly, we construct our basic econometric specification as

$$VI_{it} = \beta_0 + \beta_1 \cdot WTO_t \times OutT01_i + \beta_2 \cdot WTO_t \times InT01_i + \mathbf{X}'_{it}\mathbf{\Gamma} + \lambda_t + \lambda_i + \epsilon_{it}. \tag{1}$$

In Model (1), VI_{it} is the total number of acquisitions with the targets in industry i (at ISIC four-digit level) and the acquirers from the downstream of industry i, in year t. This dependent variable is the count of vertical integrations, specified for the upstream industry. WTO_t is a dummy variable indicating the years after 2001, the post-reform period, i.e., it takes 0 for all years before 2002, and 1 for all years from 2002 onwards. $OutT01_i$ is the level of output tariff of industry i in year 2001. Similarly, $InT01_i$ is the level of input tariff of industry i in 2001. Because the tariff levels in 2001 are positively correlated with the degrees of tariff reductions associated with the WTO accession, $OutT01_i$ and $InT01_i$ capture the extents of output and input tariff reductions (treatment intensity), respectively. We use year fixed effect λ_t to control for time trend and all other possible time-specific shocks. The sizable variations in vertical integration activities across industries (see details in subsection 3.4) suggest that industries might have different patterns of vertical integration. Accordingly, we include industry fixed effect λ_i to control for those time-invariant industry characteristics. We also include a set of time-varying industry characteristics that might affect vertical integrations. This set of variables, represented by $\mathbf{X}'_{it}$ (with $\mathbf{\Gamma}$ as the vector of the corresponding parameters), includes the average age of the firms in the industry, the size of the industry, the degree of market competition of the industry, and the time-varying international shocks to the industry. The last term in Model (1), ϵ_{it}, is the robust error term clustered at the ISIC four-digit industry level. Because the dependent variable is a count variable, we use the fixed effects Poisson model to obtain the estimation results.

In Model (1), β_1 and β_2 capture the effects of trade liberalization on vertical integrations. If output tariff reductions discourage (encourage) vertical integrations, we should expect β_1 to be negative (positive); whereas if input tariff reductions promote (reduce) vertical integrations, β_2 should be positive (negative).

The reliability of our estimation depends on the validity of our model specification, that is, whether our regressors of interest are independent of the error term conditional on all control variables. China's WTO accession is a long negotiation process and the timing of accession is highly political and unpredictable, which implies that our WTO_t variable is very likely to be exogenous (Bloom et al., 2016).

However, the degree and procedure of tariff reductions across industries may be an outcome of negotiation and therefore, may not be completely exogenous. To deal with this problem, instead of using the actual tariff reductions, we purposely use the initial levels of tariff ($OutT01_i$ and $InT01_i$) before WTO accession to measure the treatment intensity. This measure helps alleviate the potential concern of endogeneity because the initial tariff levels are basically fixed during the pre-WTO period and thus are largely pre-determined before our sample period. In addition, we follow Goldberg et al. (2010) and Liu and Qiu (2016) to check whether the levels of output and input tariffs in 2001 and their actual changes after the WTO entry are related to industry performances in the pre-WTO period. Specifically, we regress some pre-WTO performances on the input and output tariffs, respectively. The regression results are reported in Table 2. If tariffs were influenced by lobbying pressures or by other government policies targeting specific industries, the tariffs would have been related to pre-WTO industry performances. That is, we would expect a statistically significant correlation between tariffs and industry performances in the pre-WTO period. On the contrary, column (1) of Table 2 shows that vertical integration activities in the pre-WTO period are not correlated with the initial levels of output and input tariffs in 2001. In columns (2)-(5), the dependent variables are other pre-WTO industry performance measures, including output (sales) of all firms, output of domestic firms, value added per capita, and capital-labor ratio, respectively, at industry level. The results show that they are also not significantly related with the initial tariff levels in 2001. In columns (6)-(10), we use actual reductions of tariffs in the post-WTO period as our independent variables. The conclusion is the same. Hence, we are confident in claiming that the output and input tariffs in 2001 are not influenced by industry performances in the pre-WTO period.

<Insert Table 2 here>

3.2 Construction of the Key Variables

Our empirical analysis has two key variables: vertical integration and tariff.

In the main analysis, we measure vertical integrations using the number of acquisitions by firms from downstream industries with the targeting firms from a specific upstream industry i (VI_{it}). We will check the robustness of our results using the value of those acquisitions for VI_{it}.[5] In either case,

[5] As argued by Breinlich (2008), using the count instead of total value of transactions has at least two advantages.

we need to first define and identify upstream and downstream. For any given industry, defining the upstream and downstream industries is straightforward theoretically, but is less so in practice. We follow Antras et al. (2012) to identify upstream and downstream based on the upstreamness index. The upstreamness index captures the average position of an industry's product in the entire value chain. Note that for each industry, i, its gross output (Y_i) equals the sum of its use as final goods (F_i) and its use as intermediate inputs to other industries. Let d_{ij} denote the dollar amount of industry i's output needed to produce one dollar's worth of industry j's output and assume N industries in the economy. Then, by definition,

$$Y_i = F_i + \sum_{j=1}^{N} d_{ij} F_j + \sum_{j=1}^{N} \sum_{k=1}^{N} d_{ik} d_{kj} F_j + \sum_{j=1}^{N} \sum_{k=1}^{N} \sum_{l=1}^{N} d_{il} d_{lk} d_{kj} F_j + \cdots.$$

Antras et al. (2012) define the upstreamness index (U_i) by multiplying each of the terms in the above equation by their distance from final use plus one and dividing by Y_i, that is,

$$U_i = 1 \cdot \frac{F_i}{Y_i} + 2 \cdot \frac{\sum_{j=1}^{N} d_{ij} F_j}{Y_i} + 3 \cdot \frac{\sum_{j=1}^{N} \sum_{k=1}^{N} d_{ik} d_{kj} F_j}{Y_i} + 4 \cdot \frac{\sum_{j=1}^{N} \sum_{k=1}^{N} \sum_{l=1}^{N} d_{il} d_{lk} d_{kj} F_j}{Y_i} + \cdots.$$

A higher U_i means the industry is more upstream in the value chain.

We use China's Input-Output Table (2002) to calculate the upstreamness index and match it with ISIC (Revision 3) industries.[6] For each M&A, if the target is at a more upstream position (higher upstreamness index) than the acquirer, this M&A is defined as a backward vertical integration. We also use other measures of vertical integration in the robustness checks.

Trade liberalization in each industry includes both input and output tariff reductions. Our output tariffs, $OutT_{it}$, are AHS simple average tariffs at ISIC four-digit product level, which are available directly from the World Integrated Trade Solution (WITS). We construct input tariffs following Topalova (2010) and Liu and Qiu (2016). Specifically, input tariff for industry i (according to the classification in Input-Output Table) in year t is defined as the weighted average of tariffs on goods used as inputs

First, the count measure is more readily available in the database because some transactions do not publish transaction values. Second, the distribution of transaction values is quite dispersed.

[6] We use the IO table of 2002 because China's IO table is available every five years and 2002 is in the middle of our sample and close to the time of China's WTO entry.

for industry i, that is,

$$InT_{it} = \Sigma_j CostShare_{ij} \cdot OutT_{jt},$$

where InT_{it} is the input tariff of industry i in year t, $OutT_{jt}$ is the output tariff of industry j in year t, and $CostShare_{ij}$ is the cost share of industry j in producing 1 unit of output of industry i. $CostShare_{ij}$ is based on China's Input-Output Table (2002). Thus, the initial input tariff of 2001 in Model (1) is obtained as $InT01_i = InT_{i2001}$.[7]

3.3 Data

Our empirical analysis relies on many types of data. We construct our dataset based on three important data sources.

The first data source is the M&As database from Thomson Reuters SDC Platinum (SDC). This database includes transaction-level data of M&As involving at least 5% ownership of the target and a transaction value of one million U.S. dollars or more, or where the value of the transaction is undisclosed, all around the world. The SDC data are collected mainly from over 200 news sources (including English and other languages), SEC filings and their international counterparts, trade publications, and proprietary surveys of investment banks, law firms, and other advisors.[8] The database provides information on the targets and acquirers, such as the firm name, country, major industry, parent firm information, and many financial characteristics. It also provides information on the M&A deal, such as the announced time, status, completion time, value of transaction, and share of transaction.

We calculate the value of our vertical integration variable (VI_{it}) based on the SDC database. Because our VI_{it} is the number of domestic backward vertical integrations, we extract all completed transactions from SDC database with both acquirer and target nations stated as "China" in each transaction (excluding Hong Kong, Macao, and Taiwan for the purpose of pure "domestic firms" by convention), with targets in manufacturing sector and acquirers from targets' downstream industries.

[7]Since the input tariff is constructed from the output tariff, multicollinearity problem is a potential concern in our regression model. However, as stated by Wooldrige (2016), multicollinearity problem is not really well-defined. It mainly leads to a larger estimated standard error, causing the estimated coefficients insignificant and unstable. Our robustness checks in later sections suggest that multicollinearity is not a severe issue in our settings because our results are highly significant and stable. We also calculate the variance inflation factor (VIF) to test the multicollinearity based on our baseline specification. The VIFs of our two key variables are 3.99 and 3.85 respectively, smaller than the commonly used cutoff value 10, which also suggests no severe multicollinearity.

[8]An SEC filing is a financial statement or other formal document submitted to the Securities and Exchange Commission (SEC).

We calculate the total number of backward vertical integration targeting industry i at year t as our main measure of VI_{it}. For example, a car producer acquiring an engine supplier is one backward vertical integration in the engine industry. If a truck producer is also acquiring an engine supplier in the same year, it is another backward vertical integration in the engine industry. If these are the only two engine suppliers being acquired by the downstream firms, then $VI_{it} = 2$ for the engine industry in that year.

The second data source is the WITS, which provides import tariff data of many countries including China. As pointed out earlier, we use the AHS simple average tariff data at ISIC four-digit product level, which is available directly from the WITS.[9]

The third data source is the Above-Scale Industrial Firms Panel (ASIFP), which is available for the time period 1998-2007. The ASIFP is provided by China's National Bureau of Statistics (NBS). It covers all SOEs and non-SOEs with annual sales of at least 5 million RMB in China's mining, manufacturing, and utilities industries. The number of firms in this database varies from over 140,000 in the late 1990s to over 336,000 in 2007. Firms are from all 31 provinces and directly-administrated municipalities in China. We confine to firms from manufacturing industries. The ASIFP contains detailed information of each firm, including the firm's official name, industry, location, and ownership. It also contains many operation and performance items of each firm such as age, employment, capital, intermediate inputs, and new product sales. We clean the ASIFP data by dropping observations according to the basic rules of Generally Accepted Accounting Principles (Cai and Liu, 2009). We drop firms with fewer than eight workers because those firms are subject to a different legal regime (Brandt et al., 2012), and firms with obviously wrong establishment years such as 1900 and before. We also drop firms in tobacco manufacturing because the tobacco industry is highly regulated and thus, the M&A activities could be very different from other industries. With the above effort, we obtain a dataset containing a set of time-varying industry-level control variables.[10]

[9] We use tariff data instead of Non-Tariff Barriers (NTB) because the comparability of NTB is problematic and NTB data are more difficult to acquire. In contrast, tariff data are price-based measures, more comparable across sectors and time. Moreover, compared to other indirect measures such as import penetration rates, tariff cuts are a direct policy instrument and suffer less from endogenous problems (Trefler, 2004; Breinlich, 2008).

[10] Although the ASIFP data is at firm level, we only use it to construct time-varying industry level covariates. We do not conduct firm level analysis partly because of the matching problem: the firms' names in ASIFP are in Chinese while those in SDC are in English. The quality of matching Chinese names with English names is very bad and using other information of identity cannot generate good matches either.

We merge the above three databases to construct our dataset at the ISIC four-digit industry level.[11] The starting time of our dataset is 1998, which is the earliest available year from the ASIFP data. The ending time is 2007, which is subject to data availability and also chosen to avoid potential biases caused by the worldwide financial crisis in 2008. In our merged dataset, we have data for 102 ISIC four-digit industries in 1998-2007.

3.4 Summary Statistics

Table 3 presents the descriptive statistics on vertical integrations and tariffs across ISIC two-digit industries in different time periods. Column (1) is the total number of backward vertical integrations in each industry during the entire sample period, 1998-2007. A large variation across industries exists. The most active industry, chemicals and chemical products, has 156 acquisitions. Column (2) is the total number of vertical integrations in the pre-WTO period, 1998-2001, while column (3) is the total number in the post-WTO period, 2002-2007. Column (4) reports the difference between columns (3) and (2). The columns show that an increase in vertical integrations occurred after the WTO entry, which is true even after considering the different time span of the two periods. The changes in vertical integrations also vary significantly across industries.

Output and input tariffs are reported in columns (5)-(10). Column (5) presents the levels of output tariff in year 2001, column (6) is the levels of output tariff in 2007, and column (7) reports the difference between columns (6) and (5). It is evident that most industries experienced huge tariff reductions from 2001 to 2007, but a large variation across industries is also observed in terms of the degree of reduction. A similar pattern is found for input tariffs in columns (8)-(10), but the changes and variations are smaller.

<Insert Table 3 here>

[11] All M&A transactions in SDC are classified into SIC four-digit industries based on the primary field of the target company or acquired division. We convert SIC four-digit industry to ISIC four-digit industry using the correspondence table provided by UNSTAT. Variables from the ASIFP database are classified by Chinese Industry Classification, which is modified from the ISIC (Revision 3). Thus, we also need to reclassify firms into ISIC four-digit industries.

4 Econometric Analysis

4.1 Basic Results

Table 4 reports our basic regression results. In all regressions, the dependent variable is the number of backward vertical integrations targeting at industry i. We find consistent results that output tariff reduction in an industry significantly *decreases* the industry's vertical integrations, and input tariff reduction significantly *increases* the number of vertical integrations.

Specifically, column (1) is the basic result with only the industry and year fixed effects being controlled. We find a significant and negative estimate for $WTO_t \times OutT01_i$, and a significant and positive estimate for $WTO_t \times InT01_i$. These findings indicate that after China's accession to the WTO, firms in industries that experienced larger output tariff reductions are less likely to be integrated by their downstream firms, but firms in industries that experienced larger input tariff reductions are more likely to be integrated by their downstream firms. We will offer an explanation for this finding in Section 5. To check whether this finding is obtained due to some omitted driving forces, we further control for industry time-varying characteristics that might be related to the decision of vertical integration.[12]

First, the life-cycle status of each industry may matter for vertical integrations, and thus in column (2) we add the logarithm of average firm age of industry i to the basic regression. We find that the sign and significance of the key estimates (i.e., output and input tariffs) are not affected by firm age. The estimate of firm age is negative and significant. When additional control variables are included in columns (3)-(5), the sign of firm age estimate remains negative but no longer statistically significant. Younger firms may be more dynamic and grow faster, and thus attract more downstream firms to vertically integrate them.

Second, the availability of potential targets in each industry is likely to be related to the number of M&As.[13] In a larger industry, more firms are available as potential targets for vertical integration. This fact is especially true because our dependent variable is the count of vertical integration, not adjusted by industry size. The number of firms in an industry may reflect the competition of the

[12] The fixed effect Poisson estimation automatically drops industries with no vertical integration during the entire sample period, so we have 580 observations in these regressions. In the robustness check, we show that including those dropped industries without vertical integrations does not change our results.

[13] In the literature of M&As (mostly for horizontal M&As), the number of firms in the industry plays an important role in affecting M&A incentives and equilibrium (Salant et al., 1983).

industry, which in turn may affect the incentive for vertical integration. To control for these effects, we add a new variable, $logN_{it}$ which is the logarithm of total number of firms in each industry in each year, to the basic regression in column (3). We find that the estimate of industry size is positive, as expected, but not statistically significant. More importantly, our main results (effects of tariff reductions) remain unchanged.

Third, although the number of firms in an industry is related to competition, the Herfindahl-Hirschman Index (HHI) is a better measure of competition. Fiercer competition may induce firms' restructuring activities. Accordingly, we add the Herfindahl-Hirschman Index (HHI) to our regression to control for competition in each industry. This control also helps address the concern that the effect of China's trade liberalization on vertical integration is due to the change in the level of competition. The result is reported in column (4). The effect of HHI is positive but statistically insignificant, and the coefficients of our regressors of interest are not affected. Thus, competition is not an important factor for explaining China's vertical integration.

Finally, although we include industry and time fixed effects in our specification to control for time-invariant industry specific and general time trends of vertical integration, vertical integration might also be affected by omitted time-varying international industry shocks (e.g., global technology shocks). Hence, to control for those shocks, we follow Breinlich (2008) and include the total number of completed vertical integrations in each industry in some other countries. In particular, we choose India and Brazil because they are similar to China in many dimensions as a large developing economy. The premise is that if international factors that affect the world vertical integration activities in large developing countries exist, they are likely to be similar for China, India, and Brazil. Furthermore, no significant trade liberalization had been carried out in India and Brazil around the time of China's entry to the WTO, which makes the number of vertical integrations in these two countries a better proxy for international industry shocks. Hence, we add to our regression $India\&BrazilVI_{it}$, the total number of backward vertical integration in India and Brazil of industry i in year t. The result is in column (5). The estimate of $India\&BrazilVI_{it}$ is positive and statistically significant, which shows indeed the existence of international industry shocks. However, our key estimates (tariffs) remain unchanged.

<Insert Table 4 here>

4.2 Validity and Robustness Checks

The reliability of our estimates obtained earlier depends on the validity of our DID specification, that is, the conditional comparability of the trends between the treatment and control groups. In this subsection, we conduct a series of tests on the validity of the DID. We also perform some tests on the robustness of the results.

4.2.1 Validity of DID

□ **Flexible Estimation.** In subsection 4.1, we estimate the average treatment effect of output tariff cut and input tariff cut. The treatment effect is the difference between the treatment and control groups in their average differences between the pre-WTO and post-WTO periods. We check the differences with a more flexible model specification. This check helps answer two questions: whether the two groups have comparable trends before the WTO accession; and whether the divergence of trends emerges after the WTO accession. To address these questions, we conduct the flexible estimation by replacing the WTO dummy with a vector of year dummies λ_t, indicating the years from 1998 to 2007 with year 2001 as the omitted reference year. This specification imposes little timing structure on the model. Thus, we are simply examining how the difference in vertical integrations between industries with different tariff reduction levels vary over time.

We plot the flexible estimation results, i.e., the estimated coefficients of the interaction terms $\lambda_t \times OutT01_i$ and $\lambda_t \times InT01_i$, and also the means of the coefficients, in Figure 4.[14] Two clear patterns emerge. First, in the pre-WTO period (1998-2000) the coefficients are very unstable and the means of the coefficients are very close to zero. Second, in the post-WTO period the coefficients of output (input) tariff are consistently and significantly negative (positive), showing significant differences from those of the pre-WTO period. These results support our DID specification.

<Insert Table 5 here>

<Insert Figure 4 here>

□ **Expectation Effect.** Although the process and *timing* of China's WTO accession are highly political and widely regarded as unexpected, we still want to check whether firms somehow could

[14] We do not provide a table of the estimation results to save space. The table is available upon request.

anticipate the WTO accession time. If they had anticipated it, they would have prepared and responded rationally just as they did after 2001. To address this issue, we add the interaction terms $\lambda_{2001} \times OutT01_i$ and $\lambda_{2001} \times InT01_i$ to Model (1). The regression result is reported in column (1) of Table 5. It shows that both the coefficients of $\lambda_{2001} \times OutT01_i$ and $\lambda_{2001} \times InT01_i$ are insignificant, which implies the absence of the expectation effect and the treatment and control groups do not show differential expectation. Moreover, the coefficients of the key regressors, $WTO_t \times OutT01_i$ and $WTO_t \times InT01_i$, remain significantly negative and positive, respectively.

□ **Industry-Specific Trend.** In our DID specification, we implicitly assume that conditional on $(\mathbf{X}'_{it}, \lambda_t, \lambda_i)$, our treatment and control groups each have a common trend in the pre- and post-WTO periods. This assumption enables us to use vertical integrations of the control group as the counterfactual of the treatment group in the post-WTO accession period. Differencing out the trend of the control group allows us to isolate the effect of tariff reductions on vertical integrations. However, if industries are affected differently by confounding industry-time specific factors, they might have different trends in the pre- and post-WTO periods. One way to solve this problem is to allow industries to have different time trends in the pre- and post-WTO periods by introducing a vector of industry-WTO dummies, $\sum_i \lambda_i \times WTO_t$. However, this method is not applicable to our model because our key variables are defined at exactly the same ISIC four-digit industry level. Alternatively, we control for industry trends in a more aggregate level, ISIC two-digit industry level, by adding a set of dummies, $\sum_i ISIC2_i \times WTO_t$, to our regression model.

Column (2) of Table 5 reports the results after controlling for all ISIC two-digit industry-specific trend changes in the post-WTO period. Note that we do not report the estimates of the new set of dummies to save space. After controlling for changes of industry-specific trends, the key results of input and output tariffs stay qualitatively the same and quantitatively larger.

□ **Placebo Test: Pre-WTO Period.** Following Topalova (2010), we conduct a placebo test to examine the effects of output and input tariffs on vertical integration in the pre-WTO period. The premise is that because tariffs did not change much during that period, we should not expect any significant effects of tariffs on vertical integration; if the results are the contrary, then there might be some underlying confounding industrial factors (other than the WTO accession) that drive vertical integration. Accordingly, we replace our key variables $WTO_t \times OutT01_i$ and $WTO_t \times InT01_i$ with

$OutT_{it}$ and InT_{it} and rerun the regression for the sample of the pre-WTO period. The estimates are given in column (3) of Table 5. The effects of $OutT_{it}$ and InT_{it} are not statistically significant. This test lends further support to the validity of our DID specification.

4.2.2 Robustness

We now turn to other concerns about factors that might affect the relationship between trade liberalization and vertical integrations. All results are reported in Table 6.

□ **SOE and FDI Reforms.** If other policy reforms had been introduced around the time of China's WTO accession and might affect our treatment and control groups differently, then the effects of those policy reforms would also be included in our DID estimates. In that case, our regression results could be contaminated by those simultaneous policy reforms. Indeed, two important reforms took place in the early 2000s: the SOE reform and the relaxation of FDI entry regulations. These reforms are on-going reforms that started in the 1980s and 1990s, respectively, and accelerated after the WTO accession. The SOE reform resulted in large-scale privatization, close-down of small SOEs, and efficiency improvement of the surviving (large) SOEs. The new FDI regulations relaxed the entry requirement for foreign investors and reduced the range of industries restricted to foreign investment. The strength of these reforms may or may not vary across industries, and may or may not be closely correlated with the degree of output and input tariff reductions in each industry. In any case, to control for any possible confounding effects from these two policy reforms, we include two additional control variables in our DID estimation: $SOEShare_{it}$ (measured by the ratio of the number of SOEs over the total number of domestic firms) and $FIEShare_{it}$ (measured by the ratio of the number of FIEs over the total number of firms). The regression result is reported in column (1) of Table 6, which shows that including policy reforms on SOE and FIE does not affect our estimates of the output and input tariffs. Hence, we can rule out the possibility that our results are caused by contemporary SOE and FIE reforms.

□ **Subsidy.** Chinese government has been active in promoting industrialization using industry policies such as government subsidy (Aghion et al., 2015). The coverage of firms receiving government subsidy varies across years. For example, based on the ASIFP data, Aghion et al. (2015) document that 9.4% of the firms received subsidies in 1998. The ratio increases steadily to a peak of 15.1% in

2004 and then decreases to 12.4% in 2007. Subsidy could affect firms' M&A decisions. To rule out the potential confounding effect of the subsidy policy, we control for the log of total subsidy of each industry, $Subsidy_{it}$. The result in column (2) shows that the effect of subsidy is not significant and our main results remain significant and consistent with main regressions.

□ **Market Entry Regulation.** Although market entry is regulated in certain industries in China, especially in the early period of our sample, the government has already relaxed the entry regulations to certain degree. The *Report of the Sixteenth Party Congress* in 2002 clearly states that "Monopoly industries should carry out reforms to introduce competition mechanisms... We should expand the areas for the market access of domestic nongovernmental capital and adopt measures with regard to investment, financing, taxation, land use, foreign trade and other aspects to carry out fair competition." This reform may affect industrial reorganizations, especially in those entry-regulated industries. We calculate the logarithm of the total number of non-SOE entries in each industry, $NonSOE\_Entry_{it}$, to measure the intensity of entry regulations across industries. The result in column (3) shows that the coefficient of $NonSOE\_Entry_{it}$ is negative but not statistically significant. The effects of tariffs on vertical integrations are not affected by inclusion of this variable.

□ **Unlisted Firms**. It is clear that the *Administration of the Takeover of Listed Companies Procedures* (2002) is directly related to M&As. This is a general regulation on takeovers of *listed* companies across all industries and thus is unlikely to confound with the differential effects of trade liberalization on vertical integrations of *all* firms. However, to exclude the possibility of its confounding effect, we run the regression with the subsample of *unlisted* firms. Specifically, we exclude all vertical integrations with listed companies as targets in our data and re-count the total number of backward vertical integrations as our new dependent variable. The result is presented in column (4), which indicates that, after excluding all takeovers of listed companies, the effects of output and input tariffs on vertical integrations remain unchanged.

□ **Export Expansion.** Along with tariff cuts by China upon the WTO accession, some other countries also liberalized their markets to Chinese exports, which implies expanded market opportunities for Chinese firms.[15] This in turn may also affect the incentives of Chinese domestic vertical integrations. We control for export expansion opportunity and its effects in two ways. First, we

[15] Even if foreign countries' tariffs do not change, China's entry to the WTO removes the uncertainty of those tariff policies, which stimulates China's exports (Pierce and Schott, 2016).

add a term of logarithm of industrial total exports, $Export_{it}$, to Model (1). Any possible change that would affect the demand for Chinese exports would ultimately be reflected in increased exports. The regression result is in column (5). Second, we include the weighted average tariffs of all foreign countries faced by Chinese exporters, $ForeignTariff_{it}$, to capture possible market expansion opportunity.[16] The regression result is in column (6). The estimates of our key variables remain unchanged in columns (5) and (6) after we take the export opportunity into account.

□ **Comparative Advantage.** Industries differ in many aspects and therefore the effects of trade liberalization on vertical integrations could also differ. One of such differences is comparative advantages. Firms in industries of China's comparative advantage may not be affected too much by import tariff cuts but benefit more from foreign countries' tariff cuts. To determine whether such a difference matters and whether it affects our main results, we include the revealed comparative advantage index (RCA_{it}) in the model. As common in literature, we calculate the RCA index of an industry for each year as the ratio of the share of the industry's export in China's total exports over the share of the industry's export in the world's total exports. We report the regression result in column (7). Surprisingly, we do not find the estimate of RCA variable significant although positive. However, the estimates of the output and input tariffs remain similar.[17]

□ **Downstream Tariffs**. Alfaro et al. (2016) demonstrate that high price of downstream firms' products will incentivize the firms to acquire upstream suppliers. Trade liberalization in China also takes place in the downstream industries, which affects downstream product price, and thus may confound our estimates. To insulate this effect, for each upstream industry, we control for changes in the weighted average tariff of the downstream industries. We first construct the downstream weighted average tariff of industry i, calculated as $DownT_{it} = \Sigma_j SupplyShare_{ij} \cdot OutT_{jt}$, where $SupplyShare_{ij}$ is the supply share of industry i to downstream j over i's total supply, which captures the importance of downstream industry j as a buyer for i. We then add $WTO_t \times DownT01_i$ in our regression, where $DownT01_i = DownT_{j2001}$. Results are reported in column (8). The coefficient of the downstream tariff is not significant, but is negative as in Alfaro *et al.* (2016).[18] Estimates of our key explanatory variables (input and output tariffs of the upstream industry) keep significant and consistent with

[16] This tariff measure is directly available from the WITS database, which is the weighted average tariffs with *exporter* being "CHN" and *importer* being "All".

[17] The results are not affected even if we further include the interactions between RCA_{it} and the two tariffs.

[18] In column (11), when we include all controls, the coefficient is significant at 10% level.

previous regressions after we control for downstream tariffs.

□ **Productivity.** The impacts of trade liberalization on firms' productivity have been well explained and documented in recent trade literature. In industrial organization literature, it is found that the efficiency gain from productivity spillover is a major motivation of vertical integration.[19] Do the effects of trade liberalization on vertical integration come from the change in productivity? We check this question by controlling for the industry average productivity.[20] We first estimate each's total factor productivity (TFP) using the Olley-Pakes method, and then use them to calculate the average TFP of each ISIC four-digit industry as a proxy for industry productivity. Column (9) shows that TFP is positively correlated with the number of vertical integration in each industry, but not significant. Furthermore, including TFP does not alter our main estimates on output and input tariffs.

In column (10) of Table 6, we include all the above-discussed variables in the regression. Our findings on the key variables, i.e., input and output tariffs of the target firm's industry, remain robust.

<Insert Table 6 here>

4.3 Alternative Measures and Estimation Methods

We obtain our main results based on specific measures of dependent and independent variables, model specifications, and estimation methods. In this section, we examine whether the results are robust to alternative measures and estimation methods.

□ **Value Measure.** In the previous regressions, we use the number of backward vertical integrations as our dependent variable. We replace the count variable by the logarithm of the total value of vertical integrations. The transaction values are deflated to the 1996 US dollar using CPI index provided by the U.S. Department of Labor Bureau. Because our dependent variable is now a continuous and non-negative one, we use Tobit model to estimate it.[21] The result is reported in column (1) of Table 7. It shows that our results also hold for the value measure. Industries experiencing higher output tariff reductions have relatively lower values of backward vertical integrations, and the opposite is true for input tariffs.

[19] See Alfaro *et al.* (2016) for a brief summary.

[20] Productivity is correlated with profitability. Hence, controlling for productivity also helps alleviate another concern that trade liberalization affects vertical integration through changing the profitability of firms.

[21] When using Tobit model, all observations, including industries that do not have any vertical integrations during the entire sample period, will be included.

<Insert Table 7 here>

☐ **Different Definition of Backward Vertical Integration.** We have previously defined backward vertical integration as downstream firms acquiring upstream firms, which are obtained following Antras et al. (2012). Now we use a simpler measure: an acquisition is a backward vertical integration if the use of the target's product in the production of the acquirer's output is significant. To implement this approach, we use the input-output flows in the IO table to proxy for transaction flows between firms, following Acemoglu et al. (2010). For each completed M&A, if the input from the target's industry accounts for more than 1% of the total inputs used in the production of the acquirer's industry, we treat it as a backward vertical integration.[22] Similar methods have also been used by Atalay et al. (2014) and others. Column (2) presents our Tobit regression results using this new measure of backward vertical integrations. It shows that the effects of output and input tariff reductions are significant, with signs consistent with earlier findings.

☐ **Poisson Pseudo-Maximum Likelihood Model**

Another commonly used count model is the Poisson Pseudo-Maximum Likelihood (PPML) model. The method of PPML, developed by Santos Silva and Tenreyro (2010), identifies and drops regressors that may cause the non-existence of the (pseudo) maximum likelihood estimates. It is especially useful when the data have many zeros, which might cause potential convergence problem. Because many industries have no vertical integration in some years in our dataset, we use PPML to re-estimate the model. The result is reported in column (3), which is consistent with the results obtained earlier using the fixed effect Poisson model.

☐ **Random Effect Poisson Model**

In our main regressions, we use the fixed effect Poisson method to estimate our model. With the fixed effect Poisson method, industries with no vertical integration during the entire sample period are automatically dropped out from the regression. To determine whether this omission will affect our results, we run a regression using the random effect Poisson method, which keeps all observations. The regression result is reported in column (4), which shows that the effects of tariffs on vertical integrations are robust even if we include all zero observations.

☐ **Fixed Effect Negative Binomial Model**

[22] Changing the ratio to 5% will not alter our results.

Poisson estimators are consistent with PPML estimators regardless of the distribution of the data. However, if the data is overly dispersed, with the variance greater than the mean, using the negative binomial model will improve the estimation efficiency. Therefore, we use the fixed effect negative binomial model to perform a robustness check, in case that the data are overly dispersed. The result is presented in column (5), which is quite similar to the Poisson estimation.[23]

□ **Tobit Model**

Because our dependent variable is a count variable, we use count models in our baseline estimations. To show that the results are not driven by count models, we convert our dependent variable into a continuous variable as $VI^*_{it} = log(VI_{it} + 1)$ and use Tobit model to rerun the regression. We choose Tobit because the new dependent variable is always non-negative. The results are in column (6), which shows consistency.

□ **Two-Period Sample**

Because the occurrence of vertical integration is not very frequent, there are a lot of zeros in our data. To smooth the data and reduce the observations of zero, we follow Breinlich (2008) and construct a two-period sample to rerun the regression. Specifically, we collapse our yearly panel data to a two-period panel data, with pre-WTO and post-WTO periods, and then conduct our estimation using fixed effect Poisson regression. The result is reported in column (7). The estimation remains robust.

5 Model

We build a specific-investment model based on Ornelas and Turner (2008, 2012) to provide insights to our empirical results. Suppose that there are two domestic agents, called the (downstream) buyer and the (upstream) supplier. The supplier supplies a fully specialized *widget* to the buyer. The supplier can make an *ex-ante* relationship-specific investment $e \in [0, \bar{\imath}]$ to better adapt its widget to the buyer's need, but the investment is not contractible between the buyer and the supplier. The value of the specialized widget to the buyer is $V(e)$, which is increasing in the relationship-specific investment, with $V'(e) > 0$ and $V''(e) < 0$. The investment cost is $I(e)$, with $I'(e) > 0$. We normalize this cost function without much loss of generality: $I(e) = e$. To produce the widget, the supplier needs to

[23] The standard error in the fixed effect negative binomial model is the observed information matrix type error.

import an input. Let τ be the tariff on the imported inputs, called the *input tariff.* We write the production cost of the widget as $C(\tau)$, where $C_\tau > 0$. For simplicity, we assume that the production cost is not extremely high and $C(\bar{\tau}) < V(0)$, where $\bar{\tau}$ is the upper bound of the input tariff τ.

The buyer can either use the specialized widget produced by the supplier, or import a standardized widget from abroad.

The foreign market of the standardized widget is competitive. If the buyer imports from the foreign market, it has to pay a price p and an import tariff t, where t is the tariff on widget, called *output tariff.* Assume that p is a random variable over $[0, \infty]$ following a distribution F. The randomness of p can be attributed to information asymmetry, or shocks in the foreign market. The standardized widget provides a deterministic value V_0 to the buyer. We assume that output tariff t is not prohibitive, that is, $t < V_0 - (V(\bar{\imath}) - C)$. This condition is derived from the case that when the price of the standardized widget in the foreign market is zero, import is always the best choice for the buyer because $V_0 - t > V(\bar{\imath}) - C$.

If the buyer buys from the supplier (*outsourcing*), they sign an arm's-length contract and bargain over the price through Nash bargaining. We assume that the bargaining power is α and $(1 - \alpha)$ for the supplier and buyer, respectively, and $\alpha \in [0, 1]$.

Instead of outsourcing to the supplier, the buyer can also vertically integrate the supplier at a fixed reorganization cost $K > 0$.[24]

The timing of the game is shown in Figure 5. At time 1, the buyer and supplier decide on integration or not. At time 2, if not integrated, the supplier chooses the investment level; if integrated, the integrated firm (IF) chooses the investment level. The foreign price of widget p is realized at time 3. At time 4, without integration, the independent buyer decides whether to buy the widget from the independent supplier (outsourcing) or directly import the standardized widget from the foreign market (offshoring); with integration, the IF decides whether to produce the widget within the firm or directly import from the foreign market. At time 5, production and trade (if there is any) occur. Note that the buyer cannot commit *ex-ante* (i.e., before p is realized) to purchase the domestic specialized widget or import the foreign standardized one. Instead, it makes an efficient purchasing decision *ex-post.*

[24] This assumption is commonly used in literature, for examples, Hart and Tirole (1990), Maclaren (2000), and Ornelas and Turner (2008, 2012).

<Insert Figure 5 here>

5.1 Non-integration

Suppose that the decision at time 1 is not to integrate (*non-integration*).

At time 4, if the buyer outsources to the supplier, they determine the transaction price of the widget $\tilde{p}$ through Nash bargaining. The payoffs are $u_b^1 = V(e) - \tilde{p}$ for the buyer and $u_s^1 = \tilde{p} - C$ for the supplier. If the contract breaks down, the supplier receives nothing. As the investment cost is sunk, the supplier's payoff is $u_s^0 = 0$, which is its outside option. The buyer may import the standardized widget or merely stop producing its output, whichever yields a higher profit. Clearly, it will import the standardized widget if and only if $p + t < V_0$. Thus, the buyer's outside option is $u_b^0 = \max\{V_0 - p - t, 0\}$.

Price $\tilde{p}$ is the solution to the following Nash bargaining between the buyer and supplier: $\tilde{p}(t) = arg\max_{\tilde{p}}(u_b^1 - u_b^0)^{1-\alpha}(u_s^1 - u_s^0)^{\alpha}$, whenever $u_b^1 > u_b^0, u_s^1 > u_s^0$. Hence, we have

$$\tilde{p}(t) = \begin{cases} \alpha[V(e) - (V_0 - p - t)] + (1-\alpha)C & \text{if } \phi(e,t,\tau) \leq p < V_0 - t, \\ \alpha V(e) + (1-\alpha)C & \text{if } p \geq V_0 - t, \end{cases}$$

where $\phi(e,t,\tau) \equiv (V_0 - t) - (V(e) - C) > 0$.[25]

Consequently, the supplier's expected profit from making *ex ante* investment is

$$u_s(e,t,\tau) = \int_{\phi(e,t,\tau)}^{V_0 - t} \alpha[(V(e) - C) - (V_0 - p - t)]dF(p) + \int_{V_0 - t}^{\infty} \alpha\,(V(e) - C)\,dF(p) - e.$$

At time 2, the supplier chooses its investment level e to maximize its expected profit. Assume that the second order condition (SOC) for maximizing u_s holds, which is, $S \equiv \alpha\left(V'\right)^2 f(\phi) + \alpha V''(1 - F(\phi)) < 0$. Then, from the first order condition (FOC), we obtain the optimal investment level, e^n,

[25] Note that when $p \geq V_0 - t$, $u_b^0 = 0$, thus $u_b^1 > u_b^0$ and $u_s^1 > u_s^0$ always hold. The Nash bargaining gives $\tilde{p}(t) = \alpha V(e) + (1-\alpha)C$. When $p < V_0 - t$, $u_b^0 = V_0 - p - t$. The buyer and the supplier will sign an arm's length contract and bargain over the price if $u_b^1 > u_b^0$ and $u_s^1 > u_s^0$, which gives $p > \phi(e,t,\tau) \equiv V_0 - t - (V(e) - C)$. Hence when $\phi(e,t,\tau) \leq p < V_0 - t$, the bargaining price is given as $\tilde{p}(t) = [V(e) - (V_0 - p - t)] + (1-\alpha)C$. When $p < \phi(e,t,\tau)$, the contract is breached, and the buyer imports from the foreign market and the supplier stops producing.

under non-vertical integration, which is defined by

$$\alpha V'(e^n)\left(1-F\left(\phi\left(e^n\right)\right)\right)=1. \tag{2}$$

Differentiating the above equation with respect to α, we obtain

$$\frac{de^n}{d\alpha}=\frac{-V'(e^n)\left(1-F\left(\phi\left(e^n\right)\right)\right)}{S}>0. \tag{3}$$

This result is intuitive: if the supplier has stronger bargaining power (α), it can get a larger part of benefit from its investment, and thus invests more.

Similarly, we obtain the response of optimal investment to tariff changes as

$$\frac{de^n}{dt}=-\frac{\alpha V'(e^n)f(\phi\left(e^n\right))}{S}>0, \quad \text{and} \quad \frac{de^n}{d\tau}=\frac{\alpha V'(e^n)f(\phi\left(e^n\right))C_\tau}{S}<0. \tag{4}$$

When the output tariff (t) is reduced, the buyer's outside option is better and the buyer will obtain a larger part of benefit from the contract with the supplier. This reduces the supplier's incentive to make relationship-specific investment. In contrast, if the input tariff (τ) decreases, the cost of the specialized widget $C(\tau)$ becomes cheaper. The higher profit margin from investment induces the supplier to invest more.

At the supplier's optimal investment level e^n, the supplier's expected profit is $u_s(e^n(t,\tau),t,\tau)$, and the buyer's expected profit is given by

$$\begin{aligned}
u_b(e^n(t,\tau),t,\tau) &= \int_0^{\phi(e^n)}(V_0-p-t)dF(p)+\int_{\phi(e^n)}^{V_0-t}(1-\alpha)[(V_0-C)+\alpha(V_0-p-t)]dF(p) \\
&\quad +\int_{V_0-t}^{\infty}(1-\alpha)(V_0-C)dF(p) \\
&= \int_0^{V_0-t}(V_0-p-t)dF(p_f)+\frac{1-\alpha}{\alpha}(u_s(e^n,t,\tau)+e^n).
\end{aligned}$$

The sum of the expected profits of the buyer and supplier under non-integration is

$$U^n(t,\tau)=u_b(e^n(t,\tau),t,\tau)+u_s(e^n(t,\tau),t,\tau).$$

5.2 Vertical Integration

Suppose that at time 1, the two firms decide to integrate.

At time 4, the integrated firm decides to produce the specialized widget by itself or import the standardized one from the foreign market, depending on which would yield a higher operational profit. If the former is higher, which is the case when $p > \phi(e, t, \tau)$,[26] the integrated firm will produce the specialized widget by itself; otherwise, it will import the standardized one from the foreign market. Hence, the expected profit of making *ex ante* investment is given by

$$u_v(e, t, \tau) = \int_0^{\phi(e)} (V_0 - p - t)dF(p) + \int_{\phi(e)}^{\infty} (V(e) - C)dF(p) - e.$$

At time 2, the integrated firm chooses its investment level e to maximize the above expected profit. Assume that the SOC for maximizing u_v holds. Then, from the FOC, we obtain the optimal investment level, e^v, as defined by

$$V'(e^v)(1 - F(\phi(e^v)) = 1. \tag{5}$$

Analogous to the non-integration case, the responses of optimal investment to tariff changes under integration are

$$\frac{de^v}{dt} > 0, \quad \text{and} \quad \frac{de^v}{d\tau} < 0.$$

At the optimal investment level e^v, the integrated firm's expected profit is

$$U^v(t, \tau) = u_v(e^v(t, \tau), t, \tau).$$

5.3 Organizational Choice

We first compare the optimal level of investment under integration to that under non-integration. Notice that equations (2) and (5) are identical at $\alpha = 1$. Thus, $e^v = e^n$ when $\alpha = 1$. This result together with (3) yields the following outcome: $e^n < e^v$ for all $\alpha < 1$. This result is well known in

[26]The operational profit of producing the widget by the IF is $V(e) - C(\tau)$, and the one of importing is $V_0 - p - t$. The IF chooses to produce by itself if and only if $V(e) - C(\tau) > V_0 - p - t$, which gives $p > \phi(e, t, \tau)$.

literature: with incomplete contract, a party will under invest because of the hold-up problem; and integration helps to solve the under-investment problem.

We now turn to the organizational choice of the firms, i.e., decision at time 1. Suppose that there is no wealth constraint and all agents are risk neutral. Then, by Coase Theorem, integration will happen if and only if the difference between the expected total profit under integration and that under non-integration is large enough to cover the re-organization cost K. We explore how tariff changes affect the comparison of the two organizational choices.

Define $\Delta U(t,\tau) = U^v(t,\tau) - U^n(t,\tau)$, which captures the incentive for integration. In what follows we investigate how tariff changes affect this incentive.

We first focus on the case of changes in output tariff t. Under non-integration, we differentiate the supplier's profit with respect to t and obtain

$$\begin{aligned} \frac{du_s(e^n(t,\tau),t,\tau)}{dt} &= \frac{\partial u_s(e^n(t,\tau),t,\tau)}{\partial e^n(t,\tau)}\frac{de^n(t,\tau)}{dt} + \frac{\partial u_s(e^n(t,\tau),t,\tau)}{\partial t} \\ &= \frac{\partial u_s(e^n(t,\tau),t,\tau)}{\partial t} = \alpha(F(V_0 - t) - F(\phi(e^n))) > 0, \end{aligned}$$

where the second equality is obtained by applying Envelope Theorem. As $U^n(t,\tau) = \int_0^{V-t}(V - p - t)dF(p_f) + \frac{1}{\alpha}u_s(e^n(t,\tau),t,\tau) + \frac{1-\alpha}{\alpha}e^n$, we have $\frac{dU^n(t,\tau)}{dt} = -F(\phi(e^n)) + \frac{1-\alpha}{\alpha}\frac{de^n}{dt}$.

Under integration, we obtain

$$\begin{aligned} \frac{dU^v(t,\tau)}{dt} &= \frac{\partial u_v(e^v(t,\tau),t,\tau)}{\partial e^v(t,\tau)}\frac{de^v}{dt} + \frac{\partial u_v(e^v(t,\tau),t,\tau)}{\partial t} \\ &= \frac{\partial u_v(e^v(t,\tau),t,\tau)}{\partial t} = -F(\phi(e^v)) < 0, \end{aligned}$$

where the second equality follows from Envelope Theorem.

The above results lead directly to

$$\frac{d\Delta U(t,\tau)}{dt} = \left[F\left(\phi(e^n)\right) - F\left(\phi(e^v)\right)\right] - \frac{1-\alpha}{\alpha}\frac{de^n}{dt}. \tag{6}$$

The first term of (6) is positive as $e^n < e^v$, which implies $\phi(e^n) > \phi(e^v)$, while the second term is negative because $\frac{de^n}{dt} > 0$. Therefore, a reduction in upstream output tariff imposes two opposing forces on the integration decision. To determine what determine the relative magnitudes of these two forces, we rewrite (6) by making use of (2) and (5) for the first term, and (4) for the second term:

$$\frac{d\Delta U(t,\tau)}{dt} = \frac{\alpha V'(e^n) - V'(e^v)}{\alpha V'(e^n)V'(e^v)} - \frac{(1-\alpha)}{\alpha}\frac{V'(e^n)f(\phi(e^n))}{(-V''(e^n))(1-F(\phi(e^n))) - \alpha V'(e^n)^2 f(\phi(e^n))}. \tag{7}$$

Note that the first term of (6) is positive and thus $\alpha V'(e^n) - V'(e^v) > 0$. Then, if $V''(e)$ is smaller (i.e., more negative, or the V function is concave enough), then the first term above becomes larger (because $V'(e^v)$ will be much smaller than $V'(e^n)$) while the second term becomes smaller, and so $\frac{d\Delta U}{dt}$ is more likely to be positive. Thus, a sufficient condition for $\frac{d\Delta U}{dt} > 0$ is that the value function V is concave enough.

We next turn to the case of input tariff. Under non-integration, differentiating the total expected profit with respect to τ yields $\frac{dU^n(t,\tau)}{d\tau} = -C_\tau(1 - F(\phi(e^n))) + \frac{1-\alpha}{\alpha}\frac{de^n}{d\tau} < 0$.

Under integration, $\frac{dU^v(t,\tau)}{d\tau} = -C_\tau(1 - F(\phi(e^v))) < 0$.

Hence, we obtain

$$\frac{d\Delta U(t,\tau)}{d\tau} = C_\tau[F(\phi(e^v)) - F(\phi(e^n))] - \frac{1-\alpha}{\alpha}\frac{de^n}{d\tau}. \tag{8}$$

In (8), the first term is negative for the same reason as that in (6) and $C_\tau > 0$, and the second term is positive because $\frac{de^n}{d\tau} < 0$. Hence, a reduction in upstream input tariff also imposes two opposing forces on integration incentive. Similarly, using (4) we can rewrite (8) as

$$\frac{d\Delta U(t,\tau)}{d\tau} = -C_\tau \frac{d\Delta U(t,\tau)}{dt}.$$

Thus, a sufficient condition for $\frac{d\Delta U(t,\tau)}{dt} > 0$ is also a sufficient condition for $\frac{d\Delta U(t,\tau)}{d\tau} < 0$.

The above analysis allows us to establish the following proposition.

Proposition 1. *Suppose that the value function $V(e)$ is concave enough (i.e., $V''(e) < 0$ and $|V''|$ is large). Then, a decrease in the upstream industry's output tariff will lead to fewer vertical integrations ($\frac{d\Delta U(t,\tau)}{dt} > 0$), while a decrease in the upstream industry's input tariff will result in more vertical integrations ($\frac{d\Delta U(t,\tau)}{d\tau} < 0$).*

To obtain the intuition, we first examine the effect of a tariff change on the profit under non-integration and that under integration, respectively. Under non-integration, the total profit (net of investment cost) is $U^n = \int_0^{\phi(e^n)}(V_0 - p - t)dF(p) + \int_{\phi(e^n)}^{\infty}(V(e^n) - C(\tau))dF(p)$. Differentiating U^n with respect to t yields

$$\begin{aligned}\frac{dU^n}{dt} &= -F(\phi(e^n)) + (1 - F(\phi(e^n)))\frac{dV(e^n)}{dt} \\ &\quad + (V_0 - p - t)f(\phi(e^n))\frac{d\phi(e^n)}{dt} - (V(e^n) - C(\tau))f(\phi(e^n))\frac{d\phi(e^n)}{dt}.\end{aligned}$$

The change in output tariff has three effects on profit U^n. The first is the direct effect of the tariff change: when p belongs to $(0, \phi(e^n))$, the buyer imports the inputs and hence, a reduction in t directly increases the profit $(V_0 - p - t)$. This effect is captured by the first term $(-F(\phi(e^n)))$ in the above equation. The second is the indirect effect through investment on profit when the buyer purchases the input from the supplier, which is captured by the second term. This effect is small when $V(e)$ is concave enough.[27] The third is the effect on the likelihood of buying from the supplier. A reduction in tariff t increases the likelihood of importing, which is captured by the third term; and it also reduces the likelihood of buying from the supplier, which is captured by the fourth term. However, the third and fourth effects offset each other completely because $(V_0 - p - t) = (V(e^n) - C(\tau))$ at $p = \phi(e^n)$.

Under integration, the total profit (net of investment cost) is $U^v = \int_0^{\phi(e^v)}(V_0 - p - t)dF(p) + \int_{\phi(e^v)}^{\infty}(V(e^v) - C(\tau))dF(p)$. Differentiating U^v with respect to t yields

$$\frac{dU^v}{dt} = -F(\phi(e^v)) + (V_0 - p - t)f(\phi(e^v))\frac{d\phi(e^v)}{dt} - (V(e^v) - C(\tau))f(\phi(e^v))\frac{d\phi(e^v)}{dt}.$$

As in the non-integration case, a reduction in tariff t decreases the likelihood of producing the input within the integrated firm while increases the likelihood of importing; but these two effects offset each other completely because $(V_0 - p - t) = (V(e^v) - C(\tau))$ at $p = \phi(e^v)$. That is, the second and third terms cancel out. Then, the first term represents the net effect of a tariff change: the output tariff reduction increases the profit $(V_0 - p - t)$ in the range of $(0, \phi(e^v))$.

A comparison of these two cases shows two key differences. On the one hand, due to the problem of under-investment associated with non-integration, importing the input occurs more often under

[27] $\frac{dV(e^n)}{dt} = \frac{\partial V(e^n)}{\partial e^n}\frac{de^n}{dt} = \frac{V'(e^n)f(\phi(e^n))}{-\alpha(V'(e^n))^2 f(\phi(e^n)) + \alpha(-V''(e^n))(1-F(\phi(e^n)))}$, which is small when $|V''|$ is large. Note that this property holds even if we also include the investment cost in the profit function. In that case, t affects U^n indirectly through investment cost, and the total indirect effect through e^n is $\frac{(1-\alpha)}{\alpha}\frac{V'(e^n)f(\phi(e^n))}{(-V''(e^n))(1-F(\phi(e^n))) - (V'(e^n))^2 f(\phi(e^n))}$, which is also small when V is concave enough.

non-integration than under integration ($F(\phi(e^n)) > F(\phi(e^v))$ because $\phi'(e) < 0$ and $e^n < e^v$). Consequently, the direct benefit from a trade liberalization in output tariff, $(V_0 - p - t)$, is larger under non-integration. On the other hand, the tariff cut decreases relationship-specific investment under non-integration ($\frac{de^n}{dt} > 0$), which makes non-integration less attractive. However, when $V(e)$ is very concave, the decrease in investment will not reduce $V(e)$ by much. Therefore, the first effect dominates and non-integration becomes more attractive after output tariff reduction. Note that although integration is associated with additional cost, K, the fixed cost does not affect the *change* in the incentive for integration versus non-integration in response to tariff changes.

Turning to the case of trade liberalization in input tariff τ. Based on the above detailed analysis for the case of t, we learn that we can ignore the effects on the likelihood of importing the widget as they cancel out. Then, a reduction in τ benefits the firms in both non-integration and integration, as seen from the increase in the profit of producing the widget inhouse, $(V - C(\tau))$. However, as the input is produced more often inhouse under integration than non-integration, this direct benefit is larger under integration. Although input tariff reduction helps mitigate the under-investment problem, thereby benefiting non-integration, this effect is small when $V(e)$ is concave enough. Therefore, the first effect dominates and integration becomes more attractive after a reduction in τ.

To put our model in perspective of the related literature, we compare it to some existing models. Ornelas and Turner (2008) analyze exactly the opposite issue: the buyer's decision to integrate or offshore to a *foreign* firm (foreign supplier), with passive domestic suppliers as the outside option. Ornelas and Turner (2008) find that lower tariff (i.e., output tariff t as in our model) promotes (cross-border) vertical integration. The trade liberalization in input tariff in our model (i.e., τ) is absent in their model.

Ornelas and Turner (2012) is a normative theoretical analysis on optimal trade policy in the presence of endogenous organizational choice of firms. Input tariff faced by the domestic supplier is not considered in their model either.

Alfaro et al. (2016) investigate how the price of the final product (the downstream industry's output in our model) affects vertical integration. In contrast, our model complements theirs in the sense that we explore how the prices of upstream output and input affect vertical integration.[28] Our

[28] Their paper also mentions the effect of the price of intermediate inputs on the organizational choice (see Footnote 14 of their paper). They argue that the effect depends on whether the firm is a net buyer or seller of the intermediate

model includes relationship-specific investment and hold-up problem, but theirs does not.

5.4 Welfare

In this subsection, we explore the welfare implications of trade liberalization that not only changes the prices but also alters the organizational structure of firms.

In the context of our model, we define the expected welfare as the sum of the total expected profits of the two domestic firms and the expected tariff revenue. We assume that the production of one unit of widget requires one unit of imported input to simplify the analysis, and thus, the cost function becomes $C(\tau) = C_0 + \tau$, where C_0 is the deterministic price of the input. Then, we can write the expected welfare under non-integration (W^n) and that under integration (W^v) as

$$
\begin{aligned}
W^n &\equiv U^n + \int_0^{\phi(e^n)} t dF(p) + \int_{\phi(e^n)}^{\infty} \tau dF(p) = \int_0^{\phi(e^n)} (V_0 - p) dF(p) + \int_{\phi(e^n)}^{\infty} (V(e^n) - C_0) dF(p), \\
W^v &\equiv U^v + \int_0^{\phi(e^v)} t dF(p) + \int_{\phi(e^v)}^{\infty} \tau dF(p) - K = \int_0^{\phi(e^v)} (V_0 - p) dF(p) + \int_{\phi(e^v)}^{\infty} (V(e^v) - C_0) dF(p) - K.
\end{aligned}
$$

Given any t and τ, there will be an equilibrium organizational outcome: integration or non-integration. We confine our analysis to the situation of $t > \tau$, which is realistic and helps present the main results as clearly as possible.[29]

When a change in tariffs occurs, the equilibrium organizational outcome may or may not change. We first focus on the case in which the change in tariffs does *not* alter the firms' organizational decision. Differentiating W^n with respect to t yields

$$
\frac{dW^n}{dt} = -(t-\tau) f(\phi(e^n)) \left(1 + \frac{dV(e^n)}{dt}\right) + \frac{1-\alpha}{\alpha V'(e^n)} \frac{dV(e^n)}{dt} \approx -(t-\tau) f(\phi(e^n)),
$$

where the approximation is obtained because $\frac{dV(e)}{dt}$ is very small ($V(e)$ is concave enough). Similarly,

$$
\frac{dW^n}{d\tau} = (t-\tau) f(\phi(e^n)) \left(1 - \frac{dV(e^n)}{d\tau}\right) + \frac{1-\alpha}{\alpha V'(e^n)} \frac{dV(e^n)}{d\tau} \approx (t-\tau) f(\phi(e^n)).
$$

inputs. Our paper takes a different approach in examining the organizational form, which is determined by the two opposing effects associated with the hold-up problem.

[29] The results are just reversed if $t < \tau$, but the key message we want to deliver in this section does not change.

Differentiating W^v yields

$$\frac{dW^v}{dt} \approx -(t-\tau)f(\phi(e^v)) \quad \text{and} \quad \frac{dW^v}{d\tau} \approx (t-\tau)f(\phi(e^v)).$$

The above analysis immediately implies that a reduction in t (τ) always increases (decreases) the social welfare if $t > \tau$.

We now turn to the case in which the change in tariffs *alters* the firms' organizational decision. Proposition 1 indicates the presence of two possibilities for the change in the organizational outcome: (i) a reduction in t changes integration to non-integration, and (ii) a reduction in τ changes non-integration to integration. As there are many corresponding cases to analyze, let us just focus on case (i) to bring out the importance of organization in welfare analysis. In Appendix, we show that output tariff reduction leads to additional welfare gains from the resulting organizational change compared to the case when organizational change were not allowed. This finding gives the following proposition.

Proposition 2. *Suppose that $t > \tau$. An output tariff reduction (a decrease in t) always increases social welfare. An additional welfare gain occurs if the trade liberalization triggers an organizational change.*

The intuition is simple. When organizational change is not allowed, trade liberalization increases social welfare because of the conventional efficiency gain from cheaper imported widgets. However, when organizational change is allowed and the liberalization triggers the change, firms will switch to the organization that can make better use of those cheaper imported widgets.

5.5 Testable Predictions

Our theoretical framework emphasizes the importance of the hold-up problem in understanding the effects of input and output tariff changes on firms' organizational choices. Proposition 1 gives a sufficient condition under which the prediction of the theoretical model is consistent with earlier empirical findings. Although we cannot verify the validity of the condition and its applicability to China directly, in this subsection, we conduct further empirical analysis to determine whether the insight from the theoretical analysis (especially the hold-up problem) is relevant in the reality (in our data). To this end, we first derive two hypotheses.

The value of relationship-specific investment is more important in industries where goods are more differentiated. Production of differentiated goods requires differentiated inputs. In contrast, if the inputs bought from the supplier and that imported from overseas are homogenous, the buyer will simply buy from the low price source. In the latter case, the organizational decision is simple and the change in tariffs will not play an important role in determining the equilibrium outcome of the organizational form. According to Nunn (2007), if a product is sold on an organized exchange or with reference price, then its market is thick and the scope of hold-up is limited. Thus, we expect to have the following hypothesis.

Hypothesis 1. *The effects of tariff changes on firm's organizational choice are stronger in differentiated-goods industries than homogenous-goods industries.*

The hold-up problem exists because the supplier and buyer cannot write a complete contract to specify the investment level and payment. When the contract is incomplete, firms rely on *ex post* bargaining. Tariffs affect the outside option of the bargaining. Thus, the hold-up problem is more serious in an environment in which writing complete contracts is more difficult, and we have the following hypothesis.

Hypothesis 2. *The effects of tariff changes on firm's organizational choice are stronger in industries with lower contractibility.*

We conduct further empirical analysis to test the above two hypotheses.

□ **Homogenous vs. Heterogenous Industries**

Rauch (1999) classifies SITC four-digit products into three groups: goods traded on an organized exchange, goods traded with reference price, and differentiated goods. We group Rauch's classification into two types of industries: the homogenous industry, which mainly produces the first two types of goods in Rauch (1999), and the heterogenous industry, which produces differentiated goods. We match SITC four-digit products to ISIC four-digit industries based on the concordance provided by UNSTAT.[30]

[30] After the match, we have a total of 56 ISIC industries, with 27 heterogenous ones and 29 homogenous ones.

We run regressions based on Model (1) and report the results in Table 8. We first run the regression using the subsample of heterogenous industries and report the results in column (1). We then run the regression using the subsample of homogenous industries and report the results in column (2). In heterogenous industries, the effect of output tariff is significant and negative, and the effect of input tariff is significant and positive. The effects (the coefficients) are much larger than the average effects obtained in Section 4 using the full sample. In homogenous industries, the effect of output tariff is negative and significant at 10% level, and the effect of input tariff is not significant. These results support Hypothesis 1.

<Insert Table 8 here>

□ **Contractibility**

Contractibility is affected by the uncertainty of the market. The general argument for incomplete contract is that contracts cannot specify all possible contingencies that firms might face. We use the supplier's sales volatility to proxy uncertainty, and thus to represent contractibility. Higher uncertainty means lower contractibility.

We measure sales volatility by average variation (ratio of standard deviation to mean) of the supplier's annual sales in the pre-WTO period, 1998-2001. Specifically, we first calculate the mean and standard deviation of log sales for each firm during 1998-2001, based on ASIFP, to obtain the ratio of standard deviation to mean for each firm, and then take the average ratio of all firms in each industry as the proxy for sales volatility in the corresponding industry. We divide our sample into two subsamples: high volatility industries, which have sales volatility larger than the median, and low volatility industries, which have sales volatility lower than the median. We run regressions based on these two subsamples, and report the results in columns (3) and (4) of Table 8, respectively. The effects of tariffs on integration are evidently more pronounced in high-volatility industries than in low-volatility industries, which lends a support to Hypothesis 2.

6 Conclusion

International trade and industrial reorganization are inter-related. In this study, we empirically investigate the effects of tariff changes on the domestic organizational structure between the upstream and downstream industries. We utilize the tariff changes caused by China's accession to the WTO as exogenous shock and use the DID method to identify the causal effects of trade liberalization on domestic vertical integration. We show that vertical integration is more likely to occur in industries where a large reduction in tariffs on the inputs of the upstream industry has occurred, whereas a reduction in tariffs on the upstream industry's outputs reduces domestic vertical integrations. This empirical finding can be explained by a model in which vertically related firms make relationship-specific investments and trade liberalization affects their incentives for vertical integration.

Existing empirical studies in the related literature have intensively examined the effects of trade liberalization on firm performances such as productivity, product quality, innovation, and entry and exit in the domestic and foreign markets. The present paper explores a different aspect: effects of trade liberalization on domestic industry's organizational structure, similar to Ornelas and Turner (2008, 2012) and Alfaro et al. (2016). A related and important issue, which has yet to be investigated, is how the resulting changes in industrial organization in general, and vertical integration in particular, affect firm productivity, industry efficiency, and social welfare. Although these issues have been studied, they are only in the context in which industrial organizational structure is held unchanged.

7 Appendix

Proof of Proposition 2.

The case of trade liberalization not triggering organizational change has been proved in the text preceding the proposition. We focus on the case trade liberalization triggering organizational change here.

Let (t_1, τ_1) be the original tariff levels with $t_1 > \tau_1$. τ_1 is fixed and thus we express e, U and W as functions of t only. There exists a t^*, which is determined by $U^v(t^*) - K = U^n(t^*)$, at which firms are indifferent between non-integration and vertical integration. We can adjust the level of K such that $\tau_1 < t^* < t_1$. Then, firms choose vertical integration at tariff t_1, and a trade liberalization from t_1 to t_2, where $\tau_1 < t_2 < t^*$, will trigger organizational change from vertical integration to non-integration.

Suppose that organizational change were not allowed under trade liberalization. Then, the welfare would change from $W^v(t_1)$ to $W^v(t_2)$, and $W^v(t_2) > W^v(t_1)$ because $\frac{dW^v}{dt} < 0$. The increase in welfare is due to efficiency gains from cheaper imported widgets.

When organizational change is allowed, the welfare changes from $W^v(t_1)$ to $W^n(t_2)$. By definition, $W^v(t) - W^n(t) = \Delta U(t) - K - (t - \tau_1)(F(\phi^o) - F(\phi^v))$. Note that $\Delta U(t_2) - K < 0$ because firms prefer non-integration to vertical integration at $t_2 < t^*$. Note as well that $-(t_2 - \tau_1)(F(\phi^o) - F(\phi^v)) < 0$ because $t_2 > \tau_1$. Hence, $W^v(t_2) < W^n(t_2)$.

Thus, we obtain $W^v(t_1) < W^v(t_2) < W^n(t_2)$. $W^n(t_2) - W^v(t_2)$ is the additional gain from the organizational change after trade liberalization.

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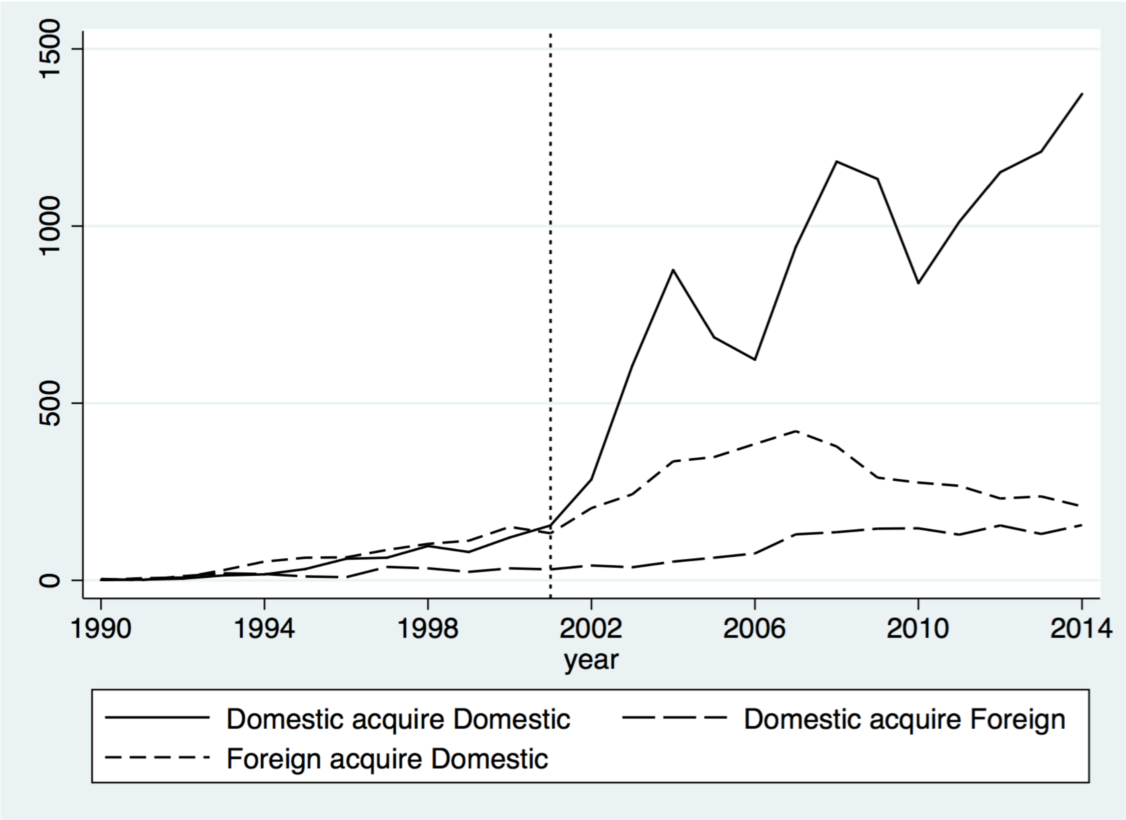
Figure 1: Domestic and Cross-border M&As Related with China



Note: M&As are calculated based on the number of each type of M&As.

Figure 2: China's Output and Input Tariffs: 1998-2007

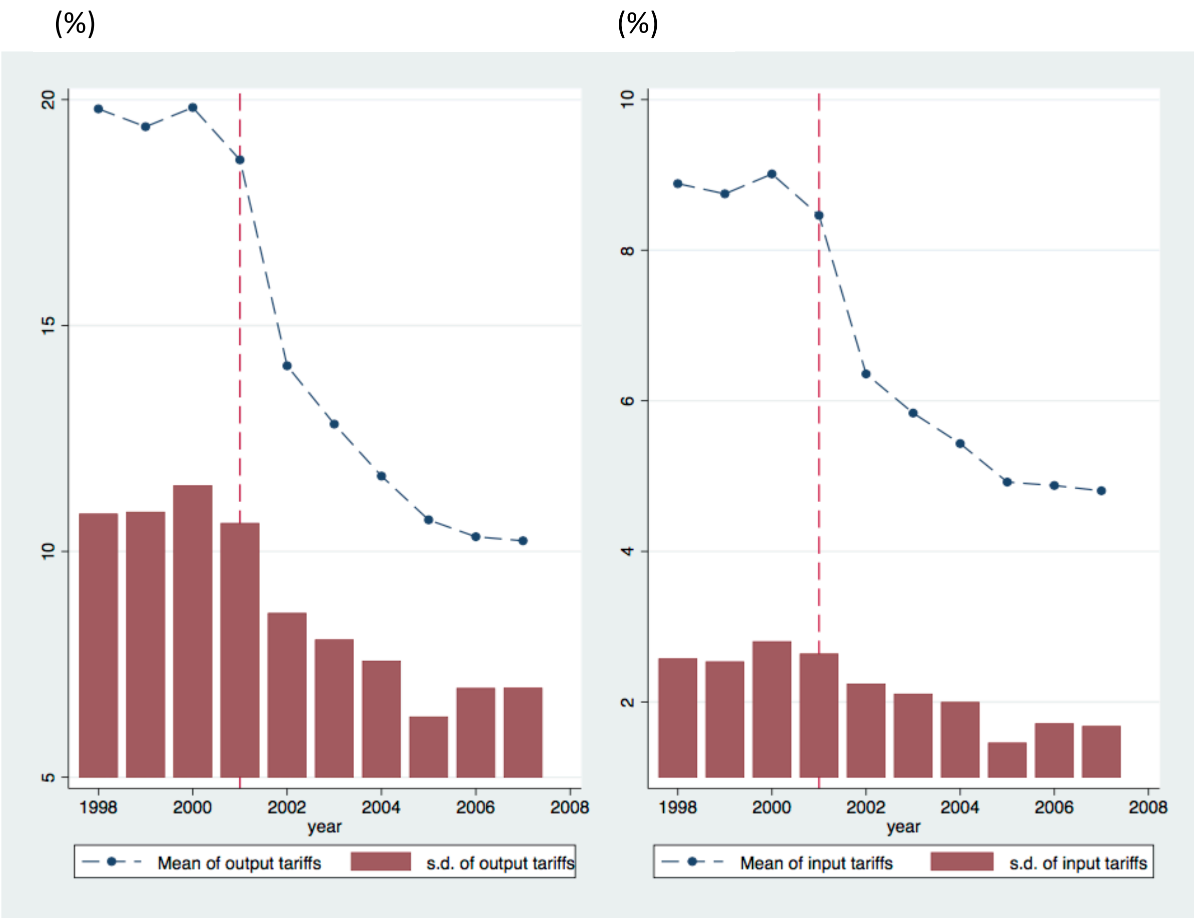


Figure 3: Initial Tariffs and Tariff Reductions across Industries

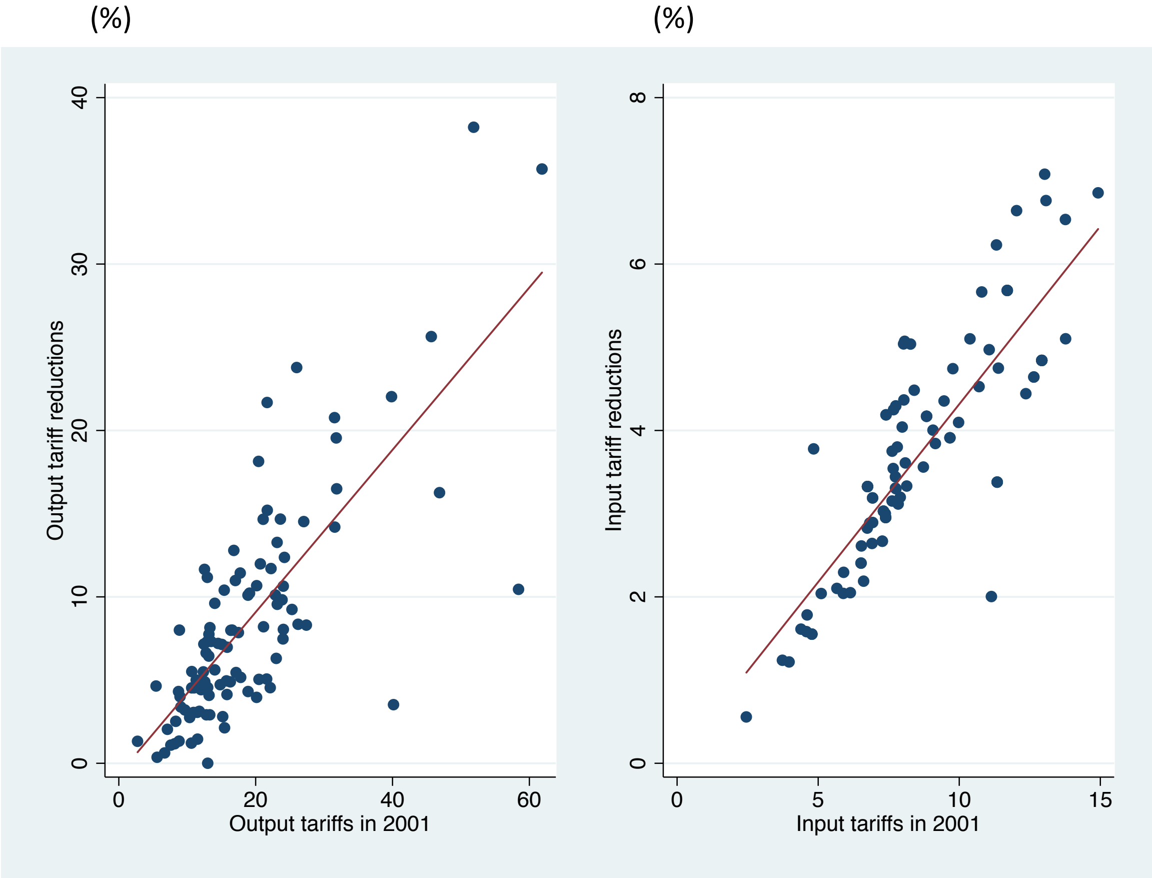
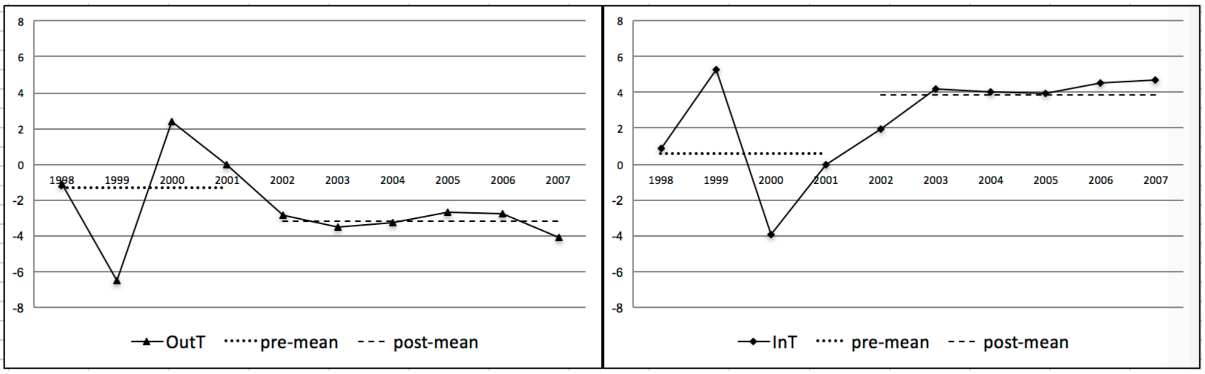


Figure 4: Flexible Estimation



(a) Output tariffs (b) Input tariffs

Figure 5: Timing of the Game

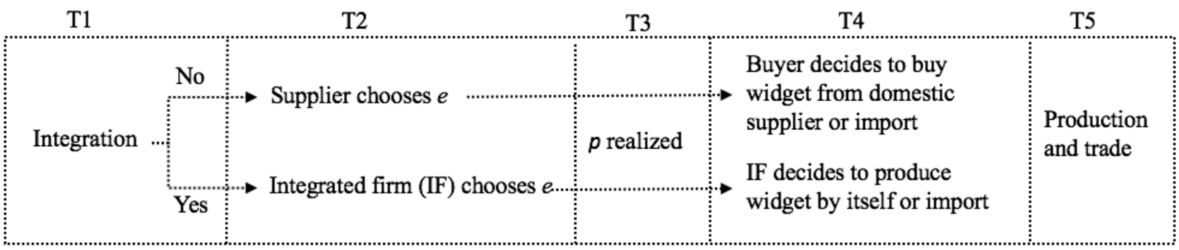


Table 1: Counts of Completed M&As in China

year	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
M&A	0	1	0	0	1	2	5	15	17	37	63
year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
M&A	65	100	82	125	162	294	640	926	718	645	969

Note: Authors' calculation based on Thomson Reuters SDC Platinum database.

Table 2: Correlation between Tariffs and Pre-WTO Industry Performance

	(1)	(2)	(3)	(4)	(5)
Variables	VI	Sales	Domestic firms' sales	Value added per capita	K/L
OutT01	0.0051	-0.0025	0.0005	0.0036	0.0066
	(0.0079)	(0.0029)	(0.0037)	(0.0050)	(0.0075)
InT01	0.0240	-0.0104	-0.0132	0.0102	0.0144
	(0.0355)	(0.0100)	(0.0113)	(0.0180)	(0.0177)
N	102	102	102	102	102
	(6)	(7)	(8)	(9)	(10)
ΔOutT	0.0004	0.0006	0.0064	0.0021	0.0100
	(0.0059)	(0.0046)	(0.0055)	(0.0084)	(0.0106)
ΔInT	0.0695	-0.0060	-0.0238	0.0222	0.0286
	(0.0750)	(0.0229)	(0.0217)	(0.0336)	(0.0328)
N	102	102	102	102	102

Note: The dependent variable in each column is the growth rate of the corresponding industry performance during 1998-2001. Robust standard errors clustered at ISIC four-digit industry.

Table 3: Backward Vertical Integrations and Tariffs in Target Industries, 1998-2007

		Backward Vertical Integrations				Output Tariffs			Input Tariffs		
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
ISIC2	Industry	All	Pre	Post	ΔN	OutT01	OutT07	ΔOutT	InT01	InT07	ΔInT
15	food products and beverages	15	3	12	9	33.19	17.35	15.83	12.75	7.61	5.14
17	textiles	14	1	13	12	21.85	10.02	11.84	10.71	5.53	5.17
19	leather and leather products	9	0	9	9	18.88	12.63	6.24	10.89	7.27	3.62
20	wood and wood products	3	0	3	3	13.25	5.01	8.24	6.95	3.60	3.35
21	paper and paper products	6	1	5	4	16.76	5.86	10.91	7.86	3.55	4.31
23	coke and petroleum products	28	3	25	22	6.61	5.88	0.72	3.65	1.48	2.17
24	chemicals and chemical products	156	9	147	138	13.12	7.17	5.95	7.02	4.14	2.88
25	rubber and plastics products	8	2	6	4	16.56	11.24	5.31	8.00	4.77	3.23
26	other non-metallic mineral products	18	1	17	16	18.03	11.59	6.44	4.95	3.22	1.73
27	basic metals	35	5	30	25	8.09	5.38	2.71	3.85	2.63	1.23
28	fabricated metal products	10	1	9	8	14.56	9.74	4.82	6.96	4.32	2.64
29	machinery and equipment	106	7	99	92	13.59	8.14	5.45	7.32	4.26	3.06
30	office, accounting and computing machinery	4	0	4	4	12.94	1.77	11.17	8.03	2.99	5.04
31	electrical machinery and apparatus	60	2	58	56	14.95	8.44	6.51	7.43	4.34	3.09
32	radio, television, communication equipment	51	3	48	45	14.76	4.84	9.92	8.00	3.45	4.55
33	medical, precision and optical instruments	20	5	15	10	12.88	8.11	4.77	7.28	3.76	3.52
34	motor vehicles, trailers and semi-trailers	5	0	5	5	28.87	12.22	16.66	11.20	5.37	5.83
35	other transport equipment	1	0	1	1	17.02	15.02	2.00	9.09	5.41	3.67
36	furniture; manufacturing n.e.c.	7	1	6	5	20.26	9.95	10.31	8.42	4.50	3.92

Note: Columns (1)-(4) show the total number of backward vertical integrations in the targets' industries. Column (1) is the count of the whole sample period, 1998-2007; (2) is the count of the pre-WTO period, 1998-2001; (3) is the count of the post-WTO period, 2002-2007; (4) is the difference between the two sub-periods, (4)=(3)-(2). Columns (5)-(7) show the simple average output tariffs, with (5) for output tariffs in 2001, (6) for output tariffs in 2007 and (7) for the difference. Columns (8)-(9) are input tariffs in 2001 and 2007, respectively, and column (10) is the difference between (8) and (9).

Table 4: Basic Results

	(1)	(2)	(3)	(4)	(5)
WTO • OutT01	-2.0530***	-2.0083***	-1.9408**	-1.9214**	-1.9005**
	(0.7768)	(0.7441)	(0.7593)	(0.7531)	(0.7447)
WTO • InT01	2.7312***	2.5687***	2.5675***	2.5324***	2.5085***
	(0.9370)	(0.9559)	(0.9564)	(0.9497)	(0.9326)
logAge		-1.4531***	-1.2212	-1.2388	-1.2447
		(0.5575)	(0.7628)	(0.7701)	(0.7657)
logN			0.2133	0.2418	0.2132
			(0.4487)	(0.4722)	(0.4586)
HHI				1.8905	1.0824
				(5.0086)	(4.8627)
India&BrazilVI					0.0319**
					(0.0161)
Industry FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
N	580	580	580	580	580

Note: Robust standard errors clustered at ISIC four-digit industry. * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

Table 5: Validity

	(1) Expectation	(2) Industry Trend	(3) Placebo
WTO • OutT01	-1.6433**	-2.8787***	
	(0.7403)	(0.8203)	
WTO • InT01	2.4161**	4.1566**	
	(1.0691)	(1.7494)	
y2001 • OutT01	0.6117		
	(1.2543)		
y2001 • InT01	-0.1864		
	(1.9967)		
OutT			2.3937
			(6.1665)
InT			-2.4991
			(8.1819)
Controls	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
N	580	580	92

Note: Robust standard errors clustered at ISIC four-digit industry. * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$. Controls include logAge, logN, HHI, and India&BrazilVI.

Table 6: Robustness

	(1) SOE&FDI Reforms	(2) Subsidy	(3) Entry Regulation	(4) Unlisted	(5) Exports	(6) Foreign Tariff	(7) RCA	(8) Downstream Tariff	(9) TFP	(10) All
WTO • OutT01	-1.8315**	-1.8991**	-1.9008**	-2.2895***	-1.8881**	-1.9224**	-1.7280**	-2.0298***	-1.8082**	-1.7806**
	(0.8140)	(0.7633)	(0.7487)	(0.8681)	(0.7452)	(0.7518)	(0.7667)	(0.7195)	(0.7605)	(0.8253)
WTO • InT01	2.1948**	2.4644***	2.4736***	2.5585**	2.4793***	2.5270***	2.1839**	2.6958***	2.3667**	1.9905*
	(1.1128)	(0.9442)	(0.9563)	(1.1893)	(0.9448)	(0.9390)	(1.0631)	(0.9055)	(0.9613)	(1.1620)
SOEShare	3.7679*									3.1862
	(2.2866)									(2.4370)
FIEShare	-2.6037									-2.8013
	(4.0147)									(4.7325)
Subsidy		0.1885								0.1754
		(0.1281)								(0.1426)
NonSOE_Entry			-0.1537							-0.1905
			(0.3028)							(0.3404)
Export					0.0587					-0.0359
					(0.1683)					(0.1587)
ForeignTariff						0.0969				0.1168
						(0.6169)				(0.6123)
RCA							0.6295			0.7121
							(0.5820)			(0.6510)
WTO • DownT01								-0.4367		-0.4052
								(0.2833)		(0.2948)
TFP									0.5887	0.2652
									(0.6013)	(0.7020)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	580	580	580	490	580	580	580	580	580	580

Note: Robust standard errors clustered at ISIC four-digit industry. * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$. Controls include logAge, logN, HHI, and India&BrazilVI.

Table 7: Different Measures and Estimation Methods

	(1) Value	(2) New VI	(3) PPML	(4) RE_Poisson	(5) FE_NB	(6) Tobit	(7) Two-Period
WTO • OutT01	-2.5338**	-1.3282***	-1.9005**	-1.5594**	-1.6926**	-1.3503***	-1.7618**
	(1.2045)	(0.7512)	(0.7512)	(0.7256)	(0.7427)	(0.4129)	(0.7398)
WTO • InT01	4.1696**	1.1537***	2.5085***	2.1270***	2.3047**	1.5701**	2.4900**
	(1.9133)	(0.9407)	(0.9407)	(0.8081)	(1.0126)	(0.6182)	(0.9998)
logAge	-0.3096	-1.2778***	-1.2447	-0.2691	-1.1080	-0.5229	-1.4691
	(2.1441)	(0.0019)	(0.7723)	(0.9728)	(0.8347)	(0.6533)	(1.2696)
logN	0.3284	-1.1957***	0.2132	0.2015	0.0417	-0.0806	0.7628
	(1.1874)	(0.0005)	(0.4626)	(0.2326)	(0.3921)	(0.3644)	(0.7539)
HHI	-24.9821	-6.2594***	1.0824	-2.6587	-0.4175	-4.8055	-4.4161
	(18.0032)	(0.1598)	(4.9052)	(9.1373)	(6.2971)	(3.2230)	(18.9078)
India&BrazilVI	-0.0260	0.0384***	0.0319**	0.0567	0.0353	0.0411	-0.3531*
	(0.0968)	(0.0015)	(0.0162)	(0.0693)	(0.0247)	(0.0274)	(0.1855)
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	1020	1020	580	1020	580	1020	116

Note: Robust standard errors clustered at ISIC four-digit industry. * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

Table 8: Tests of the Hypotheses

	(1) Differentiated	(2) Homogenous	(3) High Volatility	(4) Low Volatility
WTO • OutT01	-3.390**	-1.649*	-3.218***	-1.749**
	(1.483)	(0.912)	(0.947)	(0.833)
WTO • InT01	7.899***	1.398	3.872***	-0.813
	(2.956)	(1.377)	(1.492)	(1.596)
SOEShare	9.533***	5.726	7.431	4.163
	(3.013)	(4.024)	(5.847)	(2.669)
FIEShare	-0.516	-7.723	22.89**	-7.537
	(5.461)	(8.914)	(11.21)	(6.032)
Subsidy	192.1***	22.17	57.41	175.7**
	(70.73)	(37.89)	(39.87)	(73.54)
NonSOE_Entry	-0.471**	0.230	0.0508	-0.337
	(0.200)	(0.287)	(0.273)	(0.254)
Export	-0.148	0.266	-0.166	0.115
	(0.292)	(0.387)	(0.479)	(0.174)
ForeignTariff	2.651	-0.178	0.217	1.670
	(1.703)	(0.715)	(0.932)	(1.171)
RCA	2.401**	-0.445	0.217	0.921
	(0.988)	(1.251)	(1.325)	(0.778)
WTO • DownT01	0.415	-0.576	-1.035	0.190
	(0.447)	(0.463)	(0.934)	(0.367)
TFP	1.261	1.125	0.787	0.330
	(1.008)	(1.326)	(1.350)	(0.874)
Controls	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
N	270	290	290	290

Note: Robust standard errors clustered at ISIC four-digit industry. * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$. Controls include logAge, logN, HHI, and India&BrazilVI.