

Do Prices Determine Vertical Integration? Evidence from Trade Policy*

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Abstract

This paper shows that product prices determine organizational design by studying how trade policy affects vertical integration. Property rights theory asserts that firm boundaries are chosen by stakeholders to mediate organizational goals (e.g., profits) and private benefits (e.g., operating in preferred ways). We present an incomplete-contracts model in which vertical integration raises output at the expense of lower private benefits. A key implication is that higher prices should result in more integration, since the organizational goal becomes relatively more valuable than private benefits. Trade policy provides a source of exogenous price variation to test this proposition: higher tariffs should lead to more vertical integration; moreover, ownership structures should be more alike across countries with similar levels of protection. To assess the evidence, we construct firm-level indices of vertical integration for a large set of countries and industries and exploit cross-section and time-series variation in import tariffs to examine the impact of prices on organizational choices. Our empirical results provide strong support for the predictions of the model.

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1 Introduction

What determines firm boundaries? How many links in a supply chain are to be integrated into a single firm? Answering these questions has been a fundamental concern of organization economics since Coase's (1937)'s seminal paper. As emphasized by the modern theory of the firm (Grossman and Hart 1986, Hart and Moore, 1990, Holmström and Milgrom 1991), firm boundaries affect incentives and therefore are likely to have significant productivity impacts on individual firms. More recently, these firm-level effects have been shown theoretically to have implications for industry performance as well (Legros and Newman, 2009). Thus, an understanding of the determinants of vertical integration has implications far beyond the boundaries of organizational economics.

In incomplete contracts models, property rights over assets, which define firm boundaries and determine allocations of control over production decisions, are chosen to mediate how a firm's stakeholders trade off collective goals and private interests. Recent theoretical work has embedded these models into market settings to study how firms' boundary choices are affected by market conditions. In particular, market thickness, demand elasticities, and terms of trade in supplier markets may have an impact on firms' vertical integration decisions (e.g., McLaren, 2000; Grossman and Helpman, 2002; Legros and Newman, 2008). So far, evidence on the importance of these factors is sparse.

In this paper, we exploit variation in the degree of trade protection faced by firms to show that market conditions — in particular the level of product prices — do matter for vertical integration. The reason for this predicted result is that managers of the organization not only have a stake in the organizational goal, but also derive private, non-contractible benefits. When the organization is not integrated, managers heading its different units act independently, taking heavy account of their private benefits, which leads non-contractible production decisions that do not favor output. Integration puts more decisions in the hands of a single decision maker with strong incentives to coordinate, so as to maximize benefits to the organization. Low levels of integration are thus associated with high private benefits and low productivity, higher levels with high production and productivity but also high private costs. Market price enters the tradeoff because it directly affects the organization's profit objective, but has a negligible impact on managers' private costs. As the market price rises, the tradeoff is resolved in favor of more integration, since the organizational goal is relatively more valuable than private goals.

The straightforward empirical strategy to verify whether product prices and the degree of vertical integration are positively correlated, as suggested by this organizational theory, would be to regress some measure of vertical integration on industry prices. The main difficulty with this approach is that it would not allow us to clearly distinguish the organizational model we have outlined, in which higher prices lead to more integration, from models that predict the same positive correlation, but with causality going the opposite way. According to these “market-foreclosure”

theories, in imperfectly competitive industries, firms may integrate with their suppliers to reduce competition with their rivals, thus pushing product prices higher.¹ Testing whether product prices affect organization design thus requires an exogenous source of price variation.

In this respect, trade policy provides an ideal proving ground: the degree of trade protection obviously affects equilibrium prices, but is unlikely to be influenced by firms' vertical integration decisions. The main prediction of our theory is that import tariffs, by increasing product prices in the domestic market, should lead to more vertical integration. This effect should be stronger for firms that operate only in the domestic market, since their organizational objectives depend exclusively on domestic prices; in contrast, exporters and multinational firms should be less affected, since their decisions are also affected by prices in foreign markets. Moreover, the effect of tariffs on organization should be stronger in sectors where product prices are more sensitive to tariffs.

We examine the organizational effects of applied Most-Favored-Nation (MFN) tariffs. Under the MFN principle set out in the first article of the General Agreement on Tariffs and Trade (GATT), member countries agree not to discriminate between their trading partners (with the exception of regional trading partners and developing countries). MFN tariffs are the results of long-term multilateral trade negotiations, in which GATT/WTO members commit not to exceed certain tariff rates; if a member raises its MFN tariffs above the agreed bound level, other members can take it to dispute settlement. As a result, MFN tariffs are less responsive to domestic political pressure than administrative measures for the regulation of imports, such as anti-dumping and countervailing duties (e.g., Finger *et al.*, 1982).² In our main empirical analysis, we exploit cross-sectoral and cross-country variation in MFN tariffs applied in 2004 to study the impact of product prices on firm-level vertical integration.³ Reverse causality is unlikely to be a concern for our analysis, since the MFN tariffs faced by firms in 2004 were determined during the Uruguay Round of multilateral trade negotiations (1986-1994).⁴

To study firm organization across a wide range of countries, we use the WorldBase dataset from Dun and Bradstreet (D&B), which contains both listed and unlisted plant-level observations for a large set of countries and territories. For each plant, the dataset includes information about its different production activities at the 4-digit SIC level, as well as about ownership (e.g., its domestic or global parent). To measure vertical integration, we follow the methodology

¹See Salinger (1988) for an early contribution and Rey and Tirole (2007) for a survey.

²This is one of the reasons why empirical papers on the political economy of trade policy use of coverage ratios of non-tariff barriers (NTB) rather than MFN tariffs to test lobbying models (e.g., Goldberg and Maggi, 1999; Bombardini, 2008).

³MFN tariffs vary substantially both across sectors within countries and across countries for a given sector. For example, U.S. manufacturing tariffs in 2004 averaged 2.4 percent, with a minimum of zero and a maximum of 350 percent. As an example of cross-country variation, for a sector like SIC 3631 (Household Cooking Equipment), MFN tariffs varied between zero and 29 percent, with an average of 3.15 percent.

⁴Since the Uruguay Round, GATT/WTO members have not changed their MFN tariff bounds. Applied rates have changed little over time, since they coincide with the bound rates for most countries and sectors (see www.wto.org).

developed by Fan and Lang (2000) and Acemoglu, Johnson and Mitton (2009). By combining information on firms' production activities with input-output tables, we construct firm-level vertical integration indices that measure the fraction of inputs used in the production of a firm's final good that can be produced in house. In our main empirical analysis, we focus on firms that are located in only one country. These provide a cleaner analysis of the effects of tariffs on firms' ownership structure, since their vertical integration decisions should depend only on domestic prices. In the case of multinational corporations, on the other hand, it is harder to identify the relevant prices and tariffs. Moreover, focusing on national firms avoids issues having to do with the strategic behavior of multinationals across markets (e.g., transfer pricing, tariff jumping, export platforms).

Our empirical analysis provides strong support for the predictions of the model. We find that, the higher is the MFN tariff applied by a country on the imports of a given product, the more vertically integrated are the firms producing that product in that country. The effect is larger when we would expect organizational decisions to be more responsive to import tariffs, i.e., for firms that only serve the domestic market and in sectors in which MFN tariffs have a larger impact on domestic prices. Our results are robust to constructing vertical integration indices in different ways, including standard determinants of firm boundaries, using alternative econometric methodologies, and focusing on different samples of firms and countries.

In terms of magnitude, in our baseline estimation, a 100 percent tariff increase leads to a 2.15 percent increase in the vertical integration index, implying that increasing tariffs from 1 percent to their mean level of around 5 percent would increase vertical integration by more than 8 percent. Notice, however, that our estimates should be interpreted as a lower bound on the impact of prices on vertical integration, since domestic prices do not fully adjust to tariff changes.⁵ The true impact is likely to be substantially larger.⁶

In our theory, in which firms are price takers, import tariffs affect firms' organization only through their effect on domestic prices. However, tariffs may also have an impact on the degree of competition faced by domestic firms, which may also shape vertical integration decisions (Aghion, Griffith, and Howitt, 2006). To isolate the effect of product prices, we restrict our analysis to highly competitive sectors, in which tariffs will have little or no effect on the degree of competition, obtaining even stronger results.

To establish a causal link between tariffs and vertical integration, we also show that our results are not driven by omitted variables, which might be correlated with both vertical integration decisions and MFN tariffs. First, large firms or concentrated industries could be more effective at

⁵In the case of ad valorem tariffs, domestic prices will vary by less than the tariff. Tariff pass-through may also be attenuated if firms have market power and adjust their markups. Finally, to the extent that a country is large, i.e., can affect world prices, imposing a tariff will have an impact on the world price and the elasticity of domestic prices with respect to tariffs will also be less than one.

⁶To get a sense of the magnitude of the effects of prices on organization, one would ideally instrument prices with MFN tariffs; however, this would require comparable cross country data on domestic prices, which are very difficult to obtain (see Bradford, 2003).

lobbying for protection and may also be more vertically integrated. Second, tariffs that exporters face in other markets or tariffs on imported inputs are likely to be correlated with tariffs on final products and may also affect firms' organization decisions. Our results are unaffected when including these controls in our analysis.

An alternative strategy to verify the impact of trade policy on firm boundaries is to focus on trade liberalization reforms — major unilateral or multilateral liberalization episodes, or the creation of regional trade agreements — thus exploiting time variation in the degree of protectionism faced by firms. The challenge with implementing this strategy is data availability, since we can only construct firm-level vertical integration measures for recent years, during which there have been few trade liberalization reforms.⁷ The only major trade liberalization episode that has occurred in recent years is arguably the entry of China into the WTO in 2001: to be accepted as a WTO member, China had to undertake a series of important tariff reductions so as to substantially expand market access for goods from foreign countries. We examine the organizational effects of these trade policy changes, comparing the ownership structure of Chinese firms before and after WTO accession (in 1999 and 2007). Consistent with the predictions of our theoretical model, we find that firm-level vertical integration has fallen more in sectors that have experienced larger tariff cuts.

We also study the effect of trade policy on the degree of organizational convergence across countries. Our theory suggests that countries with similar domestic price levels should have firms with similar ownership structures. In line with this prediction, we show that differences in vertical integration across countries are significantly larger in sectors in which differences in MFN tariffs (and therefore differences in domestic prices) are larger. Moreover, we find that differences in vertical integration indices are smaller for country pairs engaged in regional trade agreements.⁸ This effect is stronger for customs unions, which impose common external tariffs vis-à-vis non-members and should thus be characterized by stronger price convergence.

Our paper contributes to a recent stream of empirical work that examines the determinants of firms' vertical integration decisions (i.e., firm boundaries/ownership structure). Some studies focus on single industries. These include the seminal papers by Stuckey (1983) on integration between aluminium refineries and bauxite mines and Joskow (1987) on ownership arrangements in electricity generating plants, as well as the more recent studies by Baker and Hubbard (2003, 2004) on the trucking industry, Woodruff (2002) on Mexican footwear. More closely related to our analysis is the paper by Hortaçsu and Syverson (2007) on vertical integration in the U.S. cement industry, which examine whether vertical integration leads to higher prices. In contrast with the

⁷Important trade liberalization episodes, such as the conclusion of the Uruguay Round of GATT/WTO trade negotiations, the North American Free Trade Agreement (NAFTA), or the free trade agreements between Eastern European countries and the European Community, all occurred in the early or mid-nineties.

⁸As mentioned above, under Article I of the GATT, countries have to apply the same MFN tariff to all trading partners. Preferential treatment can only be granted to partners in regional trade agreements (Article XXIV of the GATT) or to developing countries (in the context of the Generalized System of Preferences (GSP) allowed by the Enabling Clause).

predictions of market foreclosure theories, they find that prices fall when markets become more integrated. The focus of our analysis is on the opposite direction of causality, i.e., the impact of product prices on vertical integration decisions. Other studies have focused on a single country. For example, Acemoglu, Aghion, Griffith and Zilibotti (2010) use data on British manufacturing plants to study the relationship between vertical integration and rates of innovation. Aghion, Griffith and Howitt (2006) investigate whether the propensity for firms to vertically integrate varies systematically with the extent of competition in the product market. In terms of data and methodology, our analysis is closely related to the paper by Acemoglu, Johnson and Mitton (2009), who study the determinants of vertical integration using a cross-section of D&B data for 93 countries, focusing on the role of financial development and contracting costs. Ours is the first paper to examine how product prices affect integration decisions.

Another stream of the literature has not focused on vertical integration decisions, but rather on other aspects of organization, such as management practices or the degree of delegation within firms. Bloom and Van Reenen (2007) study managerial practices in medium-sized manufacturing firms in the US and Europe (France, Germany and the UK), finding that best practices are strongly associated with superior firm performance. Bloom, Sadun and Van Reenen (2010), using survey data on medium-sized manufacturing firms across a dozen countries, find that greater product market competition increases decentralization. Bloom, Sadun and Van Reenen (2012) collect data on the decentralization of investment, hiring, production, and sales decisions for almost 4,000 firms in the United States, Europe, and Asia, finding that firms headquartered in high trust regions are more likely to decentralize. Marin and Verdier (2008) show that, at intermediate levels of competition, the CEO of the corporation delegates control to lower levels of the firm's hierarchy. Guadalupe and Wulf (2010) show that the 1989 Canada-United States Free Trade Agreement (CUSFTA) led large U.S. firms to flatten their hierarchies.

Finally, various papers examine whether goods are sold within or across firm boundaries in the global economy, focusing mostly on the importance of contract enforcement and relationship-specific investments (e.g., Antras, 2003; Nunn, 2007). In this literature, only a few papers have considered the role of trade policy. These include Ornelas and Turner (2008), which examines the impact of tariffs on suppliers' hold-up incentives, Conconi, Legros and Newman (2012), which examines how the liberalization of product and factor markets affects the ownership structure of firms, and Antras and Staiger (2012), which studies the trade policy implications of the offshoring of intermediate inputs. This is the first paper to examine how tariffs affect vertical integration decisions through their impact on product prices.

The rest of the paper is organized as follows. Section 2 presents a theoretical framework to guide our empirical analysis. Section 3 describes our data. Section 4 presents our main results on tariffs and vertical integration, including both cross-sectional and time series evidence. Section 5 analyzes the impact of trade policy on the degree of cross-country organizational convergence. The last section concludes.

2 Theoretical framework

In what follows, we describe a simple theoretical framework to guide our empirical analysis. This is meant to capture the features of a class of organizational models in which vertical integration decisions mediate how a firm’s stakeholders trade off their pecuniary stake in the organizational goal against their private interests.

We adapt the model by Legros and Newman (2009), inspired by Hart and Holmström (2010), in which managers of different production units trade off the benefits of coordinating production decisions against the cost of accommodating to common ways of doing things. A feature of this model is that vertical integration generates more output than non-integration, but imposes a fixed cost on managers, who lose the ability to operate in their preferred ways. For simplicity, in the simple version of the model described below, there are only two inputs of production, so vertical integration is a dichotomous choice. The analysis can be generalized to a setting with N inputs, in which stakeholders choose the optimal degree of integration.

Setup

We consider a perfectly competitive industry populated by “organizational” rather than “neo-classical” firms. Production requires certain non-contractible decisions that are undertaken by managers running different supplier units, whose interests are imperfectly aligned with each other and with the goal of the enterprise; the choice of ownership structure helps to govern the tradeoff between the managers’ organizational and private goals. The general property of this model is that vertical integration generates more output than non-integration, but involves higher (fixed) costs for the managers. As a result, the price of output helps determine firm boundary decisions; since tariffs affect output prices, they also influence firm boundaries.

Demand for that good is given by $D(p)$ (consumers have quasi-linear utility), where p is the industry price. Production of the good requires the cooperation of two types of input suppliers, denoted A and B . B suppliers generate no value without being matched with an A ; A suppliers can either match with a B or engage in stand-alone production of a numeraire good, the price of which is normalized to 1. Many interpretations of the A and B firms are possible. For example, A suppliers may represent light assembly plants or basic inputs, such as energy, or various business services (e.g., IT, retailing, logistics) that can be used to produce basic consumer goods or combined with other inputs (B suppliers) to produce more complex goods.

All goods are sold under conditions of perfect competition. There is a continuum of each type of supplier, with a measure $n < 1$ of B ’s, and a unit measure of A ’s. Since the aggregate supply of A ’s exceeds that of the B ’s, a positive amount of numeraire is produced in equilibrium.

An equilibrium in the supplier market consists of a stable match between each B supplier and an A supplier: given the surplus allocation among all the suppliers, no (A, B) pair can form an enterprise that generates higher than equilibrium payoffs for each partner. All A suppliers

are equally productive when matched with one of the B 's. A stand-alone A produces α units of the numeraire good. Since the price of the numeraire is equal to unity, this also pins down the equilibrium payoff for all A 's.⁹

Individual enterprises

We adopt a simple model of firm boundaries based on a tradeoff between the pecuniary benefits of coordinating production decisions and managers' private benefits of operating in their preferred ways. As in Grossman and Hart (1986), integration and non-integration *both* suffer from incentive costs. However, in the framework described below, these emerge in a particularly tractable way: integration, though more productive because of better coordination, imposes a fixed cost on managers, by forcing them to adopt a common "compromise" solution.¹⁰

Once an enterprise composed of an A and a B has formed in the supplier market, a non-contractible decision (e.g., choosing compatible technologies, deciding on marketing campaigns) about the way in which production is to be carried out must be made by each unit. Denote the A and B decisions respectively by $a \in [0, 1]$ and $b \in [0, 1]$. Successful production requires coordination between the two suppliers. More precisely, the enterprise will succeed with a probability $1 - (a - b)^2$, in which case it generates $R > 0$ units of output; otherwise it fails, yielding 0. Output realizations are independent across enterprises (A - B pairs). We allow R to vary across enterprises, so it can be interpreted as some measure of enterprise-specific productivity.

Managers are risk-neutral and bear a private cost of implementing the decision made by their units. The A manager's utility is $y_A - (1 - a)^2$, the B manager's is $y_B - b^2$, where $y_A, y_B \geq 0$ are their respective incomes and $(1 - a)^2$ and b^2 are their costs. Though both managers of the A and B units enjoy monetary returns, they view their operations differently: A 's most preferred action is 1, while B 's is 0. For instance, a standardized production line could be convenient for A suppliers, but may not fit the specific design needs of the B suppliers. Because managers' primary function is to implement decisions and convince their workforces to comply, they bear the cost of decisions even if they don't make them.

Assignment of decision rights via possible sale of assets is the organizational design problem in the model. Managers may remain *non-integrated* and retain control over their respective decisions. Or they can choose to *integrate* into a single firm by engaging a headquarters (HQ), transferring to it, in exchange for an acquisition fee, a share of the realized revenue and the power to decide a and b . HQ is motivated only by monetary considerations (the desire to maximize the integrated firm's income) and incurs no costs for operating in a particular way.

⁹See Conconi, Legros and Newman (2011) for a more general setup, in which the outside option of A suppliers is endogenously determined

¹⁰It is this feature that leads to the main comparative static for our empirical investigation: at low prices, revenues are small enough that managers are more concerned with their private benefits and remain non-integrated; at higher prices, output is more valuable, so managers prefer vertical integration.

Before production, B managers match with A managers and sign contracts specifying an ownership structure and payment scheme. For simplicity, we take the payment scheme to be a fixed payment T from B to A . Because A 's are in excess supply, they must all receive α in equilibrium. Thus T will just cover A 's anticipated private cost of production together with the opportunity cost α .¹¹

For each match (A,B) , total revenue in event of success is given by the number of units produced, R , times the product market price, p , which is taken as given and correctly anticipated when managers and HQ's sign the contracts and make their decisions. After contracts are signed, managers and HQ's make their production decisions, output is realized, product is sold, and revenue shares are distributed.

Integration

HQ's are elastically supplied at a cost normalized to zero. After paying its acquisition fee and receiving its compensating share of revenue, an HQ's payoff is proportional to $(1 - (a - b)^2)Rp$.¹² HQs decide both a and b , and since their incentive is to maximize the integrated firms' expected revenue, they choose $a = b$. Among the choices in which $a = b$, the Pareto-dominant one is that in which $a = b = 1/2$, which minimizes the total cost of the A and B managers. We assume HQs implement this choice. The private cost to each manager is then $\frac{1}{4}$, and the payoffs to the A and B managers are equal to α and $Rp - \alpha - \frac{1}{2}$, respectively (thus $T = \alpha + \frac{1}{4}$).

Non-integration

Under non-integration, managers retain control of their respective activities. The decisions chosen are the (unique) Nash equilibrium of the game with payoffs $T - (1 - a)^2$ for A , who chooses a , and $(1 - (a - b)^2)Rp - b^2 - T$ for B , who chooses b . Nash decisions are $a = 1$ and $b = Rp/(1 + Rp)$, with resulting expected output $1 - \frac{1}{(1+Rp)^2}$. Notice that output increases with price: as p becomes larger, the revenue motive becomes more important for B managers, pushing them to better coordinate with their A partners. The equilibrium transfer from B to A under non-integration is $T = \alpha$; the payoffs are α for A 's and $\frac{(Rp)^2}{1+Rp} - \alpha$ for B 's.

Choice of ownership structure

To determine managers' choice of firm boundaries, we must compare their payoffs under integration and non-integration. Notice that A suppliers obtain α in both cases, so they are indifferent

¹¹In general, B may prefer to give A a positive contingent share of revenue. This complicates notation but does not change any qualitative conclusion regarding the dependence of integration on price (see Legros and Newman, 2009).

¹²The size of HQ's share is indeterminate and could be pinned down in many ways not modeled here; all that matters for our purposes is that it is positive. In fact, an HQ with control over a and b would never accept a zero revenue share: she could always renegotiate to something positive. See Legros-Newman (2012).

about the organizational choice. B suppliers obtain a higher payoff under integration if and only if $Rp - \frac{1}{2} > \frac{(Rp)^2}{1+Rp}$ or $p > 1/R$. Thus managers' organizational choices depend on product prices. At low prices, revenues are small enough that integration's better output performance is not valuable enough to the B to be worth the private cost he would have to bear; thus, B opts for the "quiet life" of non-integration, wherein both profits and costs are low. At higher prices, the B manager's revenue motive now makes higher output and therefore coordination more valuable. Coordinating under non-integration would entail large and costly concessions from B to A , who chooses $a = 1$ independently of the price; the compromise choice $a = b = \frac{1}{2}$, is now preferable, so B chooses to integrate. Clearly, the price at which an enterprise integrates is lower when its productivity R is higher.

Product market equilibrium and the OAS curve

A industry equilibrium entails clearing supplier and product markets. We have already characterized the supplier market: every A receives α , either by producing by herself α units of the numeraire, or by matching with with a B to produce the industry good for a net payoff of α .

In the product market, the large number of enterprises implies that with probability one the supply is equal to the expected value of output given p ; equilibrium requires that this price adjusts so that demand equals supply.

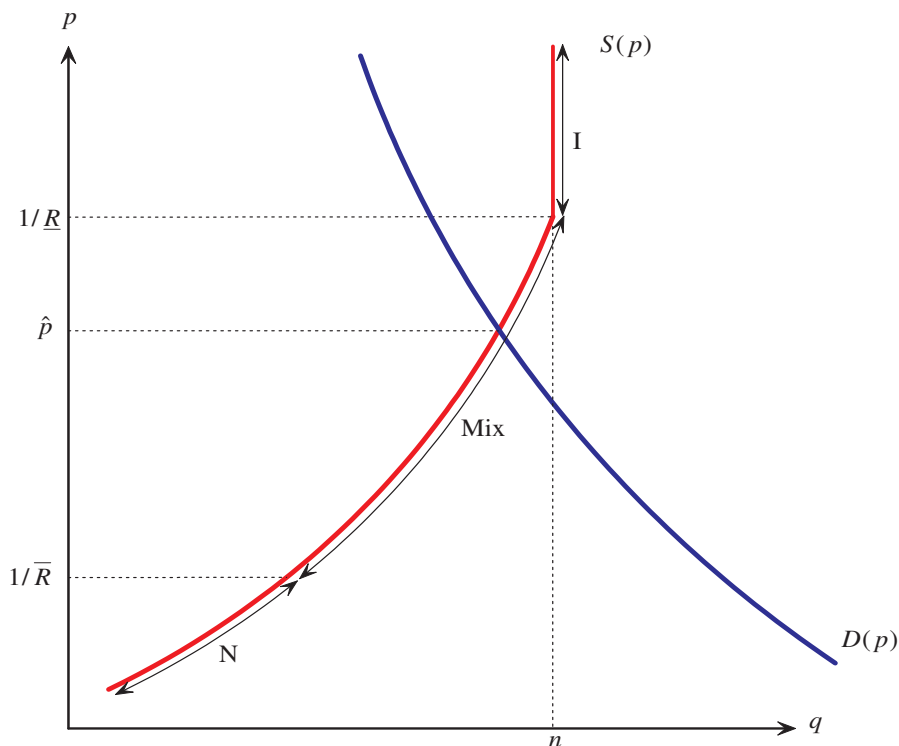
To derive industry supply, suppose R is distributed in the population according to some continuous c.d.f. $G(R)$ with mean 1 and support $[\underline{R}, \bar{R}]$. Since all enterprises with $R < 1/p$ remain non-integrated, and the remaining ones integrate, total supply at price $p \in [1/\bar{R}, 1/\underline{R}]$ is (recall that n is the measure of B suppliers)

$$S(p) = n \left[\int_{\underline{R}}^{1/p} R \left(1 - \left(\frac{1}{1+Rp}\right)^2\right) dG(R) + \int_{1/p}^{\bar{R}} R dG(R) \right]. \quad (1)$$

If $p < 1/\bar{R}$, supply is $n \int_{\underline{R}}^{\bar{R}} R \left(1 - \left(\frac{1}{1+Rp}\right)^2\right) dG(R)$; if $p > 1/\underline{R}$, it is n .

Figure 1 depicts the Organizationally Augmented Supply (OAS) curve, which incorporates the ownership structure decisions of the industry's enterprises as well as the usual price-quantity relationship. It also illustrates the price regions indicated by the black arrows in which enterprises are all non-integrated (**N**), all integrated (**I**), and the middle range in which only the more productive ones integrate (**Mix**). When $p < 1/\bar{R}$, the industry is entirely non-integrated, but supply increases with price, since non-integration expected output increases. As price rises above $1/\bar{R}$, the most productive enterprises integrate, producing more than they would under non-integration; those that remain non-integrated also produce more, so that industry output rises further. Once p reaches $1/\underline{R}$, all firms are integrated and industry supply is fixed at n (the mean R being 1) for prices higher than that threshold. In the absence of trade, the equilibrium

Figure 1: The OAS and market equilibrium



price \hat{p} equates domestic supply and demand.

Observe that, for a given market price p , more productive enterprises (those with higher R) are more likely to be vertically integrated. The degree of integration of the industry (i.e., the fraction $1 - G(1/\hat{p})$ of firms that integrate) is therefore a nondecreasing function of the equilibrium price, strictly increasing on $[\underline{R}, \bar{R}]$.

Trade policy and firms' organization

The key prediction of this theoretical framework is that higher prices on final goods should lead firms to be more vertically integrated. As discussed in the introduction, testing this prediction requires an exogenous source of price variation. Trade policy provides an ideal proving ground: the degree of trade protection obviously affects product prices, but is unlikely to be affected by firms' boundary choices.

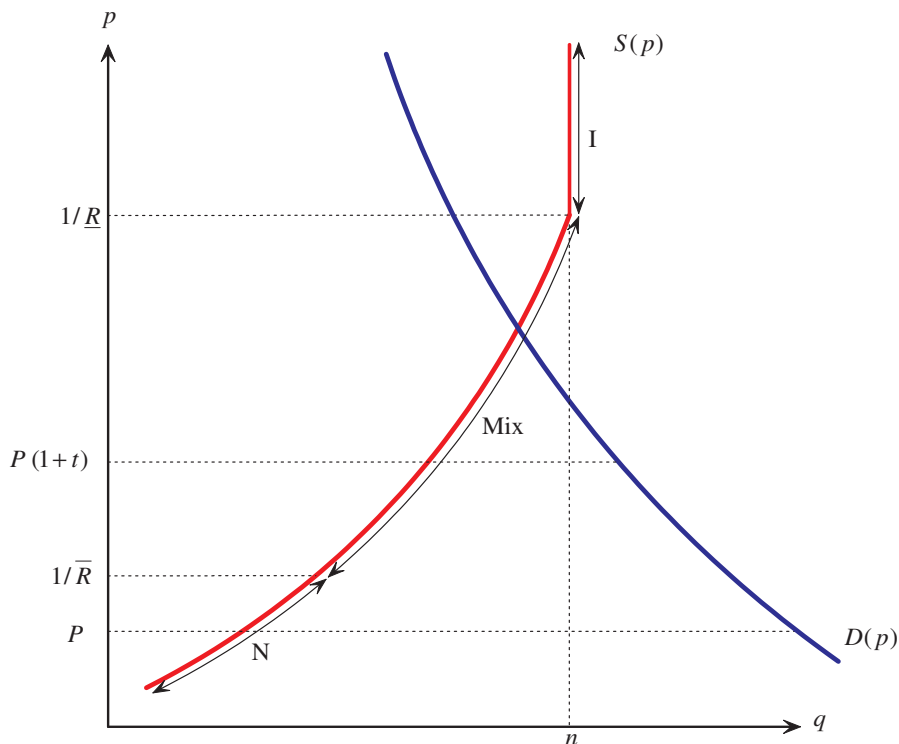
Suppose now that the industry is *import competing*: at the world price P for the good, $D(P) > S(P)$, so that some of domestic demand must be satisfied by imports. Suppose further that the country in which our industry resides is "small": the world price P is unaffected by its trade policy.

Consider the introduction of an ad valorem tariff t , which drives a wedge between the world price and the domestic price, $p = P(1 + t)$. By increasing the domestic price, the tariff increases

managers' incentives to vertically integrate, since the organizational goal becomes relatively more important than their private goals.

Trade policies affect ownership structures through their impact on product prices. In particular, an increase in t leads to an increase in the domestic price of the good; an enterprise with productivity R will choose integration if the new price exceeds $1/R$. Figure 2 depicts the OAS curve of the industry. In this example, absent any tariff, the domestic price would be equal to the world price P , and all firms in the domestic industry would be non-integrated. Now consider a tariff t that raises the domestic price to $p' = P(1 + t)$, which lies between $1/\bar{R}$ and $1/\underline{R}$. At this price, more productive enterprises (with $R > 1/p'$) will integrate and less productive ones will remain non-integrated. Clearly, a lower tariff would lead to fewer integrated firms, a higher one to more. Integration therefore increases with the tariff level.

Figure 2: Firm organization in the presence of a tariff



The impact of the import tariff on integration decisions should be stronger for domestic firms that only serve the domestic market, for which the organization's objective depends only on domestic prices; the effect should be weaker for exporting firms (and multinationals), since their profits depend also on product prices in foreign markets.

The impact of trade policy on the degree of vertical integration should also depend on the extent to which import tariffs affect domestic prices. In turn, this should depend on the share of imports that are subject to the tariff. Thus membership in regional trade agreements (in which

member countries freely trade with each other) and differences across countries and sectors in the share of imports that are exempt from tariffs provide an additional source of variation to test our hypothesis.

This theoretical framework can also be used to examine how trade policy affects the degree of organizational similarity across countries. In effect, the law of one price implies organizational convergence: countries with low trade barriers ought to have similar prices and therefore similar organization. For a pair of countries c and c' , the difference in degree of integration within a sector will depend on the difference in their applied tariffs: the closer are t^c and $t^{c'}$, the smaller the difference between p^c and $p^{c'}$ and the more similar firms' ownership structures within the industry. For countries in the same RTA, all tariffs among them are eliminated. This implies that prices should tend to converge across member countries. We would also expect customs unions, in which members adopt common external tariffs, to be characterized by more similar ownership structures than free trade areas, in which differences in external tariffs, together with problems in implementing rules of origins, reduce the extent of price convergence.

For the purpose of our empirical analysis, the main predictions of our theoretical framework can be summarized as follows:

1. Higher import tariffs on final goods should lead domestic firms to be more vertically integrated.
2. The effect of tariffs on integration should be larger for firms selling only in the domestic market.
3. The effect of tariffs on integration should be larger in sectors in which a smaller fraction of imports are exempt from the tariff.
4. Country pairs should have more similar ownership structures in sectors where they have similar levels of protection; RTAs, especially customs unions, should display similar ownership structures among members.

3 Dataset and variables

3.1 The WorldBase database

Increasingly, researchers use multi-country firm-level data to study issues of organization economics (e.g., Bloom and Van Reenen, 2007; Bloom, Sadun and Van Reenen, 2012). However, cross-country empirical investigations at the firm level are notoriously challenging due to both the lack of data and the difficulty of comparing the few high quality time-series datasets that are available (mostly in rich countries). The reason for the data constraint is simple: economic

censuses of firms are infrequently collected due to high costs and institutional restrictions, especially in poor countries. No institution has the capacity or resources to collect census data for a wide range of countries and periods. This is why researchers have to use other sources, such as business “compilations” (registries, tax sources) or surveys.

To measure vertical integration, we use data for 2004 from Dun & Bradstreet’s WorldBase, a database of public and private plant-level observations in more than 200 countries and territories.¹³ WorldBase contains information on public and private companies in more than 200 countries. The unit of observation in WorldBase is the establishment/plant. With a full sample, plants belonging to the same firm can be linked via information on domestic and global parents using the DUNS numbers.¹⁴

The WorldBase dataset has been used extensively in the literature. Early uses of D&B data include Caves’ (1975) analysis of size and diversification patterns between Canadian and U.S. plants. More recent uses include Harrison, Love, and McMillian (2004), Black and Strahan (2002), Alfaro and Charlton (2009), and Acemoglu, Johnson and Mitton (2009). One of the advantages of WorldBase compared to other international datasets is that it is compiled from a large number of sources (e.g., partner firms, telephone directory records, websites, self-registration). Admittedly, sample coverage may vary across countries, but this problem can be mitigated by focusing on manufacturing firms above a size threshold of twenty employees (see discussion below).¹⁵

3.2 The sample

We use data from the 2004 WorldBase file, excluding records that lack primary industry and year started, for a total of more than 24 million observations. The unit of observation in WorldBase is the establishment (a single physical location at which business is conducted or services or industrial operations are performed) rather than the firm (one or more domestic establishments

¹³WorldBase is the core database with which D&B populates its commercial data products, including Who Owns WhomTM, Risk Management SolutionsTM, Sales & Marketing SolutionsTM, and Supply Management SolutionsTM. These products provide information about the “activities, decision makers, finances, operations and markets” of the clients’ potential customers, competitors and suppliers. The dataset is not publicly available but was released to us by Dun and Bradstreet. For more information see: http://www.dnb.com/us/about/db_database/dnbinfoquality.html.

¹⁴D&B uses the United States Government Department of Commerce, Office of Management and Budget, Standard Industrial Classification Manual 1987 edition to classify business establishments. The Data Universal Numbering System — The D&B DUNS Number — introduced in 1963 to identify businesses numerically for data-processing purposes, supports the linking of plants and firms across countries and tracking of plants’ histories including name changes.

¹⁵Other datasets use different methodologies in different countries. For example, the Amadeus dataset, provided like Orbis by Bureau Van Dijk, uses data from national public body in charge of collecting the annual accounts in some countries (e.g., the UK) and collects it direct from firms in other countries (most of Eastern Europe). Because of different disclosure requirements, the amount and type of information also varies among countries. See Alfaro and Charlton (2009) for a more detailed discussion of the WorldBase data and comparisons with other data sources.

under common ownership or control). Establishments, which we also refer to as plants, have their own addresses, business names, and managers, but might be partly or wholly owned by other firms. As mentioned above, plants can be linked via information on domestic and global parents using DUNS numbers.

We use different categories of data recorded by WorldBase records for each establishment:

Industry information: the 4-digit SIC code of the primary industry in which each establishment operates, and for most countries, the SIC codes of as many as five secondary industries, listed in descending order of importance.

Ownership information: information about the firms' family members (number of family members, its domestic parent and its global parent).¹⁶

Location information: country, state, city, and street address of each family member (used to link establishments within a family to the relevant tariff data).

Basic operational information: sales and employment.

Information on the firm's trade status (exporting/non-exporting).

We exclude countries and territories with fewer than 80 observations and those for which the World Bank provides no data. We further restricted the sample to World Trade Organization (WTO) members for which we have data on tariffs/regional trading arrangements (see the discussion below).

We focus on manufacturing firms (i.e., firms with a primary SIC code between 2000 and 3999), which best fit our theory of vertical integration and for which data on MFN tariffs are widely available. We exclude government/public sector firms, firms in the service sector (for which we have no tariff data) or agriculture (due to the existence of many non-tariff barriers), and firms producing primary commodities (i.e., mining and oil and gas extraction).

We exclude firms with fewer than 20 employees, as our theory does not apply to self-employment or small firms with little prospect of vertical integration (see also Acemoglu, Aghion, Griffith and Zilibotti, 2010). Restricting the analysis to firms with more than 20 employees also enables us to correct for possible differences in the the collection of small firms data across countries (see Klapper, Laeven, and Rajan, 2006).

We focus on firms that are located in only one country, since this provides a cleaner analysis of the effects of tariffs and RTAs on firms' ownership structure. This is because the degree of vertical integration of these firms should depend only on the price at which they sell their product in their home country. In the case of multinational corporations (MNCs), on the other hand, it is harder to identify the relevant prices and tariffs. Moreover, focusing on national firms avoids

¹⁶D&B also provides information about the firm's status (joint-venture, corporation, partnership) and its position in the hierarchy (branch, division, headquarters).

issues having to do with the strategic behavior of multinationals across markets (e.g., transfer pricing, tariff jumping).¹⁷ Multinationals are included in the robustness analysis. There, we split MNCs into separate entities — one for each country — in order to link organizational structure to domestic tariffs.

Table A-1 in the Appendix lists the countries included in our main sample.¹⁸ As a robustness check, we also exclude countries for which we have fewer than 1,000 plants that are part of firms with at least 20 employees. The countries included in this restricted sample are listed in Table A-2.

We next describe the construction of firm-level vertical integration indices, and all other variables used in our empirical analysis. Appendix Table A-3 presents summary statistics for all variables.

3.3 Vertical integration indices

Constructing measures of vertical integration is highly demanding in terms of data, requiring firm-level information on sales and purchases of inputs by various subsidiaries of a firm. Such data are generally not directly available and, to the best of our knowledge, there is no source for such data for a wide sample of developed and developing countries.

To measure the extent of vertical integration for a given firm, we build on the methodology developed by Fan and Lang (2000) and Acemoglu, Johnson and Mitton (2009). We combine WorldBase information on plant activities and ownership structure with input-output data to determine related industries and construct the vertical integration coefficients $V_j^{f,k,c}$ in activity j , where k is the primary sector in which firm f in country c is active.¹⁹

Given the difficulty of finding input-output matrices for all the countries in our dataset, we follow Acemoglu, Johnson and Mitton (2009) in using the U.S. input-output tables to provide a standardized measure of input requirements for each sector. As the authors note, the U.S. input-output tables should be informative about input flows across industries to the extent that these are determined by technology.²⁰

¹⁷We describe an establishment as foreign-owned if it satisfies two criteria: (1) it reports to a global parent firm, and (2) the parent firm is located in a different country. Parents are defined in the data as entities that have legal and financial responsibility for another firm. For purposes of matching the tariff data, we use the SIC code of the domestic ultimate for multinationals.

¹⁸Further restrictions were imposed by data availability constraints related to the control variables, as explained in the next subsections.

¹⁹In Acemoglu, Johnson and Mitton (2009), the sample is restricted to a maximum of the 30,000 largest records per country in the 2002 WorldBase file (a limit imposed by cost constraints). For countries with more than 30,000 observations, they select the 30,000 largest, ranked by annual sales. Having information on the full sample of establishments in WorldBase, we are able to link establishments to firms (see discussion below).

²⁰Note that the assumption that the U.S. IO structure carries over to other countries can potentially bias our empirical analysis against finding a significant relationship between vertical integration and prices by introducing measurement error in the dependent variable of our regressions. In addition, using the US input-output tables to construct vertical integration indices for other countries mitigates the possibility that the IO structure and

The input-output data are from the Bureau of Economic Analysis (BEA), Benchmark IO Tables, which include the make table, use table, and direct and total requirements coefficients tables. We use the Use of Commodities by Industries after Redefinitions 1992 (Producers' Prices) tables. While the BEA employs six-digit input-output industry codes, WorldBase uses the SIC industry classification. The BEA website provides a concordance guide, but it is not a one-to-one key.²¹ For codes for which the match was not one-to-one, we randomized between possible matches in order not to overstate vertical linkages. The multiple matching problem, however, is not particularly relevant when looking at plants operating only in the manufacturing sector (for which the key is almost one-to-one).

For every pair of industries, i, j , the input-output accounts support calculation of the dollar value of i required to produce a dollar's worth of j . We construct the input-output coefficients for each firm f , IO_{ij}^f by combining the SIC information for each plant in each firm, the matching codes, and the U.S. input-output information. Here, $IO_{ij}^f \equiv IO_{ij} * I_{ij}^f$, where IO_{ij} is the input-output coefficient for the sector pair ij , stating the cents of output of sector i required to produce a dollar of j , and $I_{ij}^f \in \{0, 1\}$ is an indicator variable that equals one if and only if firm f owns plants in both sectors i and j . A firm that produces i as well as j will be assumed to supply itself with all the i it needs to produce j ; thus, the higher IO_{ij} for an i -producing plant owned by the firm, the more integrated in the production of j the firm will be measured to be. Adding up the input-output coefficients IO_{ij}^f for all inputs i , gives the firm's degree of vertical integration in j .

To illustrate the procedure, consider the following example from Acemoglu, Johnson and Mitton (2009) of a Japanese establishment with, according to WorldBase, one primary activity, automobiles (59.0301), and two secondary activities, automotive stampings (41.0201) and miscellaneous plastic products (32.0400). The IO_{ij} coefficients for this plant are:

		Output (j)		
		Autos	Stampings	Plastics
Input (i)	Autos	0.0043	0.0000	0.0000
	Stampings	0.0780	0.0017	0.0000
	Plastics	0.0405	0.0024	0.0560
	SUM	0.1228	0.0041	0.0560

The table is a restriction of the economy-wide IO table to the set of industries in which this establishment is active (i.e., it contains all of the positive IO_{ij}^f values). For example, the IO_{ij} coefficient for stampings to autos is 0.078, indicating that 7.8 cents worth of automotive stampings are required to produce a dollar's worth of autos. Because this plant has the internal capability to produce stampings, we assume it produces itself all the stampings it needs.²² The

control variables are endogenous.

²¹This concordance is available upon request. The BEA matches its six-digit industry codes to 1987 U.S. SIC codes <http://www.bea.gov/industry/exe/ndn0017.exe>.

²²Many industries have positive IO_{ij} coefficients with themselves; for example, miscellaneous plastic products

bottom row shows the sum of the IO_{ij}^f for each industry. For example, given that 12.3 cents worth of the inputs required to make autos can be produced within this plant, we would say that the degree of vertical integration for this plant is 0.123.

For firm f in primary sector k located in country c , we define the integration index in activity j as

$$V_{f,k,c}^j = \sum_i IO_{ij}^{f,k}, \quad (2)$$

the sum of the IO coefficients for each industry in which the firm is active. Our measure of vertical integration is based on the firm’s primary activity:

$$V_{f,k,c} = V_{f,k,c}^j, j = k. \quad (3)$$

In the case of multi-plant firms, we link the activities of all plants that report to the same headquarters and consider the main activity of the headquarters as the primary sector.²³

The approach we follow to identify vertical integration infers a firm’s level of vertical integration from information about the goods it produces in each of its establishments and the aggregate input-output relationship among those goods. The advantage of this method is that one need not worry about the value of intra-firm activities being affected by transfer pricing. Another advantage is that using I-O tables avoids the arbitrariness of classification schemes that divide goods into “intermediate” and other categories (Hummels, Ishii, and Yi, 2001).

Summary statistics for firm-level vertical integration are presented in Appendix Table A-3, while Table A-4 reports average vertical integration indices by sector (at the 2-digit SIC level).²⁴ Table A-5 compares the firm-level vertical integration index across the different samples. Our main sample consists of 196,586 domestic manufacturing firms with at least 20 employees located in 80 countries. The histogram in Figure 3 reports the distribution of vertical integration indices for all firms in our main sample. According to our measure, most firms produce relatively few inputs in house: the median vertical integration index is around 0.044 and the mean is 0.063.²⁵

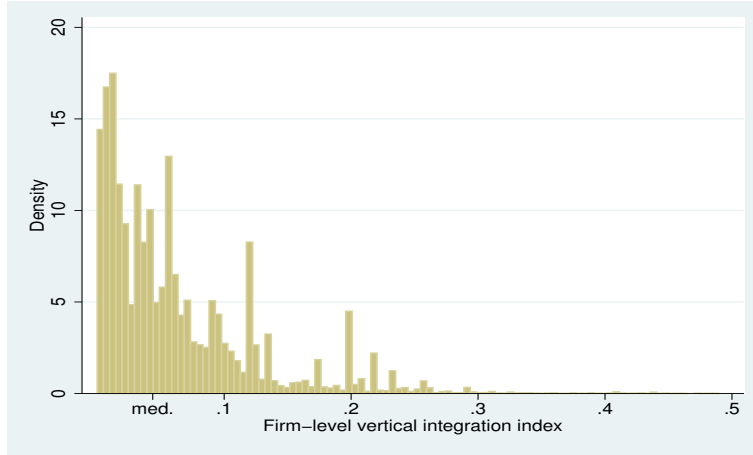
are required to produce miscellaneous plastic products. Any firm that produces such a product will therefore be measured as at least somewhat vertically integrated.

²³One might be concerned about measuring vertical integration at the firm level, in light of the results by Hortacsu and Syverson (2009), who find little evidence of commodity shipments across commonly-owned plants in US non-multinational firms. However, unless one feels comfortable extrapolating these results from between to within plants (let alone extrapolating from the US to the rest of the world), this concern does not apply to our analysis. This is because 96% of the firms in our sample are actually single plant and 87% of plants are not connected (see Table A-5). The qualitative results of our analysis are thus unaffected if we measure vertical integration at the plant-level or restrict the analysis to single-plant firms.

²⁴The descriptive statics for our vertical integration measure are similar to Acemoglu, Johnson and Mitton (2009). They report a mean of 0.0487 and median of 0.0334 for their vertical integration index. For our main sample, the primary sector vertical integration index has a mean of 0.0627 and a median of 0.0437 (see Table A-3). The ordering of industries by degree of vertical integration in Table A-4 is also similar to that reported by Acemoglu, Johnson and Mitton (2009).

²⁵It should be noted that this measure does not consider payments to capital and labor services and is thus

Figure 3: Firm-level vertical integration index



3.4 Tariffs and other trade variables

Our main strategy to empirically assess the impact of market prices on ownership structure is to use data on applied most-favored-nation (MFN) tariffs, which offer a plausibly exogenous source of price variation to the boundaries of the firm. As argued in the introduction, the degree of vertical integration of a firm is unlikely to have a systematic impact on the determination of trade policies in general, and MFN tariffs in particular. These are negotiated at the multilateral level over long periods of time and are less “political” than unilateral forms of protection such as anti-dumping duties.

We collect applied MFN tariffs at the 4-digit SIC level for all WTO members for which this information is available. We restrict the set of countries to WTO members, which are constrained under Article I of the GATT by the MFN principle of non-discrimination: each country c applies the tariff $Tariff_{k,c}$ to all imports of final good k that originate in other WTO member countries; preferential treatment is allowed only for imports originating from RTA members or from developing countries (see discussion below). The source for MFN tariffs is the World Integrated Trade Solution (WITS) database, which combines information from the UNCTAD TRAINS database (default data source) with the WTO integrated database (alternative data source). Tariffs are for 2004 unless unavailable for that year in which case the closest available data point in a five year window around 2004 (2002-2006) is chosen with priority given to earlier years.²⁶ The original classification for tariff data is the harmonized system (HS) 6-digit classification. Tariffs are converted to the more aggregate SIC 4-digit level using internal conversion tables of WITS. Here, SIC 4-digit level MFN tariffs are computed as simple averages

always less than unity. Indeed, in the U.S. an industry pays on average around 56% of gross output to intermediates, the rest being value added. Thus, even a fully vertically integrated firm in a typical sector would have an index of only 0.56.

²⁶For example, if data are available for 2003 and 2005, but not 2004, the 2003 data are chosen.

over the HS 6 digit tariffs.

Our analysis focuses on tariffs on final goods in the domestic market. In some regressions, we also control for the tariffs applied to imported inputs, using the variable *Input Tariff_{k,c}*. This is a weighted average of 4-digit SIC applied MFN tariffs, using normalized IO-coefficients from the US input-output table as weights. To proxy for the level of protection faced by exporters in foreign markets, we use the variable *Export Tariff_{k,c}*. We construct this variable by weighting tariffs in destination markets with bilateral export shares using information from COMTRADE.

The variable *MFN share_{k,c}* measures the fraction of imports to which MFN tariffs apply, for each country and sector. This excludes imports from countries with which the importer has a preferential trade agreement, which do not face tariff restrictions. The higher is this share, the more sensitive domestic prices should be to MFN tariffs. For example, the U.S. will have low MFN shares in sectors in which it imports a lot from its NAFTA trading partners (Canada and Mexico). In these sectors, the MFN tariff that the U.S. imposes on other WTO members will have little impact on domestic prices. In contrast, the effect may be substantial in sectors where most imports originate in countries with which the U.S. has no preferential trade agreement.

To distinguish between firms selling only in the domestic market and exporting firms, we construct two measures. The dummy variable *Domestic_f* is constructed from WorldBase and takes the value of 1 if firm *f* does not report to be an exporter. The variable *Import-competing_{k,c}* is a country-sector specific measure of import-competition constructed using information from COMTRADE. This is a dummy indicating whether a firm operates in one of the 25 percent most import-competing sectors, based on the ratio of a country's total imports/exports by sector.

We also collect information on all regional trade agreements in force in 2004 from the WTO Regional Trade Agreements Information System (RTA-IS).²⁷ The legal basis for the creation of RTAs can be found in GATT/WTO Article XXIV (for agreements involving developed member countries) and the Enabling Clause (for agreements among only developing countries). Under Article XXIV, member countries can form free trade areas (FTAs) or customs unions (CUs) covering “substantially all trade”, that require complete duty elimination and fixed timetables for implementation. The conditions contained in the Enabling Clause being much less stringent, RTAs between developing member countries may effectively involve less trade liberalization. Thus we construct the dummy *RTA_{c,c'}* that equals one when countries *c* and *c'* belong to a common trade agreement formed under Article XXIV.²⁸ To distinguish between different types of RTAs, we construct the dummy variables *Customs Union_{c,c'}* and *Free Trade Area_{c,c'}*. We expect the former, which imply a common external tariff and no internal trade barriers, to have a stronger effect on organizational convergence than the latter, which permit member countries to maintain different external tariffs.

²⁷Available online (<http://rtais.wto.org/UI/PublicMaintainRTAHome.aspx>).

²⁸This variable does not include a number of preferential trade agreements under the Enabling Clause that do not imply the full elimination of trade barriers.

3.5 Other controls

We collect a number of country- and sector-specific variables to control for alternative factors emphasized in the literature on vertical integration.

In terms of country-specific variables, the empirical and theoretical literatures have studied the role of institutional characteristics and financial development.²⁹ We use the variable *Legal Quality_c* to proxy for the quality of a country’s institutions. This is the variable “rule of law” from Kaufmann, Kraay, and Mastruzzi (2003), which is a weighted average of a number of variables (perception of incidences of crime, effectiveness and predictability of the judiciary, and enforceability of contracts) between 1997 and 1998. The variable ranges from 0 to 1 and is increasing in the quality of institutions. The variable *Financial Development_c* measures private credit by deposit money banks and other financial institutions as a fraction of GDP for 2004 and is taken from Beck, Demigurc-Kunt, and Levine (2006).

We also construct the variable *Capital Intensity_k*, using data from the NBER-CES manufacturing industry database (Bartelsmann and Gray, 2000) at the 4-digit-SIC level. In line with the literature, capital intensity is defined as the log of total capital expenditure relative to value added averaged over the period 1993-1997.

To control for domestic industry concentration, we construct *Herfindahl_{k,c}* indices using information on sales of all plants in a given country and sector.³⁰

To proxy for the degree of product differentiation, we use two dummy variables. The variable *Homogeneous1_k* is equal to 1 when a sector is homogeneous according to the well-known classification by Rauch (1999).³¹ The dummy variable *Homogeneous2_{k,c}* is constructed using information on sector-country-specific import demand elasticities estimated by Broda, Greenfield and Weinstein (2006).³² It takes value 1 whenever the elasticity is above the median for the country. Broda, Greenfield and Weinstein (2006) show that sectors with more homogeneous products are characterized by higher import demand elasticities.

In some specifications, we include the variable *Size_f*, using information on firm-level employment from WorldBase. Since firm size is clearly endogenous to vertical integration, we always use predicted size as an instrument, constructed by regressing firm size on sector-country dummies.

In the regressions on organizational convergence, we also use a number of bilateral variables from CEPII: bilateral *Distance* measured as the simple distance between the most populated cities (in km), dummies for *Contiguity_{c,c'}*, for *Common Language_{c,c'}* (official or primary), and

²⁹Poor legal institutions may affect vertical integration decisions through their impact on the severity of hold-up problems. A sufficient level of financial development may be necessary for upstream and downstream firms to be able to integrate. As Acemoglu, Johnson and Mitton (2009) note, the effect of each of these variables may be ambiguous when considered separately and there are more robust predictions of their combined effect.

³⁰These include sales by foreign-owned plants that operate in the given country-sector.

³¹Rauch (1999) classifies products according to three different types: homogeneous goods, which are traded in organized exchanges; goods that are not traded in organized exchanges, but for which a published reference price can be found; and differentiated goods, which fall under neither of the two previous categories.

³²We thank David Weinstein for making these data available to us.

*Colonial Relationship*_{*c,c'*} (current or past). In some specifications, we also include the variable *Difference GDP*_{*c,c'*} for the year 2004 constructed from the World Development indicators.

4 Tariffs and vertical integration

In this section, we assess the empirical validity of the main prediction of our theoretical model that higher prices for the final good lead to more vertical integration at the firm level. The section is divided in two parts. First, we exploit cross-sectional variation in applied MFN tariffs to verify whether trade policy affects firms' ownership structures in the way predicted by our model. Second, we exploit time-series variation in the degree of protection faced by firms, examining the organizational effects of China's accession to the WTO.

4.1 Cross-sectional evidence

To examine the organizational effects of trade policy, we first exploit variation in applied MFN output tariffs across countries and sectors. We estimate the following reduced form regression model:

$$V_{f,k,c} = \alpha + \beta_1 \text{Tariff}_{k,c} + \beta_2 \mathbf{X}_{f,k,c} + \delta_k + \delta_c + \epsilon_{f,k,c}, \quad (4)$$

where $\mathbf{X}_{f,k,c}$ is the vector of explanatory variables, δ_k and δ_c are sector and country dummies and $\epsilon_{f,k,c}$ is an error term with $E(\epsilon_{f,k,c} | \mathbf{X}_{k,c}, \delta_k, \delta_c) = 0$. Thus, the effect of $\text{Tariff}_{k,c}$ on $V_{f,k,c}$ is causal conditional on covariates.

The dependent variable is the log of one plus $V_{f,k,c}$, the vertical integration index of firm f , with primary sector k , located in country c , as defined in (3). We take logs of (one plus) the vertical integration index to mitigate problems with outliers.³³

Our main regressor of interest is the variable $\text{Tariff}_{k,c}$, which is the log of (one plus) the MFN tariff applied to output in sector k by country c .³⁴ Our model predicts that higher final good tariffs within an industry should lead firms in that industry to be more vertically integrated. We thus expect the coefficient β_1 to be positive.³⁵

The vector $\mathbf{X}_{f,k,c}$ includes a series of firm- and sector-country-specific controls, that we will discuss below. We also include sector fixed effects at the 4-digit SIC level (δ_k), which allows us to

³³We also used the log of the vertical integration index (removing zero observations) obtaining similar results. There are very few zeros in the dependent variable, so there is no need to perform a Tobit analysis. All results not shown due to space considerations are available upon request.

³⁴Tariffs are expressed in ad-valorem terms. In the main specifications, we use log of (one plus MFN tariff) in order to be able to include zero tariffs. Although the distribution of tariffs is extremely skewed, log tariffs are approximately normally distributed. Using, in alternative specifications, the log of the tariff variable yields similar results.

³⁵We have also performed a series of estimations including a quadratic term for $\text{Tariff}_{k,c}$, finding no evidence of a non-monotonic relationship between tariffs and vertical integration.

capture cross-industry differences in technological or other determinants of vertical integration (e.g., a sector’s capital intensity). Finally, we add country fixed effects (δ_c), which capture cross-country differences in institutional determinants of vertical integration (e.g., a country’s level of financial development and the quality of its contracting institutions) and also control for country-specific differences in the way firms are sampled.³⁶ Given that tariffs vary only at the sector-country level, while the dependent variable varies at the firm level, we cluster standard errors at the sector-country level.

4.1.1 Main results

Table 1 reports the results of estimations in which we test the main predictions of our theoretical framework.

Column (1) presents the results of the basic specification, which includes only the variable *Tariff* and country and sector fixed effects. The estimated coefficient for the tariff is positive and strongly significant. Thus, consistently with the first prediction of our theoretical model, higher tariffs lead firms to be more vertically integrated. The point estimate for β_1 implies that a 100 percent tariff increase leads to a 2.03 percent increase in the vertical integration index. In terms of economic magnitudes, this implies that an increase in manufacturing tariffs from 1 percent to their mean level of 4.85 percent (a 385 percent increase) increases vertical integration by $0.0203 \times 385 = 7.82$ percent.³⁷

The estimate for β_1 can be interpreted as the impact of prices on vertical integration if and only if prices and tariffs vary one to one. This would be true for a specific (per-unit) tariff imposed by a small country in a competitive environment. In the case of ad-valorem tariffs, the relation would be weaker. This would also be true if the country is large, i.e., can affect world prices. In this case, imposing a tariff will have an impact on the world price and the elasticity of domestic prices with respect to tariffs will be less than one.³⁸ Ideally, one would use industry-level price indices and instrument them with tariffs. Unfortunately, reliable price data is unavailable.³⁹ These arguments imply that the estimate for β_1 should be interpreted as

³⁶D&B samples establishments in the formal sector (and there are, of course, differences in the size of the formal sector across rich and poor countries). As a robustness check, we also tried restricting the sample to countries for which we have at least 1,000 plants that are part of firms with at least 20 employees (see section 4.1.4).

³⁷The coefficient for *Tariff* in the log-log specification, where we have only 149,574 observations since we lose observations with zero tariffs, is 0.03 and significant at the one-percent level. This implies that an increase in manufacturing tariffs by 385 percent increases vertical integration by $0.03 \times 385 = 11.55$ percent.

³⁸Denote the domestic price of good k in country c as $p_{k,c} = (1 + t_{k,c})P_k$, where P_k is the world price of good k . Then $\frac{\partial p_{k,c}}{\partial t_{k,c}} \frac{t_{k,c}}{p_{k,c}} = \frac{t_{k,c}}{1+t_{k,c}} + \frac{\partial P_k}{\partial t_{k,c}} \frac{t_{k,c}}{P_k}$, where the first part on the right is the direct impact of an ad-valorem tariff on domestic prices (< 1) and the second term is the terms of trade effect (< 0). Notice also that, to the extent that countries are able to manipulate tariffs to improve their terms of trade, high tariffs are likely to be observed precisely in sectors in which they increase domestic prices only by a small amount. Broda, Limao and Weinstein (2008) provide evidence that non-WTO countries exploit their market power in trade by setting higher tariffs on goods that are supplied inelastically.

³⁹Unit values, which are widely available, cannot be used for our purposes: we require data on domestic prices,

a lower bound on the impact of prices on vertical integration.

In columns (2) and (3) we verify whether the effect of domestic tariffs on organization is larger for firms that operate only in the domestic market (for which only this price should affect the degree of vertical integration). To do so, we interact the variable $Tariff_{k,c}$ with two dummy variables: $Domestic_f$, which is constructed using information on from WorldBase and takes the value of 1 if firm f does not report to be an exporter; and $Import-competing_{k,c}$, which is constructed using information from COMTRADE and indicates whether a firm operates in one of the 25 percent most import-competing sectors, based on the ratio of a country's total imports/exports by sector. We expect the coefficients on the interaction terms to be positive.

In column (2), the coefficient for tariffs (which measures the impact of tariffs on vertical integration for exporters) is positive but insignificantly different from zero. On the other hand, the coefficient on the interaction term is positive, strongly significant and similar in magnitude to the baseline specification. Thus, import tariffs have a significant affect on vertical integration only for firms that sell only in the domestic market. In column (3), we use the alternative measure to identify firms that do not export to foreign markets. Again, the coefficient on the interaction term is positive and significant at the five-percent level, indicating that import tariffs have a bigger impact on vertical integration decisions for firms that operate in import-competing sectors.⁴⁰

In column (4) we test if tariffs have a larger impact on vertical integration when the share of imports to which they apply is larger (and thus domestic prices should be more affected). To do this, we include the variable $MFN\ share_{k,c}$, capturing the fraction of imports to which MFN tariffs apply in a given country and sector, as well as the interaction between this variable and the tariff. The coefficient in the first row now measures the impact of MFN tariffs when no imports are subject to them (i.e., in a sector in which a country imports only from regional trading partners). Not surprisingly, this coefficient is not significant, since in this case MFN tariffs should have no impact on the price faced by domestic firms. The interaction term is instead positive and significant at the one-percent level, indicating that the effect of MFN tariffs on vertical integration is positive and increasing in their importance for import volumes.

In columns (5)-(8) we repeat the same specifications, adding institutional interaction terms that have been emphasized in previous studies on vertical integration. In particular, Acemoglu, Johnson and Mitton (2009) find evidence that contracting costs and financial development have a stronger impact on vertical integration in more capital-intensive sectors. We thus introduce two interaction terms: one between $Capital\ Intensity_k$ and $Financial\ Development_c$ and the other one between $Capital\ Intensity_k$ and $Legal\ Quality_c$. The coefficient on the first interaction term is positive and significant, indicating that more capital intensive sectors are more integrated in

while unit values (CIF or FOB) are measures of import prices at the border, *before* tariffs are applied.

⁴⁰As discussed in section 4.1.3, our results are robust to including additional controls for firms (e.g., instrumented size and ratio of sales to employment) and sectors (e.g., industry concentration).

countries with more developed financial markets. The second interaction term has the expected negative sign but it is not significant. In all specifications, our results on the effect of tariffs on vertical integration are unaffected.

4.1.2 Prices versus competition

In this section, we try to disentangle two channels through which tariff changes may affect vertical integration. On the one hand, a fall in tariffs lowers product prices. According to our theory, in which firms are price takers, this should decrease vertical integration. On the other hand, trade liberalization might also increase the degree of competition faced by domestic firms. Aghion, Griffith and Howitt (2006) suggest a U-shaped relationship between competition and vertical integration: a small increase in competition reduces a producer’s incentive to integrate by improving the outside options of non-integrated suppliers and hence raising their incentive to make relationship-specific investments; too much competition raises the producer’s incentive to integrate, by allowing non-integrated suppliers to capture most of the surplus.

To isolate the effect of product prices, in Tables 2 and 3 we restrict our analysis to competitive sectors, in which tariffs will have little or no effect on the degree of competition. To show the robustness of our results, we use several alternative criteria to define competitive sectors.

In Table 2, we only include sectors in which at least 20 domestic firms operate in a given country and for which the dummy variable $Homogeneous1_k$ is equal to 1. This identifies industries in which goods are traded in organized exchanges, classified as homogeneous according to Rauch (1999). Thus, these are sectors for which a market price exists and where many firms operate, implying a high level of competition. In columns (1)-(2), these are the only restrictions that we impose on the sample. In the rest of the table, we introduce additional restrictions to define competitive sectors. Columns (3)-(4) include only sectors with low levels of protection ($Tariff_{k,c} < 10\%$), in which domestic firms face also a high level of foreign competition. In columns (5)-(6) the sample is restricted to sectors in which some foreign owned firms operate in the domestic market. Since firms that foreign firms investing in FDI are typically more productive than foreign exporting firms, this should imply a high competitive pressure on domestic firms. In columns (7)-(8), we exclude from our analysis concentrated sectors, i.e., industries for which the $Herfindahl_{k,c}$ index above 0.1. In all specifications, the coefficient on the tariff is positive and significant at least at the five-percent level. Notice that when we use a stricter definition of competitive sectors we obtain estimates that are up to three times larger in magnitude and more significant. We can thus conclude that import tariffs, by raising product prices, lead domestic firms to be more vertically integrated.

In Table 3, we repeat the analysis using the dummy $Homogeneous2_{k,c}$ to define homogeneous sectors. This identifies sectors with high import demand elasticities according to Broda, Greenfield and Weinstein (2006), which, as explained above, should also be more competitive.

Notice that the sample is much larger than in Table 2, since the variable $Homogeneous2_{k,c}$ varies at the country-sector level. The estimates for $Tariff_{k,c}$ are always positive, larger than for the full sample, and significant at the one-percent level, confirming that higher prices lead to more vertical integration.

4.1.3 Omitted variables

Our analysis shows that firms are more vertically integrated when import tariffs on their final product are higher. In this section, we show that this result is robust to controlling for other channels through which import tariffs can affect firm organization decisions.

As argued above, reverse causality is unlikely to be a concern, since there is no reason to believe that vertically integrated firms should be particularly interested or able to obtain high levels of protection. However, MFN tariffs on final products could be correlated with omitted variables that also affect firms' ownership structures.

In what follows, we show that our results are robust to controlling for two sets of potential omitted variables. First, we include measures of input tariffs and export tariffs, which are correlated with output tariffs⁴¹ and may also affect vertical integration decisions. Second, we control for firm size and industry concentration, which can affect the degree of protection through their impact on lobbying pressure (e.g., Mitra, 1999; Bombardini, 2008) and may also be correlated with firms' ownership structures.

The results of these regressions are presented in Table 4. For comparison, in the first two columns, we report the results of the baseline specifications. In column (3)-(8), we add additional controls, first one by one and then simultaneously: $Input\ Tariff_{k,c}$, $Export\ Tariff_{k,c}$, $Herfindahl_{k,c}$, and $Size_f$ (instrumented with predicted size).⁴² Notice that, in all specifications, the coefficient on $Tariff$ is positive, highly significant, and very stable. These results confirm that omitted variables are not a concern and that higher output tariffs lead to more vertical integration. Of the additional controls, only input tariffs and firm size have a (positive) significant effect on organization.⁴³

4.1.4 Additional robustness checks

Here, we perform a number of additional robustness checks. We show that our results on MFN tariffs and firms' vertical integration are robust to employing different samples; to using different

⁴¹The simple correlation of output tariffs with input tariffs is 0.78 and the one with export tariffs is 0.31.

⁴²In unreported regressions, we have also included the log of sales/employment (instrumented with sector-country dummies). The coefficient of this variable was positive and significant and the coefficient of the $Tariff$ was unaffected.

⁴³In a simple extension of our framework, in which the different units of the enterprise each produce a good that may be sold to the outside market, and in which the total enterprise revenues are shared among the members, increasing an "input" price has the same effect as increasing the final good price, namely to increase the marginal value of integration. This could explain the positive coefficient on input tariff.

econometric methodologies; and to measuring vertical integration in a different way. The tables reporting these results are in the Appendix.

In a first set of regressions, we add multinational firms to the main sample. As noted above, since multinational firms have plants in different countries, it is harder to identify with precision the tariffs that affect their organization decisions. We thus split multinationals into separate firms by country and use the primary activity of the respective domestic ultimate to identify the relevant tariff. In Table A-6 we reproduce all the specifications of Table 4, including multinationals firms in the sample and adding a dummy variable for multinational status. As expected, the coefficient for $Tariff_{k,c}$ is slightly reduced in magnitude, but remains positive and strongly significant in all specifications.

In Table A-7 we repeat the analysis for the sample of countries for which we observe at least 1,000 plants that are part of firms with at least 20 employees. The point estimates for the tariff coefficient remain similar in magnitude, and the significance of the estimates is not affected by restricting the sample of countries.

In Table A-8 we use a different econometric methodology and employ a Poisson quasi-maximum likelihood (PQML) estimator to assess the effect of tariffs on vertical integration. The rationale for this exercise is that Santos Silva and Tenreyro (2006) have shown that for log-linear models the OLS estimator gives inconsistent estimates in the presence of heteroscedasticity and have suggested the PQML estimator as an alternative with good statistical properties. Vertical integration is now estimated in levels, which allows to include observations for which the dependent variable is zero, while the explanatory variables are in logs and can thus be interpreted as elasticities. Standard errors are again clustered at the sector-country level. The results remain consistent: depending on the specification, the coefficient for $Tariff_{k,c}$ is always between 0.011 and 0.028 and significant at least at the ten-percent level.

In our analysis, we cluster standard errors at the sector-country level. In unreported regressions, we have alternatively clustered standard errors at the sector and at the country level. In both cases, the coefficient for $Tariff_{k,c}$ remained strongly statistically significant.

Finally, in a series of additional regressions we used an alternative measure of vertical integration, constructed based on all the firm's activities rather than its primary activity: $\bar{V}_{f,k,c} = \frac{1}{N_f} \sum^j V_{f,k,c}^j$, where N_f is the number of industries in which firm f is active. The coefficients for MFN tariffs remained strongly significant but, not surprisingly, they dropped slightly in magnitude. The results of these regressions are available upon request.

4.2 Time-series evidence: China's accession to the WTO

As noted in the introduction, China's accession to the WTO in 2001 is arguably the only major trade liberalization episode that has occurred in the last decade, for which we can use D&B data to construct vertical integration measures. To be accepted as a member of the WTO, China

agreed to undertake a series of important commitments to better integrate in the world economy and offer a more predictable environment for trade and foreign investment in accordance with WTO rules.⁴⁴ In particular, China had to substantially expand market access to goods from foreign countries, reducing its import tariffs from an average of 13.3 percent in 2001 to 6.8 percent by the end of the implementation period.⁴⁵

Our identification strategy is based on the comparison of two periods, a pre-accession one and a post-accession one, to verify whether firm-level vertical integration was reduced by more in those sectors that experienced larger tariff cuts. We thus construct vertical integration measures for all Chinese manufacturing firms that are in the WorldBase dataset for the years 1999 (pre accession) and 2007 (post accession), following the same procedure described in Section 3.3. We use 2007 instead of 2004 as the post-accession period because we expect firms' ownership structure to react slowly to price changes induced by tariff reductions.

Figure 4 provides the histograms of the MFN tariffs applied by China in 1999 and 2007. This is based on those manufacturing sectors for which we observe firms (with at least 20 employees, excluding multinationals) in both years, consisting of almost 29,000 firms that we observe in at least one year. For the sectors in this sample, applied tariffs fell from an average 20 to an average of 9.9 percent between 1999 and 2007, with a lot variation across sectors.⁴⁶ At the same time, the average level of vertical integration for the sample of firms declined from 0.111 to 0.084⁴⁷

In what follows, we examine whether Chinese firms have adjusted their vertical integration structure following WTO accession. To this purpose, we run two sets of regressions. First, we use a very similar specification as in our main test (4), using only those sectors for which we observe some firms in both 1999 and in 2007:

$$V_{f,k,t} = \alpha + \beta_1 \text{Tariff}_{k,t} + \beta_2 \mathbf{X}_{f,k,t} + \delta_k + \delta_t + \epsilon_{f,k,t}. \quad (5)$$

Here, $\mathbf{X}_{f,k,t}$ is again a vector of controls, which includes $Public_{f,t}$, a dummy for public ownership from Worldbase, and $Herfindahl_{k,t}$. We control for $Public_{f,t}$ since public ownership is very common in China and may be correlated with vertical integration. Again, we expect the coefficient

⁴⁴A detailed list of China's commitments can be found in its Protocol of Accession. China's accession implied few trade policy changes for other WTO members, since most of them had already been granting it MFN status.

⁴⁵The implementation period lasted until 2010, though most tariff reductions had to be completed by 2005.

⁴⁶The maximum reduction in tariffs was 415 percent (SIC 3578, Calculating and Accounting Machines), the median reduction was 51 percent. Only in a few sectors, tariffs did not change or actually increased (e.g., SIC 2084 Wines, Brandy and Brandy Spirits).

⁴⁷One may be concerned that tariff levels and reductions may be endogenous to industry characteristics, for example because industries with larger firms, more concentrated industries, or industries with more prevalence of public ownership would lobby for higher initial tariff levels and smaller subsequent tariff reductions. If on the other hand, these sectors are systematically different in terms of vertical integration, one may spuriously obtain negative correlations between vertical integration and tariffs. In our sample, however, this is not the case: the level of tariffs in 1999 is neither significantly correlated with sector-level average firm size, nor with industry concentration or public ownership in the same year. Moreover, changes in tariffs between 1999 and 2007 are also not significantly correlated with the level of the previous variables in 1999.

Figure 4: Chinese import tariffs, 1999 and 2007

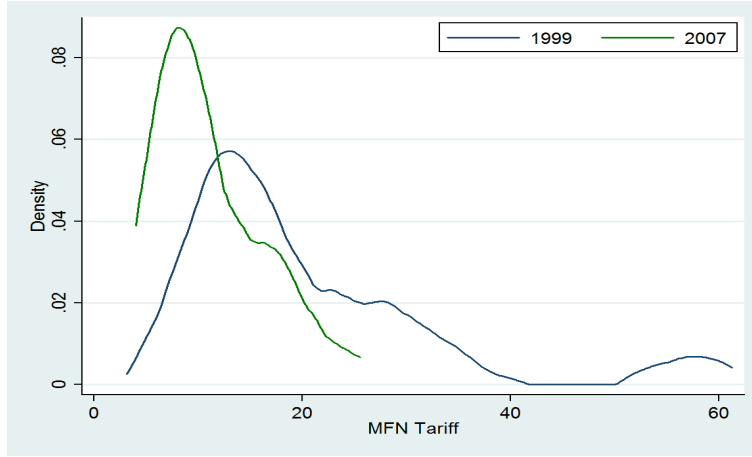
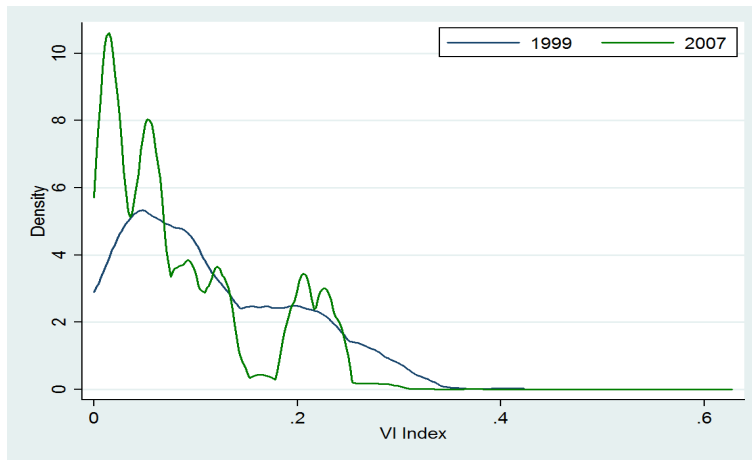


Figure 5: Chinese vertical integration indices, 1999 and 2007



of $Tariff_{k,t}$ to be positive. Notice that, by controlling for sector fixed effects, we exploit the time variation of tariffs within sectors. Specifically, the tariff coefficient is identified by the deviation of firm-level vertical integration from its sector mean that is due to the time variation in tariffs relative to their sector mean. Given that we only consider sectors for which we can observe firms in both periods, sector averages of vertical integration and tariffs are well identified. General trends in vertical integration, which may be due to other reforms that occurred in China over the sample period, are picked up by time dummies.⁴⁸

In a second set of regressions, we focus on within-firm variation in VI indices. Unfortunately, the overlap between the firms sampled in 1999 and 2007 is small. Once we exclude multinationals and plants with less than 20 employees, as we have done in our earlier analysis, there are 145

⁴⁸In these regressions, unobserved firm-specific effects are implicitly assumed to be common for all firms in a given sector.

firms that we can observe in both years. For this set of firms, we take time differences of equation (5) and estimate

$$\Delta V_{f,k} = \alpha + \beta_1 \Delta \text{Tariff}_k + \beta_2 \Delta \mathbf{X}_{f,k} + \Delta \epsilon_{f,k}. \quad (6)$$

Again, we expect the coefficient of ΔTariff_k to be positive. In these regressions, we control not only for changes in firm size, industry concentration and public ownership status, but alternatively also for changes in the degree of state ownership by sector, by including the variable *Privatization*. This measures the fraction of government-owned firms that were privatized in a given sector (at the 2-digit industry level) between 1999 and 2004 and is taken from Bai, Lu and Tao (2009).

Table 5 presents the results for both sets of regressions. Columns (1)-(4) reports the results for the regressions with sector dummies. In all specifications, we find a positive and significant (at the one percent level) coefficient on the tariff variable, implying larger reductions in vertical integration in sectors that have experienced larger tariff reductions. The coefficient magnitude is around 0.03, which is slightly larger than our cross-section estimates. The coefficient of the public-ownership dummy is positive and highly significant, indicating that publicly owned firms are more vertically integrated. Finally, the level of industry concentration has no significant effect on vertical integration.

Turning to the specification in differences, in columns (5)-(10) we obtain similar results. The coefficient of tariff changes is always positive, significant and similar in magnitude to the specification with sector dummies. In column (6) we add changes in industry concentration as control, which leaves the tariff coefficient unaffected. Column (7) adds change in public ownership status as control, which is insignificant and does not change the tariff coefficient. In column (8) we alternatively use *Privatization* as a control, which is again insignificant and also leaves the coefficient of tariffs unchanged. Finally, in columns (9) and (10), we simultaneously control for changes in public ownership structure and changes in industry concentration by adding the Herfindahl index. While changes in tariffs remain positive and significant, changes in industry concentration and changes in public ownership have no significant effects.

5 Trade policy and organizational convergence

The purpose of this section is to assess the validity of the prediction of our model on the relationship between cross-country differences in vertical integration and differences in their trade policies. We construct sector-country-specific measures of vertical integration by regressing firm-level vertical integration on industry-sector dummies and firm size. The estimate for the sector-country dummy gives us a measure of the average level of vertical integration of industry k in country c , denoted by $\hat{V}_{k,c}$.

5.1 Tariff differences

We first examine whether cross-country differences in sectoral organizational structure are affected by differences in tariffs. Our model predicts that, for a given country-pair cc' , organizational differences should be smaller for sectors characterized by similar levels of protection. To verify this, we estimate the following model:

$$|\hat{V}_{k,c} - \hat{V}_{k,c'}| = \alpha + \beta_1 |\text{Tariff}_{k,c} - \text{Tariff}_{k,c'}| + \beta_2 |\mathbf{X}_{k,c} - \mathbf{X}_{k,c'}| + \delta_k + \delta_{c,c'} + \epsilon_{k,c,c'}. \quad (7)$$

The dependent variable is the absolute difference between countries c and c' in the estimated vertical integration indices for sector k . All differences are expressed in logs. The main regressor of interest is the (log of the) absolute difference between these countries' MFN tariffs in sector k . The term $|\mathbf{X}_{k,c} - \mathbf{X}_{k,c'}|$ captures differences in other sector-country characteristics that may affect the degree of organizational convergence. Note that, because we are including dyad fixed effects ($\delta_{c,c'}$), β_1 is identified by the cross-sectoral variation in the tariff difference for a given country pair. To allow for correlation of the errors between sectors for a given country pair, we cluster standard errors by dyad.

In the first column of Table 6, the only explanatory variable is the log-difference in MFN tariffs. In line with our predictions, we find that, for a given country-pair differences in sectoral vertical integration indices are significantly (at the one percent level) larger in sectors in which differences in MFN tariffs are larger. A 100 percent increase in the difference in MFN tariffs leads to a roughly 0.9 percent increase in the difference in vertical integration indices.

The second column adds interactions between *Capital Intensity* and differences in *Financial Development* and *Legal Quality*. The coefficient on the difference in MFN tariffs remains relatively unchanged in magnitude and is significant at the 5 percent level.

In the middle and right panel of Table 6, we report the results of robustness checks using different samples. As done for the results presented in Section 4, we first try adding multinationals to our main sample, and then restrict the sample to countries for which we observe at least 1,000 plants that are part of firms with at least 20 employees. Adding multinationals to the analysis, we find that the impact of tariff differences on differences in vertical integration remains positive and highly significant in all specifications. With respect to the results on organizational convergence when the sample size is restricted, tariff differences continue to have a significant positive effect on differences in vertical integration in all specifications.

5.2 Regional Trade Agreements

In the remainder of this section, we examine the relation between the degree of sectoral organizational convergence and common membership in a regional trade agreement. In contrast to the previous regressions, a causal interpretation of these regression results is more difficult, since it

is possible that countries that are generally more similar are more likely to form RTAs.

To assess the validity of our final empirical prediction, we explore how RTAs affect the extent to which two countries have similar vertical integration structures at the industry level.

$$|\hat{V}_{k,c} - \hat{V}_{k,c'}| = \alpha + \beta_1 RTA_{c,c'} + \beta_2 \mathbf{X}_{c,c'} + \delta_k + \delta_c + \delta_{c'} + \epsilon_{k,c,c'}. \quad (8)$$

The dependent variable is as in model (7), expressed as before in logs. The main regressor of interest is now $RTA_{c,c'}$, a dummy that equals one if countries c and c' are members of the same RTA. The vector $\mathbf{X}_{c,c'}$ captures a series of bilateral controls, such as dummies for contiguity, common language, and colonial relationship, as well as variables that capture the distance between countries, and differences in GDP (differences expressed in logs of absolute values). Finally, we include sector fixed effects (δ_k) and country fixed effects (δ_c and $\delta_{c'}$). Standard errors are clustered by country-pair.

Table 7 presents the results for this regression. The left panel presents the estimates obtained when using our main sample. In the first column of the left panel, in which we include only a dummy for regional trade agreements, the coefficient of RTA is negative and significant at the one-percent level. This implies that the difference in vertical integration indices for a country pair in an RTA is about 9.2 percent smaller than for a country pair without an RTA. The results for an alternative specification, which separates customs unions (CUs) from free trade areas (FTAs), are presented in column two. As expected, the quantitative impact on organizational convergence is greater for CUs than for FTAs. Country pairs that belong to the same CU have a approximately 18.5% smaller difference in organizational structure than country pairs without a RTA, while membership to FTAs has no significant impact on differences in organizational structure. In the third column, we keep the coefficients for CUs and FTAs separate and add a series of bilateral control variables that may have an impact on similarity of organizational structure. The coefficient for CUs is reduced somewhat in size, but remains significant at the 10 percent level. Contiguity and common language have a significant negative effect on the difference in vertical integration indices, while differences in GDP have a significant positive effect. Colonial relationship and distance do not significantly affect the degree of organizational convergence.

The middle and right panels of Table 7 show that the results for regional trade agreements are also robust to using different samples. Membership in RTAs, and CUs in particular, continues to reduce differences in vertical integration among member countries when we include multinationals in our analysis, as shown in columns (4)-(6). The results continue to hold when we restrict the sample to the subset of countries for which we have more than 1000 observations, though the coefficient for CUs is insignificant in column (9), where we control for other country-pair variables. However, in this case we have only 33 country pairs instead of 101.⁴⁹

⁴⁹Note that we have more countries (101 instead of 80) than in the tariff regressions. This is because information

6 Conclusions

Traditional organizational economics has studied ownership decisions without much regard for markets. Given technology and contractibility, there is a uniquely optimal organizational design, the one that delivers the goods at least cost. Demand plays no role.

This paper provides evidence for the more recent view that markets do matter and that demand is an essential determinant of firm boundaries. Demand affects product prices, prices affect profitability, and profitability affects the tradeoffs organization designers face when determining ownership structures. This causal link is captured by a model in which vertical integration generates more output than non-integration because of its comparative advantage in coordinating operating decisions. But it imposes higher private costs on enterprise managers, forcing them to accommodate to common ways of doing things. At low prices, the productivity gains from integrating have little value, and managers choose non-integration. At high prices, the relative value of coordination increases, favoring integration.

To assess the validity of the model's predictions, we examine the organizational effects of trade policy, which provides a source of price variation that is exogenous to firms' ownership decisions. We use a new dataset that enables us to construct firm-level vertical integration indices for a large set of countries and industries. To study the link between product prices and firm boundaries, we exploit cross-country and cross-sectoral differences in applied MFN tariffs, as well as time variation in the degree of protection faced by firms. In line with the model's predictions, we find that market conditions — in particular the level of product prices — do affect vertical integration: higher tariffs on final goods lead firms to be more vertically integrated, and this effect is stronger for non-exporting firms, which are more sensitive to domestic prices, and for sectors in which domestic prices are expected to be more sensitive to import tariffs.

Our empirical results thus lend support to a simple model of the determination of firm boundaries. As such, they have implications beyond the positive theory of the firm. If integration generates more output than non-integration, as it does in our model, then organizational choices affect consumer welfare and aggregate economic performance (Legros and Newman (2009); Conconi, Legros and Newman (2012)). This calls for a reassessment of the effects not only of tariffs, but of any price-distorting policy, in light of its potential impact on the organization and productivity of firms.

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Table 1: Tariffs and vertical integration

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Tariff _{k,c}	0.0203*** (0.0061)	0.0034 (0.0088)	0.0160** (0.0063)	0.0042 (0.0080)	0.0202*** (0.0600)	0.0035 (0.0086)	0.1600*** (0.0061)	0.005 (0.0081)
Domestic _f		-0.0926*** (0.0108)				-0.0923*** (0.0109)		
Tariff _{k,c} x Domestic _f		0.0214*** (0.0054)				0.0212*** (0.0054)		
Import-competing _{k,c}			-0.0362*** (0.0135)				-0.0351*** (0.0134)	
Tariff _{k,c} x Import-competing _{k,c}			0.0155** (0.0070)				0.0148** (0.0070)	
MFN share _{k,c}				-0.0237 (0.0190)				-0.0215 (0.0190)
Tariff _{k,c} x MFN share _{k,c}				0.0245*** (0.0074)				0.0230*** (0.0075)
Capital Intensity _k x Financial Development _c					0.0322** (0.0142)	0.0321** (0.0144)	0.0297** (0.0148)	0.0293** (0.0145)
Capital Intensity _k x Legal Quality _c					-0.0833 (0.0564)	-0.0823 (0.0573)	-0.0774 (0.0589)	-0.0735 (0.0572)
# Observations	196,586	196,586	196,586	196,586	196,586	196,586	196,586	196,586
# Sectors	386	386	386	386	386	386	386	386
R ²	0.117	0.119	0.117	0.117	0.117	0.119	0.117	0.117
Sector Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES
Country Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES
Cluster	Country- sector	Country- sector	Country- sector	Country- sector	Country- sector	Country- sector	Country- sector	Country- sector

Notes: Robust standard errors clustered at the sector-country level in parentheses denoting *** 1%, **5%, and *10% significance. The sample includes firms ≥ 20 employees in the manufacturing sector, excluding MNCs. Dependent variable: log of one plus $V_{f,k,c}$, the vertical integration index of firm f , with primary sector k , located in country c . Explanatory variables are in logs, except MFN tariffs, where we use log of one plus the tariff. The variable $Tariff_{k,c}$ is the MFN tariff imposed by country c in sector k . The dummy variables $Domestic_f$ and $Import-competing_{k,c}$ are alternative ways to capture firms that only sell in the domestic market. $Domestic_f$ identifies firms that do not export. $Import-competing_{k,c}$ identifies the top 25 percent most import-competing, as measured by a country's total imports/exports. $MFN\ share_{k,c}$ measures the fraction of imports of good k by country c that are subject to the MFN tariff, i.e., do not originate from countries with which country c has a regional trade agreement. $Capital\ Intensity_k$ is the total capital expenditures divided by value added. The variable $Financial\ Development_c$ measures private credit by deposit money banks and other financial institutions as a fraction of GDP. The variable $Legal\ Quality_c$ proxies for the quality of a country's institutions.

Table 2: Tariffs and vertical integration, competitive industries

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Homogeneous large sectors	Homogeneous large sectors with low tariff	Homogeneous large sectors with low tariff	Homogeneous large sectors with low tariff	Homogeneous large sectors with foreign presence	Homogeneous large sectors with foreign presence	Homogeneous large sectors with low concentration	Homogeneous large sectors with low concentration
Tariff _{k,c}	0.0290** (0.0117)	0.0292** (0.0117)	0.0380** (0.0149)	0.0381** (0.0154)	0.0316** (0.0145)	0.0315** (0.0144)	0.0747*** (0.0228)	0.0982*** (0.0216)
Capital Intensity _k x Financial Development _c		0.0063 (0.0524)		0.0203 (0.0436)		- 0.0035 (0.4420)		0.68 (0.1610)
Capital Intensity _k x Legal Quality _c		-0.0615 (0.1950)		-0.2330 (0.1440)		0.0499 (0.1870)		1.027 (0.7290)
Observations	13,095	13,095	11,279	11,279	10,918	10,918	8,539	8,539
# Sectors	56	56	54	54	53	53	37	37
R ²	0.073	0.073	0.052	0.052	0.068	0.068	0.047	0.047
Sector Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES
Country Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES
Cluster	Country- sector	Country- sector	Country- sector	Country- sector	Country- sector	Country- sector	Country- sector	Country- sector

Notes: Robust standard errors clustered at the sector-country level are in parentheses; denoting *** 1%, **5%, and *10% significance. The sample includes firms ≥ 20 employment in the manufacturing sector, excluding MNCs. Dependent variable: log of one plus $V_{f,k,c}$, the vertical integration index of firm f , with primary sector k , located in country c . Explanatory variables are in logs, with the exception of MFN tariffs, where we use log of one plus the tariff. $Tariff_{k,c}$ is the MFN tariff imposed by country c in sector k . $Capital Intensity_k$ is the total capital expenditures divided by value added. The variable $Financial Development_c$ measures private credit by deposit money banks and other financial institutions as a fraction of GDP. The variable $Legal Quality_c$ proxies for the quality of a country's institutions. In all columns, the sample is restricted to sectors that satisfy the following two restrictions: they are classified by Rauch (1999) as homogeneous (i.e., $Homogeneous_k = 1$); and at least 20 domestic firms operate in the sector. Columns (3)-(4) include only sectors in which $Tariff_{k,c} < 10\%$. Columns (5)-(6) include only sectors in which some foreign firms operate in the domestic market. In columns (7)-(8), the sample is restricted to sectors in which $Herfindahl_{k,c} \leq 0.1$.

Table 3: Tariffs and vertical integration, competitive industries

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Homogeneous large sectors		Homogeneous large sectors with low tariff		Homogeneous large sectors with foreign presence		Homogeneous large sectors with low concentration	
Tariff _{k,c}	0.0257*** (0.0083)	0.0248*** (0.0084)	0.0345*** (0.0085)	0.0341*** (0.0084)	0.0363*** (0.0101)	0.0363*** (0.0102)	0.0648*** (0.0112)	0.0639*** (0.0116)
Capital Intensity _k x Financial Development _c		0.0216 (0.0248)		0.0041 (0.0245)		0.0560 (0.0367)		-0.0267 (0.0299)
Capital Intensity _k x Legal Quality _c		-0.1240 (0.0875)		-0.0952 (0.1170)		- 0.3018** (0.1306)		-0.0840 (0.1400)
Observations	78,437	78,437	69,823	69,823	69,980	69,980	50,315	50,315
# Sectors	337	337	328	328	309	309	234	234
R ²	0.106	0.107	0.099	0.099	0.111	0.111	0.087	0.087
Sector Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES
Country Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES
Cluster	Country- sector	Country- sector	Country- sector	Country- sector	Country- sector	Country- sector	Country- sector	Country- sector

Notes: Robust standard errors clustered at the sector-country level are in parentheses; denoting *** 1%, **5%, and *10% significance. The sample includes firms ≥ 20 employment in the manufacturing sector, excluding MNCs. Dependent variable: log of one plus $V_{f,k,c}$, the vertical integration index of firm f , with primary sector k , located in country c . Explanatory variables are in logs, with the exception of MFN tariffs, where we use log of one plus the tariff. $Tariff_{k,c}$ is the MFN tariff imposed by country c in sector k . $Capital Intensity_k$ is the total capital expenditures divided by value added. The variable $Financial Development_c$ measures private credit by deposit money banks and other financial institutions as a fraction of GDP. The variable $Legal Quality_c$ proxies for the quality of a country's institutions. In all columns, the sample is restricted to sectors that satisfy the following two restrictions: they are classified as homogeneous if import-demand elasticity is higher than the median for the country (i.e., $Homogeneous_{k,c} = 1$); and at least 20 domestic firms operate in the sector. Columns (3)-(4) include only sectors in which $Tariff_{k,c} < 10\%$. Columns (5)-(6) include only sectors in which some foreign firms operate in the domestic market. In columns (7)-(8), the sample is restricted to sectors in which $Herfindahl_{k,c} \leq 0.1$.

Table 4: Tariffs and vertical integration, controlling for possible omitted variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Tariff _{k,c}	0.0203*** (0.0061)	0.0202*** (0.0060)	0.0203*** (0.0074)	0.0190*** (0.0058)	0.0214*** (0.0065)	0.0210*** (0.0059)	0.0212*** (0.0059)	0.0189*** (0.0062)
Capital Intensity _k x Financial Development _c		0.0322** (0.0142)	0.0333** (0.0161)	0.0387** (0.0154)	0.0425** (0.0176)	0.0401** (0.0187)	0.0319** (0.0146)	0.0513** (0.0235)
Capital Intensity _k x Legal Quality _c		-0.0833 (0.0564)	-0.0785 (0.0617)	-0.100* (0.0604)	-0.106 (0.0682)	-0.103 (0.0711)	-0.0836 (0.0577)	-0.132 (0.0895)
Input Tariff _{k,c}			0.0391*** (0.0142)		0.0330** (0.0141)			0.0480*** (0.0167)
Export Tariff _{k,c}				0.00252 (0.0052)	-0.0038 (0.0060)			-0.00548 (0.0063)
Herfindahl _{k,c}						0.0128 (0.0228)		0.0143 (0.0313)
Size _f							0.0352*** (0.0075)	0.0455*** (0.0113)
# Observations	196,586	196,586	154,915	185,630	146,228	178,199	196,586	133,545
# Sectors	386	386	311	386	311	386	386	311
R ²	0.117	0.117	0.119	0.123	0.125	0.117	0.122	0.132
Sector Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES
Country Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES
Cluster	Country- sector	Country- sector	Country- sector	Country- sector	Country- sector	Country- sector	Country- sector	Country- sector

Notes: Robust standard errors clustered at the sector-country level are in parentheses denoting *** 1%, **5%, and *10% significance. The sample includes firms ≥ 20 employment in the manufacturing sector, excluding MNCs. Dependent variable: log of one plus $V_{f,k,c}$, the vertical integration index of firm f , with primary sector k , located in country c . Explanatory variables are in logs, with the exception of output tariffs, input tariff and export tariff, where we use log of one plus the tariff. $Tariff_{k,c}$ is the MFN tariff imposed by country c in sector k . $Capital Intensity_k$ is the total capital expenditures divided by value added. The variable $Financial Development_c$ measures private credit by deposit money banks and other financial institutions as a fraction of GDP. The variable $Legal Quality_c$ proxies for the quality of a country's institutions. $Import Tariff_{k,c}$ is the tariff imposed by country c on inputs of good k . $Export Tariff_{k,c}$ is the tariff faced by firms exporting good k from country c . $Herfindahl_{k,c}$ is the Herfindahl index of sector k in country c . In columns (7)-(8) we report 2SLS estimates. $Size_f$ measures firm size (instrumented with employment predicted with sector-country dummies).

Table 5: Tariffs and vertical integration, China's accession to the WTO

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Tariff _{k,t}	0.0313*** (0.0096)	0.0356** (0.0160)	0.0313*** (0.0096)	0.0357** (0.0160)						
Herfindahl _{k,t}		-0.0040 (0.0113)		-0.0040 (0.0113)						
Public _{f,t}			0.0055*** (0.0010)	0.0059*** (0.0015)						
Change Tariff _k					0.0364* (0.0202)	0.0459* (0.0234)	0.0364* (0.0203)	0.0364* (0.0205)	0.0456* (0.0234)	0.0451* (0.0230)
Change Herfindahl _k						-0.0371 (0.0292)			-0.0307 (0.0297)	-0.0406 (0.0301)
Change Public _f							0.0007 (0.0135)		-0.0351 (0.0320)	
Privatization _k								-0.0351 (0.0798)		0.0574 (0.1180)
# Observations	28,928	13,682	28,928	13,682	145	75	145	145	75	75
# Sectors	88	88	88	88	88	75	88	88	75	75
R ²	0.921	0.902	0.921	0.902	0.042	0.087	0.042	0.042	0.104	0.089
Sector Fixed Effect	YES	YES	YES	YES	NO	NO	NO	NO	NO	NO
Time Fixed Effect	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Cluster	Sector	Sector	Sector	Sector	Sector	Sector	Sector	Sector	Sector	Sector

Notes: Robust standard errors clustered at the sector level in parentheses denoting *** 1%, **5%, and *10% significance. In columns (1)- (4), the dependent variable is the log of one plus $V_{f,k,c}$, the vertical integration index of firm f , with primary sector k , located in country c ; in columns (5)-(10), it is the change in the log of one plus the vertical integration index between 1999 (pre accession) and 2007 (post accession). The sample includes Chinese firms observed in 1999 and 2007 ≥ 20 employees in the manufacturing sector, excluding MNCs. $Tariff_k$ is the log of (one plus) MFN tariff applied by China in sector k . $Public_f$ is a firm-level dummy for public ownership, $Privatization_k$ is a sector-level measure for the amount of privatization and $Herfindahl_k$ is the Herfindahl index for sector k .

Table 6: Tariff differences and organizational convergence

	(1)	(2)	(3)	(4)	(5)	(6)
	Main Sample		Including Multinationals		Countries $\geq 1,000$ plants	
Diff. Tariffs $_{k,c,c'}$	0.0089*** (0.0034)	0.0086** (0.0037)	0.0199*** (0.0030)	0.0208*** (0.0034)	0.0091** (0.0040)	0.0070* (0.0043)
Cap. Intensity $_k$ x diff. Fin. Development $_{c,c'}$		0.0020 (0.0066)		0.0029 (0.0066)		-0.0118 (0.0075)
Cap. Intensity $_k$ x diff. Legal Quality $_{k,c,c'}$		0.0419*** (0.0062)		0.0477*** (0.0063)		0.0568*** (0.0074)
# Observations	212,770	171,908	233,105	187,182	142,573	121,709
# Country pairs	80	80	80	80	33	33
R^2	0.164	0.164	0.146	0.147	0.171	0.172
Sector Fixed Effect	YES	YES	YES	YES	YES	YES
Diadic Fixed Effect	YES	YES	YES	YES	YES	YES
Cluster	Country-pair	Country-pair	Country-pair	Country-pair	Country-pair	Country-pair

Notes: Robust standard errors clustered at the country-pair level in parentheses denoting *** 1%, **5%, and *10% significance. Dependent variable: log of (one plus) the absolute difference between countries c and c' in the estimated vertical integration index of firms with primary sector k . In columns (1)-(3) the sample include firms ≥ 20 employees in the manufacturing sector, excluding MNCs; in columns (4)-(6), the sample includes MNCs; in columns (7)-(9), the sample includes firms ≥ 20 employment in the manufacturing sector, excluding MNCs, located in countries with at least 1,000 plants.

Table 7: Regional Trade Agreements and organizational convergence

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Main Sample			Including Multinationals			Countries \geq 1000 plants		
RTA _{c,c'}	-0.0921*** (0.0235)			-0.0874*** (0.0205)			-0.0474 (0.0299)		
Customs Union _{c,c'}		-0.185*** (0.0376)	-0.0760* (0.046)		-0.177*** (0.0323)	-0.0748* (0.0396)		-0.127*** (0.0489)	-0.0132 (0.061)
Free Trade Area _{c,c'}		-0.0404 (0.0266)	0.0203 (0.0264)		-0.0356 (0.0234)	0.0222 (0.0236)		-0.00944 (0.032)	0.0531 (0.0336)
Distance _{c,c'}			0.0188 (0.0146)			0.0220* (0.0129)			0.0145 (0.0211)
Contiguity _{c,c'}			-0.196*** (0.0754)			-0.155*** (0.0641)			-0.237*** (0.0852)
Common Language _{c,c'}			-0.119*** (0.0313)			-0.109*** (0.0275)			-0.159*** (0.0433)
Colonial Relationship _{c,c'}			0.0663 (0.0421)			0.0631* (0.0348)			0.000 (0.0746)
Difference GDP _{c,c'}			0.0389*** (0.0087)			0.0357*** (0.0074)			0.0280** (0.0121)
# Observations	299,649	299,649	299,649	328,756	328,756	328,756	210,475	210,475	210,475
# Country pairs	101	101	101	101	101	33	33	33	33
R ²	0.109	0.109	0.111	0.09	0.091	0.093	0.118	0.119	0.122
Sector Fixed Effect	YES	YES	YES	YES	YES	YES	YES	YES	YES
Country Fixed Effect	YES	YES	YES	YES	YES	YES	YES	YES	YES
Cluster	Country-pair	Country-pair	Country-pair	Country-pair	Country-pair	Country-pair	Country-pair	Country-pair	Country-pair

Notes: Robust standard errors clustered at the country-pair level in parentheses denoting *** 1%, **5%, and *10% significance. Dependent variable: log of (one plus) the absolute difference between countries c and c' in the estimated vertical integration index in the primary sector k . In columns (1)-(3), the sample includes firms ≥ 20 employees in the manufacturing sector, excluding MNCs; in columns (4)-(6), the sample includes MNCs; in columns (7)-(9), the sample includes firms ≥ 20 employment in the manufacturing sector, excluding MNCs, located in countries with at least 1,000 plants.

Appendix

Table A-1: Sample frame

WB code	Freq.	Percent	Cum.	WB code	Freq.	Percent	Cum.
ALB	4	0.00	0.00	MAR	603	0.31	61.52
ARG	998	0.51	0.51	MDG	18	0.01	61.53
AUS	5,079	2.58	3.09	MEX	2,641	1.34	62.87
AUT	1,464	0.74	3.84	MLI	13	0.01	62.88
BEL	928	0.47	4.31	MOZ	16	0.01	62.89
BEN	4	0.00	4.31	MUS	46	0.02	62.91
BFA	8	0.00	4.32	MWI	2	0.00	62.91
BGD	6	0.00	4.32	MYS	3,101	1.58	64.49
BGR	360	0.18	4.50	NER	1	0.00	64.49
BOL	55	0.03	4.53	NIC	21	0.01	64.50
BRA	5,594	2.85	7.38	NLD	676	0.34	64.84
CAN	7,469	3.80	11.18	NOR	847	0.43	65.27
CHE	1,150	0.58	11.76	NZL	959	0.49	65.76
CHL	454	0.23	11.99	OMN	67	0.03	65.80
COL	550	0.28	12.27	PAK	4	0.00	65.80
CRI	176	0.09	12.36	PER	888	0.45	66.25
CZE	1,736	0.88	13.24	PHL	351	0.18	66.43
DEU	19,302	9.82	23.06	PNG	4	0.00	66.43
DNK	425	0.22	23.28	POL	446	0.23	66.66
ECU	183	0.09	23.37	PRT	5,433	2.76	69.42
ESP	2,322	1.18	24.55	PRY	50	0.03	69.45
FIN	448	0.23	24.78	ROM	614	0.31	69.76
FRA	8,965	4.56	29.34	RWA	2	0.00	69.76
GAB	3	0.00	29.34	SAU	314	0.16	69.92
GBR	6,622	3.37	32.71	SEN	47	0.02	69.94
GHA	81	0.04	32.75	SGP	790	0.40	70.35
GRC	2,231	1.13	33.89	SLV	129	0.07	70.41
GTM	93	0.05	33.93	SWE	689	0.35	70.76
HND	77	0.04	33.97	TGO	4	0.00	70.76
HUN	2,346	1.19	35.17	THA	507	0.26	71.02
IDN	233	0.12	35.29	TTO	79	0.04	71.06
IND	2,592	1.32	36.60	TUN	991	0.50	71.57
IRL	587	0.30	36.90	TUR	2,557	1.30	72.87
ISR	1,538	0.78	37.68	TZA	24	0.01	72.88
ITA	8,426	4.29	41.97	UGA	37	0.02	72.90
JAM	43	0.02	41.99	URY	114	0.06	72.96
JOR	148	0.08	42.07	USA	52,917	26.92	99.87
JPN	34,441	17.52	59.59	VEN	231	0.12	99.99
KEN	134	0.07	59.66	ZAF	1	0.00	99.99
KOR	3,060	1.56	61.21	ZMB	17	0.01	100.00
				Total	196,586	100.00	

Notes: Data from 2004 WorldBase data, Dun & Bradstreet. Sample includes firms ≥ 20 employees in the manufacturing sector, excluding MNCs.

Table A-2: Sample frame: restricted sample

WB code	Freq.	Percent	Cum.
ARG	998	0.53	0.53
AUS	5,079	2.68	3.21
AUT	1,464	0.77	3.98
BEL	928	0.49	4.47
BRA	5,594	2.95	7.43
CAN	7,469	3.95	11.37
CHE	1,150	0.61	11.98
CZE	1,736	0.92	12.9
DEU	19,302	10.2	23.09
DNK	425	0.22	23.32
ESP	2,322	1.23	24.54
FIN	448	0.24	24.78
FRA	8,965	4.74	29.52
GBR	6,622	3.5	33.01
GRC	2,231	1.18	34.19
HUN	2,346	1.24	35.43
IND	2,592	1.37	36.8
IRL	587	0.31	37.11
ISR	1,538	0.81	37.92
ITA	8,426	4.45	42.37
JPN	34,441	18.19	60.56
KOR	3,060	1.62	62.18
MEX	2,641	1.39	63.58
MYS	3,101	1.64	65.21
NLD	676	0.36	65.57
NOR	847	0.45	66.02
NZL	959	0.51	66.52
PRT	5,433	2.87	69.39
SGP	790	0.42	69.81
SWE	689	0.36	70.18
TUN	991	0.52	70.7
TUR	2,557	1.35	72.05
USA	52,917	27.95	100
Total	189,324	100	

Notes: Data from 2004 WorldBase data, Dun & Bradstreet. Sample includes firms ≥ 20 employment in the manufacturing sector located in countries with at least 1000 plants, excluding MNCs.

Table A-3: Summary statistics

	Median	Mean	Std. Dev.	N
Vertical Integration Index _f	0.044	0.063	0.063	196,586
Size _f	38.000	98.936	472.395	196,586
Domestic _f	0	0.233	0.423	196,586
Import-competing _{k,c}	0.702	0.705	0.571	196,586
Tariff _{k,c}	2.480	4.849	7.253	196,586
Input Tariff _{k,c}	2.546	3.994	4.954	154,915
Export Tariff _{k,c}	5.654	6.611	5.039	185,630
MFN Share _{k,c}	0.564	0.545	0.351	196,586
Herfindahl _{k,c}	0.053	0.132	0.188	178,199
Homogeneous1 _k	0	0.081	0.273	196,586
Homogeneous2 _{k,c}	0	0.491	0.499	173,587
Capital Intensity _k	-2.857	-2.902	0.458	387
Financial Development _c	0.332	0.554	0.479	80
Legal Quality _c	0.545	0.583	0.209	80
Difference Ver. Int. Index _{k,c,c'}	-1.593	-1.707	1.614	299,649
Regional Trade Agreement _{c,c'}	0.000	0.263	0.440	299,649
Free Trade Agreement _{c,c'}	0.000	0.148	0.355	299,649
Customs Union _{c,c'}	0.000	0.115	0.319	299,649
Distance _{c,c'}	9.017	8.629	0.965	299,649
Contiguity _{c,c'}	0.000	0.041	0.139	299,649
Colonial Relationship _{c,c'}	0.000	0.020	0.178	299,649
Common Language _{c,c'}	0.000	0.122	0.328	299,649
Difference GDP _{c,c'}	0.450	0.201	1.812	299,649

Sources: Vertical Integration Index_f, Size_f, Domestic_f and Herfindahl_{k,c} constructed using plant-level data from 2004 WorldBase, Dun & Bradstreet. Tariff_{k,c} from TRAINS/WTO; Input Tariff_{k,c}, Export Tariff_{k,c}, and MFN Share_{k,c} constructed using data from TRAINS/WTO and COMTRADE. Import-Competing_{k,c} constructed using data from COMTRADE. Information on regional trade agreements from the WTO. Homogeneous1_k from Rauch (1999), Homogeneous2_{k,c} constructed using data from Broda, Greenfield and Weinstein (2006). Capital Intensity_k from NBER-CES manufacturing industry database. Financial Development_c from Beck, Demigurc-Kunt and Levine (2006). Legal Quality_c from Kaufmann, Kraay, and Mastruzzi (2004). GDP_c from World Bank. Contiguity_{c,c'}, Colonial Relationship_{c,c'}, and Common Language_{c,c'} from CEPII. Vertical Integration Index_f, Tariff_{k,c}, Input Tariff_{k,c}, Export Tariff_{k,c}, Size_f, Herfindahl_{k,c}, and MFN Share_{k,c} are in levels; all other variables (with the exception of indicator variables) are in logs.

Table A-4: Vertical integration by 2-digit SIC industry

Industry	SIC	VI index
TEXTILES	22	0.115
APPAREL	23	0.111
CHEMICALS	28	0.098
PRIMARY METAL PRODUCTS	33	0.091
ELECTRICAL MACHINERY	36	0.089
TRANSPORTATION EQUIPMENT	37	0.067
PETROLEUM REFINING	29	0.062
LEATHER	31	0.062
RUBBER AND PLASTICS	30	0.060
MACHINERY, EXCEPT ELECTRICAL	35	0.060
MANUFACTURING NEC	39	0.059
LUMBER AND WOOD PRODUCTS	24	0.059
FOOD AND KINDRED PRODUCTS	20	0.056
TOBACCO MANUFACTURES	21	0.053
STONE, CLAY, GLASS, & CONCRETE	32	0.049
FABRICATED METAL PRODUCTS	34	0.039
PRINTING AND PUBLISHING	27	0.039
SCIENTIFIC INSTRUMENTS	38	0.036
PAPER AND ALLIED PRODUCTS	26	0.034
FURNITURE AND FIXTURES	25	0.022

Notes: Data from 2004 WorldBase data, Dun & Bradstreet. Sample includes firms ≥ 20 employment in the manufacturing sector, excluding MNCs.

Table A-5: Sample comparisons: vertical integration indices

	Main sample	Countries $\geq 1,000$ plants	Including MNCs
# of plants	225,212	217,723	279,869
# of connected plants	29,214	29,008	64,789
# of multi-plant firms	6,830	6,768	10,224
# of single-plant firms	189,756	182,556	205,062
# of firms	196,586	189,324	215,286
# of MNCs	0	0	18,700
Mean, Vertical integration index	0.0627	0.0640	0.0640
Median, Vertical integration index	0.0437	0.0439	0.0439
Min, Vertical integration index	0.0000	0.0000	0.0000
Max, Vertical integration index	0.8333	0.8333	0.8333
St. dev., Vertical integration index	0.0633	0.0623	0.0645

Notes: Plant- and firm-level data from 2004 WorldBase data, Dun & Bradstreet. All samples include firms ≥ 20 employees in manufacturing sectors. Column (1) is the main sample; columns (2) and (3) are samples used in robustness checks.

Table A-6: Tariffs and vertical Integration, including multinationals

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Tariff _{k,c}	0.0164*** (0.0062)	0.0162*** (0.0061)	0.0164** (0.007)	0.0146** (0.0057)	0.0166*** (0.0063)	0.0169*** (0.0061)	0.0176*** (0.0060)	0.0156*** (0.0061)
Multinational _f	0.0661*** (0.0144)	0.0662*** (0.0144)	0.112*** (0.0179)	0.0656*** (0.0135)	0.113*** (0.0170)	0.0817*** (0.0159)	-0.00735 (0.0125)	0.005 (0.0193)
Capital Intensity _k x Financial Development _c		0.0304** (0.0143)	0.0275* (0.0167)	0.0388** (0.0156)	0.0387** (0.0183)	0.0378** (0.0184)	0.0293** (0.0148)	0.0449* (0.0246)
Capital Intensity _k x Legal Quality _c		-0.0973* (0.0549)	-0.078 (0.0644)	-0.121** (0.0595)	-0.114 (0.0712)	-0.118* (0.0676)	-0.0976* (0.0566)	-0.133 (0.0925)
Input Tariff _{k,c}			0.0394*** (0.0128)		0.0357*** (0.0135)			0.0491*** (0.0167)
Export Tariff _{k,c}				0.001 (0.0049)	-0.00652 (0.0057)			-0.0079 (0.0064)
Herfindahl _{k,c}						0.0252 (0.0227)		0.0202 (0.0305)
Size _f							0.0499*** (0.0096)	0.0764*** (0.0124)
# Observations	215,286	215,286	168,580	203,862	159,537	193,938	215,286	144,919
# Sectors	386	386	311	386	311	386	386	311
R ²	0.105	0.105	0.113	0.11	0.118	0.107	0.122	0.132
Sector Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES
Country Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES
Cluster	Country- sector	Country- sector	Country- sector	Country- sector	Country- sector	Country- sector	Country- sector	Country- sector

Notes: Robust standard errors clustered at the country-pair level are in parentheses denoting *** 1%, **5%, and *10% significance. The sample includes firms ≥ 20 employment in the manufacturing sector, including MNCs. Dependent variable: log of one plus $V_{f,k,c}$, the vertical integration index of firm f , with primary sector k , located in country c . Explanatory variables are in logs, with the exception of output tariffs, input tariffs and export tariffs, where we use log of one plus the tariff. Explanatory variables are in logs, with the exception of output tariffs, input tariff and export tariff, where we use log of one plus the tariff. $Tariff_{k,c}$ is the log of the MFN tariff imposed by country c in sector k . $Capital Intensity_k$ is the total capital expenditures divided by value added. The variable $Financial Development_c$ measures private credit by deposit money banks and other financial institutions as a fraction of GDP. The variable $Legal Quality_c$ proxies for the quality of a country's institutions. $Import Tariff_{k,c}$ is the tariff imposed by country c on inputs of good k . $Export Tariff_{k,c}$ is the tariff faced by firms exporting good k from country c . $Herfindahl_{k,c}$ is the Herfindahl index of sector k in country c . In columns (7)-(8) we report 2SLS estimates. $Size_f$ measures firm size (instrumented with employment predicted with sector-country dummies).

Table A-7: Tariffs and vertical integration, countries $\geq 1,000$ plants

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Tariff _{k,c}	0.0202*** (0.0059)	0.0200*** (0.0057)	0.0184*** (0.0067)	0.0183*** (0.0056)	0.0187*** (0.0060)	0.0213*** (0.0059)	0.0212*** (0.0057)	0.0181*** (0.0063)
Capital Intensity _k x Financial Development _c		0.0377** (0.0169)	0.0401** (0.0192)	0.0411** (0.0171)	0.0456** (0.0197)	0.0425** (0.0207)	0.0367** (0.0174)	0.0533** (0.0255)
Capital Intensity _k x Legal Quality _c		-0.103 (0.0722)	-0.104 (0.0807)	-0.115 (0.0729)	-0.124 (0.0834)	-0.114 (0.0854)	-0.0996 (0.0742)	-0.138 (0.1060)
Input Tariff _{k,c}			0.0430*** (0.0140)		0.0378** (0.0148)			0.0484*** (0.0177)
Export Tariff _{k,c}				0.00243 (0.0055)	-0.00448 (0.0064)			-0.00549 (0.0065)
Herfindahl _{k,c}						0.0113 (0.0249)		0.0101 (0.0334)
Size _f							0.0457*** (0.0091)	0.0484*** (0.0123)
# Observations	189,324	189,324	149,791	179,960	142,362	174,479	189,324	131,421
# Sectors	386	386	311	386	311	386	386	311
R ²	0.118	0.118	0.12	0.125	0.126	0.117	0.124	0.131
Sector Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES
Country Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES
Cluster	Country- sector	Country- sector	Country- sector	Country- sector	Country- sector	Country- sector	Country- sector	Country- sector

Notes: Robust standard errors clustered at the country-pair level are in parentheses denoting *** 1%, **5%, and *10% significance. The sample includes firms ≥ 20 employment in manufacturing sectors, excluding MNCs, located in countries with at least 1,000 plants. Dependent variable: log of one plus $V_{f,k,c}$, the vertical integration index of firm f , with primary sector k , located in country c . Explanatory variables are in logs, with the exception of output tariffs, input tariffs and export tariffs, where we use log of one plus the tariff. $Tariff_{k,c}$ is the log of the MFN tariff imposed by country c in sector k . $Capital Intensity_k$ is the total capital expenditures divided by value added. The variable $Financial Development_c$ measures private credit by deposit money banks and other financial institutions as a fraction of GDP. The variable $Legal Quality_c$ proxies for the quality of a country's institutions. $Import Tariff_{k,c}$ is the tariff imposed by country c on inputs of good k . $Export Tariff_{k,c}$ is the tariff faced by firms exporting good k from country c . $Herfindahl_{k,c}$ is the Herfindahl index of sector k in country c . In columns (7)-(8) we report 2SLS estimates. $Size_f$ measures firm size (instrumented with employment predicted with sector-country dummies).

Table A-8: Tariffs and vertical integration, Poisson quasi-maximum likelihood estimator

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Tariff _{k,c}	0.0126** (0.0058)	0.0121** (0.0058)	0.0281*** (0.0086)	0.0114* (0.0061)	0.0258*** (0.0092)	0.0117* (0.0064)	0.0126** (0.0058)	0.0202* (0.0105)
Capital Intensity _k x Financial Development _c		0.0385** (0.0165)	0.0545** (0.0267)	0.0443** (0.0178)	0.0651** (0.0293)	0.0484** (0.0208)	0.0399** (0.0165)	0.0837** (0.0361)
Capital Intensity _k x Legal Quality _c		-0.153** (0.0629)	-0.232** (0.1030)	-0.164** (0.0679)	-0.265** (0.1140)	-0.189** (0.0744)	-0.163*** (0.0629)	-0.347** (0.1370)
Input Tariff _{k,c}			-0.0122 (0.0201)		-0.0042 (0.0208)			0.0204 (0.0230)
Export Tariff _{k,c}				0.0043 (0.0050)	0.0002 (0.0070)			-0.0010 (0.0072)
Herfindahl _{k,c}						0.0027 (0.0290)		0.0280 (0.0515)
Size _f							0.0438*** (0.0079)	0.0589*** (0.0141)
# Observations	149,992	149,992	116,086	142,364	110,448	133,413	149,992	99,017
# Sectors	386	386	311	386	311	386	386	311
Sector Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES
Country Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES
Cluster	Country- sector	Country- sector	Country- sector	Country- sector	Country- sector	Country- sector	Country- sector	Country- sector

Notes: Robust standard errors clustered at the country-pair level are in parentheses denoting *** 1%, **5%, and *10% significance. The sample includes firms ≥ 20 employment in manufacturing sectors, excluding MNCs. Dependent variable: $V_{f,k,c}$, the vertical integration index of firm f , with primary sector k , located in country c . Explanatory variables are in logs and can be interpreted as elasticities. $Tariff_{k,c}$ is the log of the MFN tariff imposed by country c in sector k . $Capital Intensity_k$ is the total capital expenditures divided by value added. The variable $Financial Development_c$ measures private credit by deposit money banks and other financial institutions as a fraction of GDP. The variable $Legal Quality_c$ proxies for the quality of a country's institutions. $Import Tariff_{k,c}$ is the tariff imposed by country c on inputs of good k . $Export Tariff_{k,c}$ is the tariff faced by firms exporting good k from country c . $Herfindahl_{k,c}$ is the Herfindahl index of sector k in country c . $Size_f$ is predicted (with sector-country dummies) firm size.