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Do Prices Determine Vertical Integration?*

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Abstract

A number of theories in organizational economics and industrial organization suggest that vertical integration, while costly, increases productivity. It follows from firms' maximizing behavior that higher prices in the product market ought to induce more integration. Trade policy provides a source of exogenous price variation to assess this prediction: higher tariffs should lead to higher prices and therefore to more integration. We construct firm-level vertical integration indices for a large set of countries and industries and exploit variation in applied MFN tariffs to examine the impact of tariffs on firm boundaries. The empirical results provide strong support for the view that higher output prices generate more vertical integration. Our estimates of the average price elasticity of vertical integration are in the range 0.4-2.

JEL classifications: D22, D23, L22.

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1 Introduction

The relationship between vertical integration and product prices has long been a source of controversy among economists and policymakers. Two strands of thought, broadly opposed, have emerged. In the *foreclosure* view, firms may integrate with their suppliers to reduce competition with their rivals, thus pushing product prices higher.[1] The *efficiency* view, by contrast, maintains that integration increases productivity, thereby reducing prices.[2] Discussion usually revolves around which of these opposing effects is likely to dominate in a particular market or merger case. Either way, causality runs *from vertical integration to prices.*

Efficiency theories have another implication, however, that can generate a *positive* association between prices and integration, but unlike foreclosure, do so even under perfect competition. To see this, suppose that integration increases productivity, but does so at a cost. For instance, integration might improve coordination among suppliers, but engender administrative costs that are independent of output and product price. Then a price-taking firm will choose to integrate only if the benefits in terms of increased profitability outweigh the cost of integrating. At low prices, the productivity gains resulting from integration are not very valuable, too small to justify the cost. At high enough prices, integration becomes worthwhile. Thus, if integration affects productivity, there is a force running in the opposite direction, *from prices to vertical integration.*

The possibility that product prices influence vertical integration through this pecuniary channel has important economic consequences (Legros and Newman, 2013). It implies that demand shocks can generate merger and divestiture waves that in turn affect the performance of individual firms and whole industries. It can help to explain intra-industry heterogeneity in organization and productivity. It introduces a re-organizational component to the diffusion of productivity shocks that may dampen technological progress. And it has implications for antitrust policy.

This paper is a first attempt to provide evidence that product prices affect integration. Our results suggest that this pecuniary mechanism is operative in a wide range of industries around the world. The main empirical challenge is to find sources of price variation that are exogenous to firms' vertical integration decisions. Our strategy is to exploit variation in Most-Favored-Nation (MFN) tariffs applied by GATT/WTO members. Since tariffs raise product prices in

[1] Key theoretical contributions on market foreclosure include Salinger (1988), Ordover, Saloner, and Salop (1990), Hart and Tirole (1990) and Bolton and Whinston (1993). Market foreclosure concerns have been enshrined in anti-trust policies and have motivated policies such as "divorcement" legislation. See, for example, the guidelines on the assessment of non-horizontal mergers in the United States (1984 Merger Guidelines) and in the European Union (Council Regulation 2008/C 265/07).

[2] Numerous channels have been identified through which integration enhances productivity. Technological synergies and efficiencies in asset use are frequently cited by policymakers and antitrust defendants. Organization economists have emphasized other benefits, and often associated costs: reductions in the costs of transactions, adaptation, or opportunism (Williamson, 1971, 1975; Klein, Crawford, and Alchian, 1978); better multitasking incentives (Holmström and Milgrom, 1991); alignment of control and incentives (Grossman and Hart, 1986; Hart and Moore, 1990); or improved coordination (Hart and Holmström, 2010). A complementary class of theories emphasize allocative, rather than productive, efficiency gains achieved by the elimination of double markups, though these shall concern us less. See Riordan (2008) for further discussion.

the domestic market, they should lead to more vertical integration among firms selling in that market.

There are several reasons to take MFN tariffs as exogenous to vertical integration. First, they emerge from long rounds of multilateral trade negotiation: at the end of each round, governments commit not to exceed certain tariff rates; tariff bindings can only be renegotiated in a new round. As a result, MFN tariffs are persistent, significantly more so than integration choices. In our analysis, we study vertical integration of firms in 2004. In that year, the prevailing tariffs resulted from the eight-year Uruguay Round of trade negotiation that was completed ten years earlier.[3] Second, they must be applied in a non-discriminatory manner to imports from all countries, which severely limits negotiators' flexibility to respond to lobbying; consequently, if they respond at all to short-term political pressure, governments find it much less costly to resort to non-tariff measures for regulating imports, such as anti-dumping and countervailing duties (e.g. Finger, Hall and Nelson, 1982).[4] Finally, while larger firm size and more industry concentration might lead to higher final good tariffs by alleviating free-rider problems in lobbying for protection (Mitra, 1999; Bombardini, 2008), there is no reason to believe that vertical integration *per se* should have such an effect.[5]

A basic price theoretic effect like the one we are investigating ought to manifest itself ubiquitously rather than being limited to a few sectors or countries. We therefore draw our evidence from the WorldBase dataset of Dun and Bradstreet (D&B), which includes firms in many different countries and industries. This approach allows us to exploit cross-country and cross-sector variation in MFN tariffs. The GATT non-discrimination principle implies that there is only one MFN tariff rate per industry in each country; the length of multilateral trade rounds — and the long gaps between them — imply that MFN tariffs vary little over time. Most of the variation is thus within countries across industries and within industries across countries (see Section 4.4).[6]

WorldBase contains listed and unlisted plant-level observations for a large set of countries and territories. For each plant, the dataset includes information about its production activities (at the 4-digit SIC level) and ownership (e.g. domestic or global parent). To measure vertical

[3]By 2004, most GATT/WTO members had reduced their tariffs to meet the binding obligations agreed to in 1994, at the end of the Uruguay Round of trade negotiations (Bchir, Jean and Laborde, 2006).

[4]The MFN treatment obligation stipulated in Article I of the General Agreement on Tariffs and Trade (GATT) forbids members to discriminate between trading partners. It requires that equal treatment be afforded to all imported goods, irrespective of their origin.

[5]If anything, vertical integration may have the opposite effect: compared to an independent supplier, a vertically integrated one is subject to the authority of a firm spanning several sectors and therefore has both a weaker interest and less means to coordinate lobbying with other suppliers in its own sector.

[6]An alternative strategy to verify the impact of product prices on firm boundaries is to exploit time variation in import tariffs, examining the effects of trade liberalization reforms — major unilateral or multilateral liberalization episodes, or the creation of regional trade agreements — on vertical integration decisions. 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. An earlier version of the paper examines the organizational effects resulting from the entry of China into the WTO in 2001 (see Alfaro, Conconi, Fadinger and Newman, 2013). Consistent with the predictions and results reported here, we find that firm-level vertical integration has fallen more in sectors that have experienced larger tariff cuts.

integration, we apply the approach of Fan and Lang (2000): combining information on firms' production activities with input-output tables, we construct firm-level vertical integration indices, which measure the fraction of inputs used in the production of a firm's final good that can be produced in house.

In our empirical analysis, we assess several predictions about how tariffs affect firm boundaries through their impact on product prices. First, higher tariffs, by raising product prices in the domestic market, should lead firms to be more vertically integrated. Second, this effect should be stronger for firms that operate only in the domestic market, since their revenues depend exclusively on domestic prices; by contrast, exporting firms should be less sensitive to domestic tariffs, since their revenues also depend on prices in foreign markets. Finally, the effect should be stronger in sectors where domestic prices are more sensitive to MFN tariffs, those in which the MFN tariff rate— rather than the preferential rate set by a regional trade agreement — applies to most imports.

The results provide strong support for the view that output prices are a key determinant of vertical integration. We find that the higher the MFN tariff applied by a country on the imports of a good, the more vertically integrated the country's producers of the good. The effect is larger for firms that only serve the domestic market and in sectors in which MFN tariffs have a larger impact on domestic prices. These findings are robust to the inclusion of fixed effects at the sector and country level, as well as sector-country fixed effects — which should allay concerns about unobservable sector-country factors that might be correlated with both tariffs and firms' ownership structure. The results continue to hold with alternative vertical integration indices, different econometric methodologies, and different samples of firms and countries.

In terms of magnitude, our estimates imply that price changes can have large effects on firm boundaries. Depending on the specification, we obtain estimates of the tariff elasticity of vertical integration that range from 0.02 to 0.09. Given that tariffs are expressed in ad-valorem terms, these translate into price elasticities that are much larger, in the range of 0.4-2 at the average tariff.[7]

We rule out several alternative mechanisms that could generate the positive correlation between tariffs and vertical integration. First, tariffs can have an impact on the degree of competition faced by domestic firms, which may also shape vertical integration decisions. 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. Confining attention to the subsample of competitive sectors yields even stronger results: the effect of tariffs on vertical integration is larger than for the full sample.

Another possible explanation for the positive effect of tariffs on vertical integration is that,

[7]Another way to get a sense of the effects of prices on organization would be to instrument prices with MFN tariffs. However, this would require comparable cross-country data on domestic prices, which are extremely difficult to obtain (see Bradford, 2003).

in the presence of credit constraints, protected firms may have more disposable cash to acquire their suppliers. This mechanism would be expected to be strongest where credit markets are least efficient, or in industries which are most financially dependent. We verify that the effect of tariffs on integration does not vary with either of these factors, as captured by standard measures of financial development and financial dependence.

This paper focuses on vertical integration, which involves complementary goods linked in a buyer-supplier relationship. In principle, the theoretical mechanism we investigate may also apply to horizontal integration, which involves substitute goods, or lateral integration, involving goods sold in separate markets that are complementary either in production or consumption. To the extent that these forms of integration also are costly but enhance productive efficiency, we should expect firms to be more integrated in these other dimensions when tariffs — and thus product prices — are higher. However, data limitations and the lack of unconfounded integration measures make it difficult to apply the methodology to these other cases, as discussed in Section 4.3. We thus feel that vertical integration provides the cleanest test of the theory.

The rest of the paper is organized as follows. Section 2 discusses the related literature. Section 3 presents a simple conceptual framework that illustrates the logic of pecuniary determinants of vertical integration, to motivate and guide our empirical analysis. Section 4 describes our data. Section 5 presents our main results. Section 6 rules out alternative mechanisms. Section 7 discusses a series of robustness checks. The last section concludes.

2 Related literature

Understanding vertical integration decisions has been a fundamental concern of organization economics since Coase (1937)'s seminal paper. We have already mentioned (footnote 2) some of the main contributions, both formal and informal, that have shaped economists' understanding of how ownership structure affects productivity of individual firms. Recent theoretical work has embedded models of firms 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). Legros and Newman (2013) is the first paper to point out that product prices can have a causal impact on integration decisions. So far, evidence on the implications of these models is sparse. This paper shows that market conditions — in particular, the level of product prices — do affect vertical integration decisions.

There is a large empirical literature on the determinants of firms' vertical integration decisions (i.e. firm boundaries/ownership structure), usually with a view to assessing the importance of different tradeoffs that determine firm boundaries, or to examining effects of vertical integration on market outcomes (for an excellent survey, see Lafontaine and Slade, 2007). Most studies focus

on single industries.[8] In this literature, Hortaçsu and Syverson (2007) concentrate on the U.S. cement industry and examine whether vertical integration leads to higher prices. In contrast with the predictions of market foreclosure theories, they find that more integration leads to lower prices; they do not address the opposite direction of causality that is our concern.

A few studies examine 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.

As for multi-country studies, one stream of the literature has analyzed 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 U.S. 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 manufacturing firms across a dozen countries, reveal that greater product market competition increases decentralization. Bloom, Sadun and Van Reenen (2012a) use survey data they collected from several countries to show that firms headquartered in high trust regions are more likely to decentralize.

Guadalupe and Wulf (2012) show that the 1989 Canada-United States Free Trade Agreement (CUSFTA) led large U.S. firms to flatten their hierarchies. Other papers have studied how trade liberalization, by increasing the degree of competition, affects the number of horizontally differentiated product varieties a firm chooses to manufacture (Eckel and Neary, 2010; Bernard, Redding and Schott, 2011).

Various papers examine whether goods are sold within or across firm boundaries in the global economy (e.g. Antras, 2003; Nunn, 2007). This literature considers the organizational choices of multinational firms and highlights the role of contract enforcement and relationship-specific investments. By contrast, we focus on the organizational choices of firms that operate in a single country. A number of papers study legal/institutional determinants of integration (e.g., Acemoglu, Johnson and Mitton, 2009, which employs WorldBase and a measure of VI similar to ours; Macchiavello, 2012). The present paper is the first to investigate the impact of product prices on vertical integration.

[8]These include the seminal papers by Stuckey (1983) on integration between aluminum 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; or Forbes and Lederman (2009, 2010) on airlines.

3 Conceptual framework

The fundamental logic of how product prices influence firm boundaries can be illustrated with a reduced-form competitive model, in which vertical integration has three main features: (i) it enhances productivity; (ii) it does so at a cost; (iii) the cost is independent of product price. The first assumption is the defining attribute of efficiency theories of vertical integration. The second is necessary if there is anything to discuss: without it, given the first assumption, firms would always integrate to the maximal extent. The third is commonly made, either directly, or derived from more fundamental assumptions. This framework is representative of a broad class of organizational models.[9]

Consider a price-taking enterprise that requires $N \geq 2$ complementary inputs to produce a final good priced at P. Before production, the enterprise chooses the degree of vertical integration n, which for present purposes can be taken to be the number of inputs that will be produced inside a single firm (in practice, of course, inputs do not all contribute equally to the final product, and an empirical integration measure will take this into account). The effects of integration on productivity are modeled in the simplest possible way: the output produced from an N-vector of inputs x is $\psi(n)F(x)$, where $\psi(\cdot)$ and $F(\cdot)$ are real-valued and increasing; the complementarity of inputs is represented by supermodularity of $F(\cdot)$ (this assumption can be relaxed). The function $\psi(\cdot)$ captures various possible sources of efficiency gains from integration suggested in the literature (e.g. improved coordination, reduced adjustment costs, less free riding, increased investment incentives, lower transaction costs).

Integration is costly (else n would always be set to its productivity maximizing level N). Let $\Phi(n)$, which is increasing, be the cost of integrating n units into the firm. This function may represent various types of costs (e.g. legal, administrative, monitoring; or private costs of effort, subordination, or conformity). Note that here the integration cost is independent of P and x, a feature that can be relaxed. The enterprise's net profit given a submodular cost of inputs function $c(x)$ is then

$$P\psi(n)F(x) - c(x) - \Phi(n), \tag{1}$$

which it maximizes by choosing n and x, taking P as given.

Since $\psi(\cdot)$ is increasing, the profit is supermodular in the degree of integration n and the inputs x. By basic principles of monotone comparative statics (e.g. Topkis, 1998; Vives, 2000), optimal choices of these variables will co-vary. Since profit has increasing differences in P and n, the optimal degree of integration will increase with P. The intuition is that the efficiency gains generated by integration are more valuable when the price of output is higher, so integration incentives are greater at higher prices.[10] Similarly, input choices and therefore the level of output

[9] In Appendix A-2, we study the relationship between vertical integration and productivity for firms in our sample. In line with assumption (i), we show that more vertically integrated firms exhibit higher labor productivity.

[10] To be sure, in some models, particularly those in which incentives play a role, the extent of the efficiency

$Q = \psi(n)F(x)$ are increasing in P.[11]

The increasing relationship between P and Q is, of course, just the firm's supply behavior. But note that upward movement along this supply curve also entails increases in n: supply embeds the organizational decision of the firm in addition to its quantity choice. Now consider an industry in one country composed of many price-taking firms. Addition of the supplies across all the firms yields an "organizationally augmented" industry supply curve (OAS), denoted $S(P)$, which can be used to perform standard economic exercises, such as tracing the effects of demand shocks, to simultaneously determine prices, quantities *and* vertical integration decisions of all firms.

As discussed in the introduction, testing the key prediction of this framework — that a higher price on the final good should lead a firm to be more vertically integrated — requires an exogenous source of price variation. Trade policy provides an ideal proving ground: the degree of trade protection provided by MFN tariffs affects product prices, but is unlikely to be affected by firms' boundary choices. The OAS provides a simple tool for understanding how vertical integration relates to tariffs and for illustrating our empirical strategy.

Suppose the industry is composed of many price-taking enterprises within a single country, which is part of a world trading system. An equilibrium of that system will determine a world market-clearing price P^* for the industry. In the country in question, the industry is "import competing": at P^*, domestic demand $D(P^*)$ exceeds the supply $S(P^*)$, so that some domestic demand must be satisfied by imports. Suppose further that the country in which our industry resides is "small," i.e. its tariffs do not affect the world price.[12] An ad-valorem tariff t drives a wedge between the domestic price P and the world price: $P = (1+t)P^*$. By increasing the domestic price, the tariff increases the gains from integration for domestic firms, leading them to be more vertically integrated. This effect is illustrated in Figure 1.

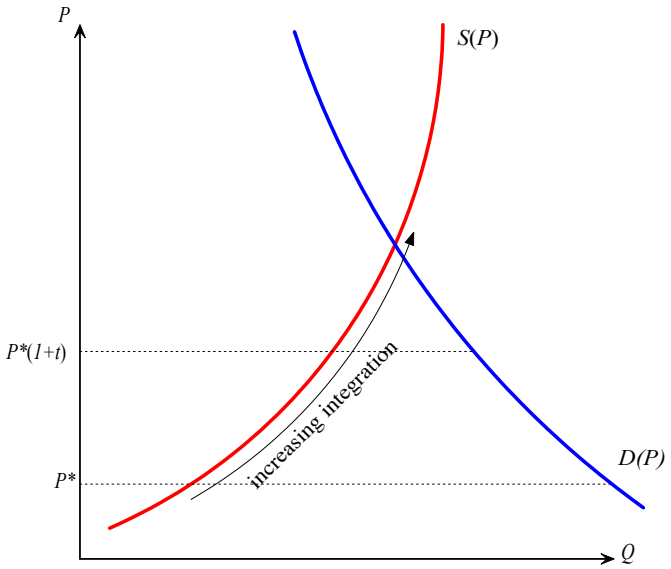
Our empirical analysis exploits cross-country variation in applied MFN tariffs for a given sector to identify the effect of tariffs on vertical integration. Effectively, we compare the degree of vertical integration of firms that produce the same manufacturing good, but are located in countries that apply different tariffs on this good. This analysis will yield estimates of the tariff elasticity of vertical integration. What we are really interested in is the effect of product prices

gains, or the costs of integrating, may depend on other variables besides n, such as the price P or the distribution of the profits among the various production units. For instance in Legros and Newman (2013), the integration cost displays decreasing differences in (n, P), which serves to ensure that n is increasing in P. Other specifications may lead to nonlinearities and non-monotonicities in the predicted relationship between integration and price (Legros and Newman, 2014). However, these complications do not affect the basic contention that product prices influence integration decisions. We did not find evidence of these more complex patterns in our data.

[11] The assumptions that $F(\cdot)$ is supermodular and $c(\cdot)$ submodular are not essential. Take $q = F(x)$ as a choice variable along with n in the auxiliary problem $\max_{(n,q)} P\psi(n)q - C(q) - \Phi(n)$, where $C(q) \equiv \min_x c(x)$ s.t. $F(x) = q$. Then if (n^*, x^*) solves problem (1), (n^*, q^*) with $q^* = F(x^*)$ solves the auxiliary problem. As the auxiliary objective is supermodular in (n, q) and there are increasing differences in (n, q) and P, (n^*, q^*) and $Q = \psi(n^*)q^*$ increase with P.

[12] See Conconi, Legros, and Newman (2012) for a model in which vertical integration decisions are embedded in an international trade model and P^* is endogenously determined.

Figure 1: Equilibrium with an import tariff



on integration. Crucially, the fact that import tariffs are expressed in ad-valorem terms allows us to derive the price elasticity of integration without actually knowing the price. To see this, note that the tariff elasticity of domestic price $P = (1+t)P^*$ for a small country (P^* unaffected by its tariff) is $\frac{\partial P}{\partial t}\frac{t}{P} = \frac{t}{1+t}$. Denote the tariff elasticity of integration by $\beta \equiv \frac{\partial n}{\partial t}\frac{t}{n}$. Then the price elasticity of integration is just $\frac{\partial n}{\partial P}\frac{P}{n} = \beta\left(\frac{1+t}{t}\right)$. Thus the price elasticity exceeds the tariff elasticity, by some twentyfold for the average tariff of 5 percent.[13]

Two corollaries follow from this basic logic. First, the impact of import tariffs on integration choices should be stronger for firms that only serve the domestic market, since their profits depend only on the domestic price. The effect should be weaker for firms that also serve foreign markets (i.e., exporting firms and multinationals), since their profits and integration decisions also depend on prices prevailing in other countries, which are not affected by the domestic tariff.

Second, the impact of an MFN tariff on the degree of vertical integration should also depend on the extent to which that tariff affects domestic prices. In particular, higher shares of imports subject to the MFN tariff (i.e., lower shares of goods imported at preferential rates from regional trading partners), should be associated with larger effects of the tariff on prices and organization.

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

> P.1: Higher import tariffs on final goods should induce domestic firms producing these goods to be more vertically integrated.

[13] As mentioned above, in our main empirical analysis we exploit cross-country variation in tariffs. In this case, the relationship between the estimated tariff elasticity of vertical integration and the corresponding price elasticity is independent of country size, as long as all countries face the same world equilibrium price.

P.2: The effect of tariffs on integration should be larger for firms serving only the domestic market.

P.3: The effect of tariffs on integration should be larger in sectors in which a smaller fraction of imports are exempt from the tariff.

It should be stressed that the above predictions apply to tariffs on final goods, which raise output prices, increasing the revenue of the enterprise. Our theory generates less clearcut predictions concerning the effects of input tariffs on boundary choices: whether higher input prices strengthen or weaken the incentives for integration depends on whether inputs sales are part of the revenue of the enterprise or part of its costs.[14] Generally speaking, tariffs on inputs for which the firm is a net seller increase its incentives to integrate, and those for which it is a net buyer reduce them. We do not have information on firm sales by sector.

Our strategy for detecting the predicted effects of price level on a firm's integration level depends on there not being a strong countervailing "general equilibrium" effect on its fixed cost $\Phi(n)$ of integrating. Conceivably, $\Phi(n)$ could rise as all firms in an industry try to increase their integration level in response to a price increase, which in turn would reduce the magnitude of the effect. However, insofar as Φ is generated by managerial private costs, as in much of the "property rights" literature, this does not appear to be a major concern. In any case, even if Φ does rise, this would only bias the magnitude of our estimates downward.

The model can be enriched by introducing variation in exogenous productivity. Represent this productivity with a parameter R, making profit equal to $PR\psi(n)F(x)-c(x)-\Phi(n)$. Plainly, R enters the enterprise's objective in the same fashion as P, implying that there are increasing differences in productivity and integration. This gives rise to a selection effect: exogenously more productive firms will choose to be more integrated (see Legros and Newman, 2013). This observation will help us to interpret some of our empirical results on the determinants of firm boundaries. It will also help us to assess the empirical validity of assumption (i) that integration increases productivity (see Appendix A-2).

4 Dataset and variables

In Sections 5-7, we will provide evidence that product prices affect vertical integration decisions in a wide range of countries and industries, in line with the above predictions. Focusing on many countries and industries allows us to exploit MFN tariffs as a source of exogenous price variation. In this section, we describe our dataset and the variables used in our empirical analysis.

[14]For example, if an automobile manufacturer produces more automotive stampings than it needs and sells the remainder on the market, then the sale of stampings will enter its revenue; in this case, the higher the price of stampings, the higher the incentives to integrate. On the other hand, if stampings are purchased on the open market, an increase in their price will diminish revenue and reduce the incentives to integrate.

4.1 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, 2012a). 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 from Dun & Bradstreet's WorldBase, a database covering public and private companies in more than 200 countries and territories.[15] The unit of observation 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.[16]

The WorldBase dataset has been used extensively in the literature. Early examples include Caves's (1975) analysis of size and diversification patterns between Canadian and U.S. plants. More recent uses include Alfaro and Charlton (2009), Acemoglu, Johnson and Mitton (2009), and Fajgelbaum, Grossman and Helpman (2015). 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 employees (see discussion below).[17]

4.2 The sample

Our main sample is based on the 2004 WorldBase dataset. As mentioned above, the unit of observation in WorldBase is the establishment/plant, a single physical location at which business is conducted or services or industrial operations are performed.

For each establishment, we use different categories of data recorded in WorldBase:

[15] WorldBase is the core database with which D&B populates its commercial data products, including Who Owns Whom™, Risk Management Solutions™, Sales & Marketing Solutions™, and Supply Management Solutions™. 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.

[16] D&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.

[17] See Alfaro and Charlton (2009) for a more detailed discussion of the WorldBase data and comparisons with other data sources.

1. Industry information: the 4-digit SIC code of the primary industry in which each establishment operates, and the SIC codes of as many as five secondary industries.

2. Ownership information: information about the firms' family members (number of family members, domestic parent and global parent).[18]

3. Location information: country, state, city, and street address of each plant.

4. Basic operational information: sales and employment.

5. Information on the trade status (exporting/non-exporting).

We carry out the analysis at the firm level, using DUNS numbers to link plants that have the same ultimate owner. As discussed below, however, since the overwhelming majority of firms in our sample have only one establishment, the qualitative results of our analysis are unaffected if we measure vertical integration at the plant level or include only single-plant firms.

We restrict the sample to Word Trade Organization (WTO) members for which we have data on tariffs/regional trading arrangements (see discussion below). Table A-1 in the Appendix lists the countries included in our main sample. Further restrictions were imposed by data availability constraints related to the control variables, as explained in the next subsections. In robustness checks, we consider two subsamples of countries: members of the OECD, and countries for which we have information on at least 1000 plants.

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 tariff data are widely available. We exclude firms that do not report their primary activity, 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 further exclude firms with less than 20 employees, as our theory is less apt to apply to self-employment or small firms with little prospect of vertical integration. Restricting the analysis to firms with more than 20 employees also enables us to correct for possible differences in the collection of data on small firms across countries (see Klapper, Laeven, and Rajan, 2006).

In our main sample, we focus on firms that have plants only in one country. There are three main reasons for this choice. First, these firms provide a cleaner setting to verify the predictions of our theoretical model, since the degree of vertical integration of these firms should only depend on the price at which they sell their product in their country. In the case of multinational corporations, on the other hand, it is harder to identify the relevant prices and tariffs. Second, excluding multinationals avoids issues having to do with their strategic behavior

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

across markets (e.g. transfer pricing, tariff jumping, export platforms). Finally, when integration occurs across international borders as opposed to within them, trade policy can alter bargaining power (surplus division) among suppliers as well as the value of what they jointly produce, further complicating the predicted effects (Ornelas and Turner, 2008; Antras and Staiger, 2012). Multinational corporations are included in the robustness analysis (see Section 7).

We next describe the construction of the vertical integration indices and the other variables used in our empirical analysis. Appendix Table A-2 presents summary statistics for all variables.

4.3 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 countries.

To measure the extent of vertical integration for a given firm, we build on the methodology developed by Fan and Lang (2000). We combine information on plant activities and ownership structure from WorldBase with input-output data to construct the index $V_{f,k,c}$, which measures the degree of vertical integration of firm f, with primary sector k, located in country c. 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.[19]

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.[20] 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).

[19]Note 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 U.S. input-output tables to construct vertical integration indices for other countries mitigates the possibility that the IO structure and control variables are endogenous. In robustness checks, we verify that our results are unaffected when restricting the analysis to OECD countries, which are closer to the U.S. in terms of technology (See Section 7).

[20]This 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.

For every pair of industries, i, j, the input-output accounts provide the dollar value of i required to produce a dollar's worth of j. By combining information from WorldBase on firms' activities with U.S. input-output data, we construct the input-output coefficients for each firm f, IO^f_{ij}. Here, $IO^f_{ij} \equiv IO_{ij} * I^f_{ij}$, where IO_{ij} is the input-output coefficient for the sector pair ij, stating the dollars of output of sector i required to produce a dollar of j, and $I^f_{ij} \in \{0, 1\}$ 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.

The firm's integration index in activity j is

$$V^j_{f,k,c} = \sum_i IO^{f,k}_{ij}, \tag{2}$$

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:

$$V_{f,k,c} = V^j_{f,k,c}, j = k. \tag{3}$$

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.

As an illustration of the procedure used to construct our dependent variable, a Japanese shipbuilder in our dataset has two secondary manufacturing activities, Fabricated Metal Structures (SIC 3441/BEA IO code 40.0400) and Sheet Metal Work (3444/40.0700).[21] The IO_{ij} coefficients for these sectors are:

		Output (j)
		Ships
Input (i)	*Ships*	0.0012
	Fab. Metal	0.0281
	Sheet Metal	0.0001

This table is just the economy-wide IO table's output column for the firm's primary industry, Ship Building and Repairing (3731/61.0100), restricted to the input rows for the industries in which it is active. The IO_{ij} coefficient for fabricated metal structures to ships is 0.0281, indicating that 2.8 cents worth of metal structures are required to produce a dollar's worth of ships. The firm is treated as self-sufficient in the listed inputs but not any others, so its vertical

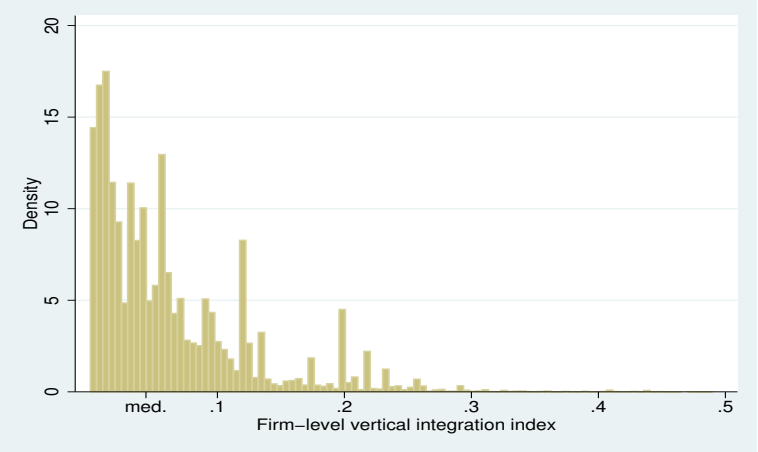
[21] There is no concern about right censoring in the number of reported activities: only 0.94 percent of establishments with primary activity in a manufacturing sector report the maximum number of five secondary activities.

integration index $V_{f,k,c}$ is the sum of these coefficients, 0.0294: about 2.9 cents worth of the inputs required to make a dollar of primary output can be produced within the firm.[22]

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 IO tables avoids the arbitrariness of classification schemes that divide goods into "intermediate" and other categories (Hummels, Ishii, and Yi, 2001).

One might be concerned about measuring vertical integration at the firm level, in light of recent studies that find little evidence of trade between plants of the same firm.[23] However, this concern does not apply to our analysis. This is because 96% of the firms in our sample have only one plant and 87% of plants are not connected (see Table A-2).[24] The qualitative results of our analysis are thus unaffected if we measure vertical integration at the plant level or include only single-plant firms.

Figure 2: Firm-level vertical integration index



Summary statistics for firm-level vertical integration are presented in Appendix Table A-2. Our main sample consists of 196,586 domestic manufacturing firms with at least 20 employees located in 80 countries. The histogram in Figure 2 reports the distribution of vertical integration indices for all firms in our main sample. From Figures A-1 and A-2 in Appendix A-1 we can see that there is more variation in firm-level vertical integration across industries (from 0 to more

[22]Many industries, including Ship Building and Repairing, have positive IO_{jj} coefficients with themselves. Any firm that produces such a product will therefore be measured as at least somewhat vertically integrated.

[23]Atalay, Hortaçsu, and Syverson (2014) find little evidence of commodity shipments across plants in U.S. non-multinational firms. Ramondo *et al.* (2015) find the bulk of intra-firm trade between affiliate and the U.S. parent to be concentrated among a small number of large affiliates.

[24]The fact that most enterprises are single-plant firms is in line with previous studies. For example, Bloom Sadun and Van Reenen (2012b) report that 84 percent of U.K. firms have only one establishment.

than 0.3) than across countries (from around 0.04 to around 0.1).

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

As mentioned in the introduction, the mechanisms outlined in our model could apply to other types of integration. In this paper, we focus on vertical integration, which we can measure using information available in our dataset on the primary and secondary activities of each firm and applying the methodology developed by Fan and Lang (2000). While it would be interesting to examine whether higher tariffs, by raising product prices, also lead firms to be more horizontally or laterally integrated, these cases present some difficulties. In the horizontal case, existing measures (e.g. a firm's size to mean size ratio or industry-level concentration measures) need not be good proxies for firm-level integration. Moreover, these measures are not invariant to industry composition and are thus vulnerable to selection effects.[25] As for lateral integration, constructing a firm-specific measure would require sales of each plant by product line for narrowly defined industries, which we do not observe in our dataset.

4.4 Tariffs and other trade variables

Our main strategy to empirically assess the impact of market prices on ownership structure is to use data on most-favored-nation (MFN) tariffs applied by GATT/WTO members. As discussed in Section 1, MFN tariffs are very persistent, i.e. vary little in between rounds of multilateral trade negotiations. At a given point in time, given the GATT principle of non-discrimination (see footnote 4), MFN tariffs vary mostly across countries (for a given industry) and across industries (for a given country).

We collect applied MFN tariffs at the 4-digit SIC level for all countries for which this information is available. We restrict the analysis 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 only allowed 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). In our main empirical analysis, we use applied

[25]For instance, to the extent that firms are heterogeneous in productivity, a reduction in tariffs may force less productive firms to exit, shifting market share towards more productive firms (Melitz, 2003). This may result in a negative relationship between tariffs and industry concentration, which is not directly related to our mechanism.

MFN tariffs for 2004.[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 over the HS 6-digit tariffs.

Applied MFN 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), the MFN tariffs applied in 2004 varied between zero and 29 percent, with an average of 3.15 percent.[27] Figures A-3 and A-4 in Appendix A-1 illustrate the variation in applied MFN tariffs across industries and countries.

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.[28] To proxy for the level of protection faced by exporters in foreign markets, we use the variable *Foreign Tariff*$_{k,c}$. We construct this variable by weighting tariffs in destination markets with bilateral sectoral export shares using information from the UN Comtrade database.

To distinguish between firms selling only in the domestic market and exporting firms, we use information from WorldBase to construct the dummy variable $Domestic_f$, which takes the value of 1 if firm f does not report to be an exporter.

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 this share is, the more sensitive its 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.

4.5 Other controls

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

[26] If information on applied MFN tariffs is unavailable for that year, we use the closest available data point in a five year window around 2004 (2002-2006), with priority given to earlier years. For example, if data are available for 2003 and 2005, but not 2004, the 2003 data are chosen.

[27] The total variance of MFN tariffs in our sample is 52. The variance of MFN tariffs across sectors for a given country is around 61 percent of this number, while the variance across countries for a given sector is around 49 percent of the total variance of MFN tariffs.

[28] $InputTariff_{k,c} \equiv \sum_{i \in N_k} w_{i,k} Tariff_{i,c}$, where $w_{i,k} \equiv IO_{ik} / \sum_{i \in N_k} IO_{ik}$

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 (2004), 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 (2000).

We also construct the variable *Capital Intensity*$_k$, using data from the NBER-CES manufacturing industry database (Bartelsmann and Gray, 1996) 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 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). He classifies products according to three different types: homogeneous goods, which are traded in organized exchanges; goods that are 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. The dummy variable *Homogeneous2*$_{k,c}$ is constructed using information on sector-country-specific import demand elasticities estimated by Broda, Greenfield and Weinstein (2006). 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.

The variable *Concentration*$_{k,c}$ is the Herfindahl-Hirschman Index (HHI), constructed using information on sales of all plants in a given country and sector (including sales by foreign-owned plants operating in the country-sector). We also use the C4 concentration ratio in robustness checks.

Governments tend to protect declining industries (e.g. Brainard and Verdier, 1997). In 1994, when the Uruguay Round of multilateral trade negotiations was concluded, GATT members may have agreed to set higher tariffs on industries that had been shrinking in terms of employment. To identify these industries, we use employment data from UNIDO-Indstat 4 to construct the dummy variable *Declining*$_{k,c}$, which is equal to 1 if employment in a country-sector declined during the 1984-1994 period. Governments' support for trade protection also depends on the

[29]Poor legal institutions may affect vertical integration decisions through their impact on the severity of hold-up problems. Financial development may affect integration positively if a sufficient level may be necessary for upstream and downstream firms to be able to integrate, or negatively insofar as integration facilitates borrowing and therefore substitutes for poor financial institutions. It can also affect entry and industry concentration, which may influence vertical integration. As Acemoglu, Johnson and Mitton (2009) and Macchiavello (2012) note, the effect of each of these variables may be ambiguous when considered separately and there may be more robust predictions of their combined effect.

degree to which industries in their constituencies are import competing (e.g. Conconi, Facchini and Zanardi, 2014). Using data from the UN Comtrade database, we construct the variable *Import competing*$_{k,c}$, which is equal to the log ratio between a country's imports and exports in a given sector.

We have also constructed the variable *Financial dependence*$_k$ to capture a sector's external dependence on finance. Following Rajan and Zingales (1998), this variable is defined as the median fraction of investment not financed with cash flow, constructed at the 4-digit sector using U.S. data from Compustat over the 1999-2004 period.

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. Similarly, we construct the variable *Productivity*$_f$ measured as firm sales divided by employment. Again, we instrument this variable using predicted (with sector-country dummies) labor productivity.

5 Empirical methodology and results

In this section, we assess the empirical validity of the predictions of our theoretical model concerning the effect of tariffs on vertical integration. To examine the organizational effects of trade policy, we exploit variation in applied MFN output tariffs across countries and sectors.

To verify prediction P.1, we estimate the following reduced form regression model:

$$V_{f,k,c} = \beta_0 + \beta_1 \text{ Tariff}_{k,c} + \beta_2 \mathbf{X}_{f,k,c} + \delta_k + \delta_c + \epsilon_{f,k,c}. \tag{4}$$

The dependent variable, $V_{f,k,c}$, is the vertical integration index of firm f, with primary sector k, located in country c, as defined in (3). Since the distribution of vertical integration indices is rather skewed (see Figure 2), we use log of one plus $V_{f,k,c}$ as our dependent variable.[30] Our main regressor of interest is the variable *Tariff*$_{k,c}$, which is the log of one plus the MFN tariff applied to output in sector k by country c.[31] The vector $\mathbf{X}_{f,k,c}$ includes a series of firm and sector-country controls. We include sector fixed effects at the 4-digit SIC level (δ_k). These capture characteristics of a firm's primary industry that may affect its vertical integration decisions (e.g.

[30] We have 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.

[31] Tariffs are expressed in ad-valorem terms. In the main specifications, we use log of (one plus the tariff) in order to be able to include zero tariffs. Although the distribution of tariffs is extremely skewed, the log of (one plus the tariff) is close to a normal distribution. The estimated tariff elasticity of vertical integration V will be $\frac{(1+V)t}{(1+t)V}$ times the estimate of β_1; around the mean values of V and t this factor is only slightly less than one, so the elasticity is close to the reported coefficient. In alternative specifications, we used log vertical integration and log tariffs, obtaining very similar results.

capital intensity, the position in the value chain). We also include country fixed effects (δ_c). These allow us to account for characteristics of a firm's location that may shape its boundary choices (e.g. the quality of a country's institution, geographic proximity to suppliers). $\epsilon_{f,k,c}$ is an error term with $E(\epsilon_{f,k,c}|\mathbf{X}_{f,k,c}, \delta_k, \delta_c) = 0$. 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. Prediction P.1 of our model states that higher final good tariffs within an industry-country should lead firms in that industry and country to be more vertically integrated. We thus expect the coefficient β_1 to be positive.

According to the second prediction of our theoretical model, the effect of tariffs on integration should be larger for firms serving only the domestic market. To verify this prediction, we run the following regression model:

$$V_{f,k,c} = \gamma_0 + \gamma_1 \text{ Tariff}_{k,c}\text{xDomestic}_f + \gamma_2 \text{ Tariff}_{k,c} + \gamma_3 \text{Domestic}_f + \gamma_4 \mathbf{X}_{f,k,c} + \delta_k + \delta_c + \epsilon_{f,k,c}. \quad (5)$$

We expect the coefficient γ_1 to be positive. To assess the validity of this prediction, we can also include sector-country fixed effects, dropping the variable $\textit{Tariff}_{k,c}$ and simply including its interaction with the dummy $\textit{Domestic}_f$:

$$V_{f,k,c} = \phi_0 + \phi_1 \text{ Tariff}_{k,c}\text{xDomestic}_f + \phi_2 \text{Domestic}_f + \phi_3 \mathbf{X}_{f,k,c} + \delta_{k,c} + \epsilon_{f,k,c}. \quad (6)$$

This specification allows us to account for any unobservable sector-country characteristics that might be correlated with both the level of protection and the degree of vertical integration. Again, according to P.2, we expect the coefficient ϕ_1 to be positive.

Finally, prediction P.3 states that the effect of tariffs on integration should be larger in sectors in which a smaller fraction of imports are exempt from the tariff. To assess the validity of this last prediction, we estimate the following model:

$$V_{f,k,c} = \omega_0 + \omega_1 \text{Tariff}_{k,c}\text{xMFN share}_{k,c} + \omega_2 \text{ Tariff}_{k,c} + \omega_3 \text{MFN share}_{k,c} + \omega_4 \mathbf{X}_{f,k,c} + \delta_k + \delta_c + \epsilon_{f,k,c}. \quad (7)$$

According to P.3, the coefficient ω_1 should be positive and significant.

Table 1: Tariffs and vertical integration

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Tariff$_{k,c}$	**0.020*** **	**0.020*** **	0.003	0.004		0.004	0.005	-0.007
	(0.006)	**(0.006)**	(0.009)	(0.009)		(0.008)	(0.008)	(0.010)
Domestic$_f$			-0.093***	-0.092***	-0.088***			-0.089***
			(0.011)	(0.011)	(0.009)			(0.011)
Tariff$_{k,c}$ **x Domestic**$_f$			**0.021*** **	**0.021*** **	**0.019*** **			**0.019*** **
			(0.005)	**(0.005)**	**(0.005)**			**(0.005)**
MFN share$_{k,c}$						-0.024	-0.022	-0.012
						(0.019)	(0.019)	(0.019)
Tariff$_{k,c}$ **x MFN share**$_{k,c}$						**0.024*** **	**0.023*** **	**0.019** **
						(0.007)	**(0.008)**	**(0.008)**
Capital Intensity$_k$ x Financial Development$_c$		0.032**		0.032**			0.029**	0.030**
		(0.014)		(0.014)			(0.015)	(0.015)
Capital Intensity$_k$ x Legal Quality$_c$		-0.083		-0.082			-0.074	-0.074
		(0.056)		(0.057)			(0.057)	(0.058)
# 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	0.117	0.119	0.119	0.002	0.117	0.117	0.119
Sector Fixed Effects	YES	YES	YES	YES	NO	YES	YES	YES
Country Fixed Effects	YES	YES	YES	YES	NO	YES	YES	YES
Sector-Country Fixed Effects	NO	NO	NO	NO	YES	NO	NO	NO

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 multinationals. 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 variable *Domestic*$_f$ identifies firms that do not export. *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. *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 1 reports the results of our benchmark regressions. In columns 1-2, we assess the validity of the first prediction of our theoretical model. Column 1 includes only the variable *Tariff* and country and sector fixed effects. The estimated coefficient for the tariff is 0.02 (implying a tariff elasticity of vertical integration of the same magnitude) and strongly significant. Consistent with P.1, higher tariffs lead firms to be more vertically integrated. Using the relationship between tariff and price elasticities observed in Section 3, for the mean values of tariffs in the sample (4.8%), this corresponds to a price elasticity of vertical integration of slightly over 0.4. As discussed below, when we restrict our analysis to the most competitive sectors, we estimate larger price elasticities, up to 2.1.

In column 2, we include 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 countries with more developed financial markets. The second interaction term has the expected negative sign but it is not significant. Our results on the effect of tariffs on firm-level vertical integration are unaffected.

In columns 3-5, we include the interaction between the variables *Tariff*$_{k,c}$ and *Domestic*$_f$ to verify whether the effect of domestic tariffs on organization is larger for firms that operate only in the domestic market. In line with P.2, the coefficient of the interaction term is positive and highly significant. In these specifications, the coefficient of *Tariff*$_{k,c}$ (which measures the impact of tariffs on vertical integration for exporters) is positive but insignificantly different from zero. These results imply that import tariffs have a significant effect on vertical integration only for firms that sell exclusively in the domestic market.[32]

In columns 6-7, we verify the third prediction of our model, whereby tariffs should have a larger impact on vertical integration when the share of imports to which they apply is larger (implying a bigger effect on domestic prices). 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 domestic prices. The interaction term is instead positive and highly significant, indicating that the effect of MFN tariffs on vertical integration is positive and increasing in their effect on import volumes.

[32]The negative coefficients of the variable *Domestic*$_f$ can be explained by combining the fact that firms operating only domestically tend to be less productive (see Melitz and Redding, 2014) and the implication of our theoretical framework that integration is less worthwhile for low productivity firms.

Finally, in column 8 we jointly consider the validity of predictions P.2 and P.3 of our model by including both interaction terms $Tariff_{k,c}$ x $Domestic_f$ and $Tariff_{k,c}$ x $MFN\ share_{k,c}$ in the same regression. The results continue to hold, with both coefficients remaining positive and significant.[33]

6 Alternative mechanisms

Our theoretical analysis focuses on a perfectly competitive setting, in which firms are price takers. According to our model, tariff changes should affect organizational choices through their impact on product prices: higher tariffs should raise prices and thus increase the incentives for vertical integration.

In reality, tariff changes may also affect vertical integration decisions through their impact on the degree of competition faced by firms. In particular, 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 option 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 organizational effects of product prices, in Table 2 we restrict our analysis to highly competitive sectors, in which tariffs changes should have little or no effect on the degree of competition. In all specifications, we impose two restrictions to define competitive industries: i) there are at least 20 domestic firms operating in that country and sector; ii) goods are homogeneous. Further restrictions are imposed in some specifications, as discussed below. To distinguish between differentiated and homogeneous sectors, we adopt two alternative methodologies: in Panel A, we use the dummy variable $Homogeneous1_k$, which identifies industries in which goods are traded in organized exchanges, classified as homogeneous according to Rauch (1999); in Panel B, we use instead the variable $Homogeneous2_{k,c}$, which identifies sectors with high import demand elasticities according to Broda, Greenfield and Weinstein (2006).

In the baseline specifications of columns 1-2, competitive sectors are identified based only on the two criteria discussed above. Additional restrictions are imposed in the rest of the table. Columns 3-4 include only sectors with low levels of protection ($Tariff_{k,c} < 10\%$), in which domestic firms face a high level of foreign competition. In columns 5-6, we restrict the sample to sectors in which some foreign-owned firms have plants in the domestic market, further increasing the competitive pressure on domestic firms. In columns 7-8, we exclude concentrated sectors, i.e. industries for which the $Concentration_{k,c}$ index is above 0.1.

[33] In a separate specification, we have also tried triple interactions. As expected, the coefficient of the term $Tariff_{k,c}$ x $Domestic_f$ x $MFN\ share_{k,c}$ is positive and significant: the positive impact of MFN share on the effect of tariffs is stronger for firms that sell only in the domestic market than for those that also sell in foreign markets.

Table 2: Tariffs and vertical integration, competitive industries

	Panel A: Homogeneous sectors based on Rauch (1999)							
	(1) Homogeneous sectors, many firms	(2) Homogeneous sectors, many firms	(3) Homogeneous sectors, many firms, low tariffs	(4) Homogeneous sectors, many firms, low tariffs	(5) Homogeneous sectors, many firms, foreign presence	(6) Homogeneous sectors, many firms, foreign presence	(7) Homogeneous sectors, many firms, low concentration	(8) Homogeneous sectors, many firms, low concentration
Tariff$_{k,c}$	**0.0290****	**0.0292****	**0.0380****	**0.0381****	**0.0316****	**0.0315****	**0.0747*****	**0.0982*****
	(0.0117)	**(0.0117)**	**(0.0149)**	**(0.0154)**	**(0.0145)**	**(0.0144)**	**(0.0228)**	**(0.0216)**
Capital Intensity$_k$		0.0063		0.0203		- 0.0035		0.68
x Financial Development$_c$		(0.0524)		(0.0436)		(0.4420)		(0.1610)
Capital Intensity$_k$		-0.0615		-0.2330		0.0499		1.027
x Legal Quality$_c$		(0.1950)		(0.1440)		(0.1870)		(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
	Panel B: Homogeneous sectors based on Broda, Greenfield and Weinstein (2006)							
	(1) Homogeneous sectors, many firms	(2) Homogeneous sectors, many firms	(3) Homogeneous sectors, many firms, low tariffs	(4) Homogeneous sectors, many firms, low tariffs	(5) Homogeneous sectors, many firms, foreign presence	(6) Homogeneous sectors, many firms, foreign presence	(7) Homogeneous sectors, many firms, low concentration	(8) Homogeneous sectors, many firms, low concentration
Tariff$_{k,c}$	**0.0257*****	**0.0248*****	**0.0345*****	**0.0341*****	**0.0363*****	**0.0363*****	**0.0648*****	**0.0639*****
	(0.0083)	**(0.0084)**	**(0.0085)**	**(0.0084)**	**(0.0101)**	**(0.0102)**	**(0.0112)**	**(0.0116)**
Capital Intensity$_k$		0.0216		0.0041		0.0560		-0.0267
x Financial Development$_c$		(0.0248)		(0.0245)		(0.0367)		(0.0299)
Capital Intensity$_k$		-0.1240		-0.0952		- 0.3018**		-0.0840
x Legal Quality$_c$		(0.0875)		(0.1170)		(0.1306)		(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

Notes: Robust standard errors clustered at the sector-country level are in parentheses; denoting *** 1%, **5%, and *10% significance. The sample includes firms $\geq$ 20 employment in the manufacturing sector, excluding multinationals. In all columns, the sample is restricted to industries in which at least 20 domestic firms operate in a given country, and in which products are homogeneous. In Panel A, homogeneous sectors are defined using the variable *Homogeneous1*$_k$ based on Rauch (1999); in Panel B, we use instead the variable *Homogeneous2*$_{k,c}$ based on Broda, Greenfield and Weinstein (2006). In columns (3)-(8), we impose further restrictions: 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 *Concentration*$_{k,c} \leq 0.1$. 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. *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 specifications, the coefficient for $Tariff_{k,c}$ is positive and significant at least at the five-percent level. The results of Table 2 allow us to identify the price-level effects of tariff changes on firm boundaries, abstracting from possible competition effects. In line with the first prediction of our theoretical model, these results suggest that higher import tariffs lead domestic firms to be more vertically integrated, by increasing the price at which they sell their final products.[34]

Table 2 implies that, in competitive sectors, the tariff elasticity of vertical integration ranges between 0.029 and 0.098. Recall from Section 3 that the *price* elasticity of integration is $\frac{1+t}{t}$ times as large. At the mean values of the variables, the estimates in the upper panel of Table 2 imply that the price elasticity of vertical integration ranges between 0.58 (column 2) and 2.14 (column 8). Price changes can thus have significant effects on firm boundaries.

Comparing Tables 1 and 2 we can see that, when we restrict the analysis to highly competitive sectors, the estimates for the import tariffs are larger in magnitude and more significant. This is also true when comparing different columns of Table 2. In particular, the magnitude of the tariff elasticity increases substantially when excluding firms in concentrated industries. A possible explanation for these differences is that in imperfectly competitive sectors tariff pass-through may be incomplete (e.g., Melitz and Redding, 2014). The effect of tariffs on domestic prices — and thus on vertical integration decisions — will then be smaller than in the case of perfect competition.

Another possible explanation for our results could be that protected firms have more disposable cash to acquire their suppliers. Notice that this explanation relies on the fact that firms are credit constrained, so that the amount of cash available matters for takeovers decisions. If this is the reason behind the positive impact of tariffs on vertical integration, we would expect the effect to be stronger in sectors and countries in which credit constraints are more severe.

To verify this, we have interacted the tariff variable with the inverse of the measure *Financial Development*$_c$ and with *Financial dependence*$_k$, which capture the extent of financial market imperfections in different countries and sectors. We have tried different specifications reported in Table 3. In all cases, the interaction terms are insignificant and the sign and significance of the tariff coefficient is unaffected, suggesting that cash availability is not the reason behind the positive effect of tariffs on vertical integration.

[34]To account for the fact that competitive pressure may vary across firms in an industry, we have also constructed a measure of a firm's distance to the industry technology frontier, in a similar way as Acemoglu, Aghion, Lelarge, Van Reenen, and Zilibotti (2007). When including this measure in our regressions, tariffs continue to have positive effect on vertical integration (and the effect is stronger for firms that are further away from the frontier). The same is true if we include in our regressions the standard deviation of productivity in a country-sector, to further control for firm heterogeneity. The results of these estimations are available upon request.

Table 3: Tariffs and vertical integration, credit constraints

	(1)	(2)	(3)	(4)	(5)	(6)
Tariff$_{k,c}$	**0.020*** **	**0.020*** **	**0.020** **	**0.020*** **	**0.021*** **	**0.021*** **
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Tariff$_k, c$ x Financial Dependence$_k$	0.000	0.000			0.001	0.001
	(0.001)	(0.001)			(0.001)	(0.001)
Tariff$_{k,c}$x Inv. Financial Development$_c$			-0.002	-0.002	-0.003	-0.003
			(0.006)	(0.006)	(0.006)	(0.006)
Tariff$_{k,c}$ x Financial Dependence$_k$					-0.001	-0.001
x Inv. Financial Development$_c$					(0.001)	(0.001)
Capital Intensity$_k$ x Financial Development$_c$		0.032*		0.032*		0.031*
		(0.014)		(0.014)		(0.014)
Capital Intensity$_k$ x Legal Quality$_c$		-0.082		-0.083		-0.082
		(0.057)		(0.057)		(0.057)
# Observations	196,586	196,586	196,586	196,586	196,586	196,586
# Sectors	386	386	386	386	386	386
R^2	0.117	0.117	0.117	0.117	0.117	0.117
Sector Fixed Effects	YES	YES	YES	YES	YES	YES
Country Fixed Effects	YES	YES	YES	YES	YES	YES

Notes: Robust standard errors clustered at the sector-country level are in parentheses; denoting *** 1%, **5%, and *10% significance. The sample includes firms $\geq$ 20 employment in the manufacturing sector, excluding multinationals. 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. *Financial Dependence*$_k$ measures capital expenditures minus cash flow from operations divided by capital expenditures. *Financial Development*$_c$ measures private credit by deposit money banks and other financial institutions as a fraction of GDP. *Capital Intensity*$_k$ is the total capital expenditures divided by value added. The variable *Legal Quality*$_c$ proxies for the quality of a country's institutions.

7 Additional robustness checks

In this section, we discuss a series of additional estimations that we have performed to verify the robustness of our results on the impact of tariffs on firm boundaries. Some of these results are not reported due to space considerations, but are available upon request.

In our analysis, we have used U.S. input-output tables to capture technological linkages between sectors. As pointed out before, this methodology introduced measurement error, thus making it harder to find a significant effect of tariffs on vertical integration (see footnote 19). We have verified that our results are robust to restricting the sample to OECD countries, which are more similar to the United States in terms of technology.[35]

Table 4 reproduces all the specifications of our benchmark Table 1, restricting the analysis to firms located in OECD countries. All our results continue to hold. In columns 1-2, the coefficient on the MFN tariff is positive and significant, indicating that higher tariffs lead firms to be more vertically integrated (in line with prediction P.1). In columns 3-5, the coefficient of the interaction between the variable $Tariff_{k,c}$ and $Domestic_f$ is positive and significant, confirming that tariffs have a bigger impact on the integration decisions of firms that serve only the domestic market (in line with prediction P.2). As in our benchmark regressions, the results reported in column 5 show that this result is robust to including sector-country fixed effects, which allow us to deal with concerns about omitted variables. Finally, in columns 6-7, the coefficient of the interaction between $Tariff_{k,c}$ and $MFN\ share_{k,c}$ is positive and significant, indicating that MFN tariffs have a bigger impact on integration decisions when they apply to a larger share of imports — and thus have a larger impact on domestic prices (as suggested by prediction P.3).

We have also verified that the effect of tariffs on integration is robust to including a series of additional firm and industry variables, which may be correlated with the level of protection and firms' vertical integration decisions. The results are reported in Table 5, in which we include the additional variables one at a time (columns 1-7) and all together (column 8).

[35] Moreover, most MFN tariffs applied by OECD countries in 2004 coincide with the bindings set in the Uruguay Round of multilateral trade negotiations (1986-1994), particularly in non-agricultural sectors (Bchir, Jean and Laborde, 2006). Governments have thus no room to adjust them under the pressure of import-competing firms.

Table 4: Tariffs and vertical integration, only firms in OECD countries

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Tariff$_{k,c}$	**0.027*** **	**0.027*** **	0.007	0.007		0.012	0.013	-0.002
	(0.007)	**(0.007)**	(0.010)	(0.010)		(0.010)	(0.010)	(0.012)
Domestic$_f$			-0.095***	-0.094***	-0.094***			-0.091***
			(0.011)	(0.011)	(0.009)			(0.011)
Tariff$_{k,c}$ **x Domestic**$_f$			**0.025*** **	**0.024*** **	**0.024*** **			**0.021*** **
			(0.006)	**(0.006)**	**(0.005)**			**(0.005)**
MFN share$_{k,c}$						-0.030	-0.026	-0.016
						(0.020)	(0.020)	(0.020)
Tariff$_{k,c}$ **x MFN share**$_{k,c}$						**0.023*** **	**0.021*** **	**0.016** **
						(0.009)	**(0.009)**	**(0.009)**
Capital Intensity$_k$ x Financial Development$_c$		0.044**		0.044**			0.041*	0.042*
		(0.020)		(0.020)			(0.021)	(0.021)
Capital Intensity$_k$ x Legal Quality$_c$		-0.097		-0.098			-0.086	-0.089
		(0.088)		(0.088)			(0.089)	(0.089)
# Observations	176,158	176,158	176,158	176,158	176,158	176,158	176158	176158
# Sectors	386	386	386	386	386	386	386	386
R^2	0.118	0.118	0.120	0.120	0.003	0.118	0.118	0.121
Sector Fixed Effects	YES	YES	YES	YES	NO	YES	YES	YES
Country Fixed Effects	YES	YES	YES	YES	NO	YES	YES	YES
Sector-Country Fixed Effects	NO	NO	NO	NO	YES	NO	NO	NO

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, located in OECD countries, excluding multinationals. 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 variable $Domestic_f$ identifies firms that do not export. $MFN\ share_{k,c}$ 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. $Financial\ Development_c$ 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 5: Tariffs and vertical integration, additional controls

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Tariff$_{k,c}$	**0.020****	**0.019****	**0.021*****	**0.028*****	**0.020*****	**0.021*****	**0.020*****	**0.030*****
	(0.007)	**(0.006)**	**(0.006)**	**(0.004)**	**(0.006)**	**(0.006)**	**(0.006)**	**(0.006)**
Input Tariff$_{k,c}$	0.039**							0.026
	(0.014)							(0.018)
Foreign Tariff$_{k,c}$		0.003						0.005
		(0.005)						(0.006)
Concentration$_{k,c}$			0.013					-0.012
			(0.023)					(0.019)
Declining Industry$_{k,c}$				0.005				-0.002
				(0.006)				(0.007)
Import-competing$_{k,c}$					0.003*			0.004
					(0.002)			(0.003)
Size$_f$						0.035***		0.035*
						(0.008)		(0.015)
Productivity$_f$							0.027***	0.021**
							(0.005)	(0.007)
Capital Intensity$_k$	0.033*	0.039*	0.040*	0.017	0.026	0.032*	0.039*	0.018
x Financial Development$_c$	(0.016)	(0.015)	(0.019)	(0.009)	(0.014)	(0.015)	(0.019)	(0.016)
Capital Intensity$_k$	-0.078	-0.100	-0.103	-0.014	-0.062	-0.084	-0.094	0.028
x Legal Quality$_c$	(0.062)	(0.060)	(0.071)	(0.032)	(0.058)	(0.058)	(0.070) X	(0.049)
# Observations	154,915	185,630	178,199	139,211	173,138	196,586	178,448	85,949
# Sectors	311	386	386	386	386	386	386	311
R^2	0.119	0.123	0.117	0.036	0.115	0.732	0.724	0.663
Sector Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES
Country Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES

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 multinationals. 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 foreign tariff, where we use log of one plus the tariff. *Tariff*$_{k,c}$ is the MFN tariff imposed by country c in sector k. *Import Tariff*$_{k,c}$ is the tariff imposed by country c on inputs of good k. *Foreign Tariff*$_{k,c}$ is the tariff faced by firms exporting good k from country c. *Concentration*$_{k,c}$ is the HHI of sector k in country c. *Declining Industry*$_{k,c}$ is a dummy equal to 1 if employment declined in a country-sector during the 1984-1994 period, constructing using employment data from UNIDO. The variable *Import-competing*$_{k,c}$ is the ratio of a country's total imports/exports by sector, constructed using information from Comtrade. *Size*$_f$ measures firm size (instrumented with employment predicted with sector-country dummies). *Productivity*$_f$ is measured as sales per worker (instrumented with sales per worker predicted with sector-country dummies). *Capital Intensity*$_k$ is the total capital expenditures divided by value added. *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.

First, we include measures of domestic tariffs on the inputs of sector k (column 1) and foreign tariffs on k (column 2); these are correlated with domestic output tariffs and may affect vertical integration decisions.[36] Second, in columns 4-6, we include other industry characteristics, which the literature on political economy of trade suggest might be correlated with the level of protection: the degree of concentration, a dummy variable identifying declining industries, and the ratio of imports/exports. Finally, we include measures of firms' size (instrumented with sector-country average size) and productivity (instrumented with sector-country average labor productivity).

In all specifications, the tariff coefficient is positive and highly significant, in line with the main prediction of our theoretical model. Of the additional controls, only firm size and labor productivity have a robust significant effect on vertical integration throughout the table. The fact that more productive firms are more likely to be integrated is consistent with our theoretical framework: firms that are exogenously more productive have stronger incentives to vertically integrate at any given price.[37] The estimated coefficient on input tariffs is positive and significant in column 1, but this result disappears in column 8. The coefficient on *Foreign Tariff* $_{k,c}$ is always insignificant. This finding is consistent with the theoretical framework described in Section 3, in which tariffs in foreign markets should have no effect on domestic prices and thus on vertical integration decisions by domestic firms.[38] Other characteristics of a country-sector (the degree of concentration, whether the industry is declining, and the imports/export ratio) have also no significant impact on the degree of vertical integration of firms in that country-sector.

Our identifying assumption is that the MFN tariff bindings negotiated during the Uruguay Round of GATT negotiations that ended in 1994 are exogenous to firms' vertical integration choices in 2004. To allay possible concerns that more vertically integrated firms might somehow have been more effective at lobbying for protection, we restrict our sample to firms established after 1994, which could not have affected the tariff bindings negotiated during the Uruguay Round. The results continue to hold: MFN tariffs have a positive impact on integration, particularly for firms serving only the domestic market. Moreover, when using the full sample of Table 1 and comparing firms established before and after 1994 we find that the effects of tariffs are quantitatively similar for the two sets of firms.

We have tried using a Poisson quasi-maximum likelihood (PQML) estimator to assess the effect of tariffs on vertical integration. Our results on the impact of output tariffs are unaffected:

[36] The simple correlation of output tariffs with input tariffs is 0.78 and the one with foreign tariffs is 0.31.

[37] We cannot formally test whether the instruments (average firm size and labor productivity in a given country-sector pair) are valid, since the model is exactly identified. However, we are confident that controlling for predicted firm size or productivity does not introduce any endogeneity bias, since the coefficient of the variable *Tariff* is unaffected when including these controls.

[38] By contrast, this result is hard to reconcile with models of vertical integration choices by multinationals, in which tariffs affect location decisions, and these are inextricably intertwined with boundary decisions. For example, in the two-country model by Diez (2014) tariffs in one country should always decrease vertical integration in the other country, so tariffs faced by exporters should have a negative effect on vertical integration.

in all specifications, the coefficient for the output tariff is always positive and significant.

We have used an alternative measure of vertical integration, based on all the firm's activities rather than its primary activity: $\overline{V}_{f,k,c} = \frac{1}{n_f} \sum^j V^j_{f,k,c}$, where n_f is the number of industries in which firm f is active (this is the measuere ised in Acemo. The coefficients for MFN tariffs remained strongly significant but, not surprisingly, they dropped slightly in magnitude.

In our main regressions, we have clustered standard errors at the sector-country level. Alternatively, we have tried clustering at the sector level, at the country level and two-way clustering at the sector and country level. In all cases, the coefficient for $\mathit{Tariff}_{k,c}$ remained strongly statistically significant.

We have also carried out the analysis on three alternative samples of firms. First, we have restricted the sample to countries for which we observe at least 1000 plants of sufficient size in order to eliminate any bias that may arise from differences in sampling across countries. Second, we have included multinational firms to the main sample. As noted above, since multinationals have plants in different countries, it is hard to identify with precision the tariffs that affect their organization decisions. In order to link their organizational structure to domestic tariffs, we split them in separate entities — one for each country — and use the primary activity of the respective domestic ultimate to identify the relevant tariff. Finally, we have excluded the U.S. from the sample, which accounts for almost 27 percent of firms in our main sample, in order to avoid any bias of our results by a single country. In all cases the coefficient on $\mathit{Tariff}_{k,c}$ remained positive and strongly significant.

In a final robustness check, we have performed a placebo test by confining attention to the ready-mix concrete sector. Tariffs should have no impact on prices and vertical integration decisions there, since ready-mix concrete is effectively non-tradable: "other than manufactured ice, perhaps no other manufacturing industry faces greater transport barriers. The problem arises because ready-mix concrete has a low value-to-weight ratio and is highly perishable — it absolutely must be discharged from the truck before it hardens" (Syverson, 2008, p. 217). Indeed, there is essentially no international trade in this type of concrete.[39] Not surprisingly, many countries (25 percent of those in our sample) report zero MFN tariffs on ready-mixed concrete. However, some countries have positive tariffs, and there is considerable variation in MFN rates: the median tariff is 2.57 percent, the standard deviation is 2.63, and the maximum tariff is 15.5 percent (Mexico and Argentina).[40] As expected, when focusing on firms whose primary activity is ready-mix concrete, we find that tariffs have no significant effect on the

[39]Ready-mix concrete is identified by the SIC code 3273 (which perfectly matches with HS code 3823.50 in the trade classification system). Prohibitive transport costs explain why there is essentially no trade in this sector. In our sample, the ratio of imports/total sales is on average 0.00001 (an over-estimate, since import data is exhaustive, while we do not have information on sales for all firms).

[40]The fact that many countries have positive MFN rates in sector SIC 3273 (HS 3823.50) is somewhat puzzling. A likely explanation is that, by setting positive tariffs, governments deter exporters of other types of concrete that are tradable and subject to import duties (e.g. "concrete mix," which can be transported in bags and to which water is added on site) from trying to misclassify their products to get a duty exemption.

degree of vertical integration; by contrast, the estimated coefficient for MFN tariffs remains positive and significant for other types of concrete that are tradable, in line with our main results.

8 Conclusions

In a break with traditional industrial economic concerns about the effects of vertical integration on product prices, recent organizational economic theory shows that prices may influence integration. The effect could arise whenever integration is costly but increases productive efficiency. As prices increase, so does the marginal value of productivity gains, and firms choose more integration. Trade policy provides a source of price variation that can be used to assess the empirical relevance of this mechanism. To study the impact of prices on firm boundaries, we have constructed firm-level vertical integration indices for a large set of countries and industries and exploited cross-country and cross-sectoral differences in applied MFN tariffs. As predicted by the model, we find that higher tariffs on final goods lead firms to be more vertically integrated; the effect is stronger for non-exporting firms, which are more sensitive to domestic prices, and in sectors in which domestic prices are more sensitive to import tariffs.

As we suggested for the cases of horizontal and lateral integration, the basic logic by which prices influence firms' vertical integration decisions applies to other "investments," both organizational and non-organizational, that increase productive efficiency. But there is a caveat. While our logic applies directly at the firm level, where the cost of investment is exogenous to the firm's choice, at the industry or macro level, there may be countervailing effects. For instance, consider investment in high-quality management, the supply of which is likely to be relatively inelastic. When output prices increase, all firms will try to invest in better management. But in aggregate, given the inelastic supply, there would be little observed effect. By contrast, in the theories of integration that have inspired this investigation, a significant part of the cost of integration is private, so these "general equilibrium" effects should matter less. Nevertheless, subject to availability of appropriate measures, investigating other channels through which prices can influence productive efficiency is an interesting topic for future research.

Our analysis has implications for antitrust policy. Positive correlations between prices and vertical integration have been observed in many industries. For example, a 1989 report on the beer industry by the British Monopolies and Mergers Commission found that retail prices were higher in integrated than non-integrated pubs (Slade, 1998). Similarly, Hastings (2004) noted that increases in gasoline prices in California in the 1990's were associated with increases in the number of vertically integrated gasoline stations. In these instances, policymakers appear to have drawn a causal inference from this correlation, that vertical integration causes higher prices.[41]

[41]Recent studies have questioned this inference in specific industries, either by providing alternative explanations for a positive correlation between prices and integration (Hastings, 2004) or by showing that the correlation

Though it is still certainly possible that vertical integration may raise prices in some industries in the manner suggested by foreclosure theories, our analysis suggests that a positive correlation between vertical integration and prices may also reflect causality working in the opposite way: higher prices may induce more vertical integration.

References

Acemoglu, D., P. Aghion, R. Griffith, and F. Zilibotti (2010). "Vertical Integration and Technology: Theory and Evidence," *Journal of European Economic Association*, 8, 1-45.

Acemoglu, D., P. Aghion, C. Lelarge, J. Van Reenen, and F. Zilibotti (2007). "Technology, Information and the Decentralization of the Firm," *Quarterly Journal of Economics* 122, 1759-1799.

Acemoglu, D., S. Johnson, and T. Mitton (2009). "Determinants of Vertical Integration: Financial Development and Contracting Costs," *Journal of Finance* 63, 1251-1290.

Aghion, P., R. Griffith, and P. Howitt (2006). "Vertical Integration and Competition," *American Economic Review Papers and Proceedings* 96, 97-102.

Alfaro, L., and A. Charlton (2009). "Intra-Industry Foreign Direct Investment," *American Economic Review* 99, 2096-2119.

Alfaro, P. Conconi, H. Fadinger, A. Newman (2013). "Do Prices Determine Vertical Integration?" NBER Working Paper 16118.

Antras, P. (2003). "Firms, Contracts, and Trade Structure," *Quarterly Journal of Economics* 118, 1375-1418.

Antras, P., and R. W. Staiger (2012). "Offshoring and the Role of Trade Agreements," *American Economic Review* 102, 3140-3183.

Atalay, E., Hortaçsu, A., and C. Syverson (2014). "Vertical Integration and Input Flows," *American Economic Review* 104, 1120-1148.

Baker, G., and T. Hubbard (2003). "Make Versus Buy in Trucking: Asset Ownership, Job Design and Information," *American Economic Review* 93, 551-572.

_____(2004). "Contractibility and Asset Ownership: On-Board Computers and Governance in US Trucking," *Quarterly Journal of Economics* 119, 1443-1479.

Bartelsman, E. J., and W. Gray (1996). "The NBER Manufacturing Productivity Database," NBER Technical Working Paper 205.

Beck T., A. Demigurc-Kunt, and R. Levine (2000). A New Database on Financial Development and Structure (1960-2006), *World Bank Economic Review*, 14, 597-605.

Bchir, H., S. Jean, and D. Laborde (2006). "Binding Overhang and Tariff-Cutting Formulas," *Review of World Economics* 142, 207-232.

Bernard, A. B., S. J. Redding, and P. K. Schott (2011). "Multi-Product Firms and Trade Liberalization," *Quarterly Journal of Economics*, 126, 1271-1318.

is actually negative (Hortaçsu and Syverson, 2007).

Bloom, N., R. Sadun, and J. Van Reenen (2010). "Does Product Market Competition Lead Firms to Decentralize?," *American Economic Review* 100, 434-438.

_____(2012a). "The Organization of Firms Across Countries," *Quarterly Journal of Economics* 127, 1663-1705.

_____(2012b). "Americans Do IT Better: US Multinationals and the Productivity Miracle," *American Economic Review* 102, 167-201.

Bloom, N., and J. Van Reenen (2007). "Measuring and Explaining Management Practices Across Firms and Countries," *Quarterly Journal of Economics* 122, 1351-1408.

Bolton, P. and M. D. Whinston (1993). "Incomplete Contracts, Vertical Integration, and Supply Assurance," *Review of Economic Studies* 60, 121-148.

Bombardini, M. (2008). "Firm Heterogeneity and Lobby Participation," *Journal of International Economics* 75, 329-348.

Bradford, S. (2003). "Paying the Price: Final Goods Protection in OECD Countries," *Review of Economics and Statistics* 85,24-37.

Brainard, S. L., and T. Verdier (1997). "?The Political Economy of Declining Industries: Senescent Industry Collapse Revisited," *Journal of International Economics* 42, 221-237.

Broda, C., J. Greenfield, and D. Weinstein (2006). "From Groundnuts to Globalization: A Structural Estimate of Trade and Growth," NBER Working Paper No. 12512.

Caves, R. E. (1975). "Diversification, Foreign Investment and Scale in North American Manufacturing Industries," *Canadian Public Policy* 2, 274-276.

Coase, R. H. (1937). "The Nature of the Firm," *Economica* 4, 386-405.

Conconi, P., G. Facchini, M. Zanardi (2014). "Policymakers Horizon and Trade Reforms: The Protectionist Effect of Elections," *Journal of International Economics* 94, 102-118.

Conconi, P., Legros, P., and A. F. Newman (2012). "Trade Liberalization and Organizational Change," *Journal of International Economics* 86, 197-208.

Diez, F. J. (2014). "The Asymmetric Effects of Tariffs on Intra-Firm Trade and Offshoring Decisions," *Journal of International Economics* 93, 76-91.

Eckel, C., and P. J. Neary (2010). "Multi-product Firms and Flexible Manufacturing in the Global Economy," *Review of Economic Studies* 77, 188-217.

Fajgelbaum, P., G.M. Grossman, G., and E. Helpman (2015), "A Linder Hypothesis for Foreign Direct Investment," *Review of Economic Studies* 82, 83-121.

Fan, J. P. H., and L. H. Lang (2000). "The Measurement of Relatedness: An Application to Corporate Diversification," *Journal of Business* 73, 629-660.

Finger, J. M., H. K. Hall, and D. R. Nelson (1982). "The Political Economy of Administered Protection," *American Economic Review* 72, 452-466.

Forbes, S. J., and M. Lederman (2009). "Adaptation and Vertical Integration in the Airline Industry," *American Economic Review* 99, 1831-1849.

_____(2010). "Does Vertical Integration Affect Firm Performance? Evidence from the Airline Industry," *Rand Journal of Economics* 41, 765-790.

Grossman S. J., and O. D. Hart (1986). "The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration," *Journal of Political Economy* 94, 691-719.

Grossman, G. M., and E. Helpman (2002), "Integration Versus Outsourcing In Industry Equilibrium," *Quarterly Journal of Economics* 117, 85-120.

Guadalupe, M., and J. Wulf (2012). "The Flattening Firm and Product Market Competition: The Effect of Trade Liberalization," *American Economic Journal: Applied Economics* 4, 105-127.

Hart, O. D., and B. R. Holmström (2010). "A Theory of Firm Scope," *Quarterly Journal of Economics* 125, 483-513.

Hart, O. D., and J. H. Moore (1990). "Property Rights and the Nature of the Firm," *Journal of Political Economy* 98, 1119-1158.

Hart, O. D., and J. Tirole (1990). "Vertical Integration and Market Foreclosure," *Brookings Papers on Economic Activity*, 205-276.

Hastings, J. (2004). "Vertical Relationships and Competition in Retail Gasoline Markets: Empirical Evidence from Contract Changes in Southern California," *American Economic Review* 94, 317-328.

Holmström, B. and P. Milgrom (1991). "Multitask Principal-Agent Analyses: Incentive Contracts, Asset Ownership, and Job Design," *Journal of Law, Economics and Organization* 7, 24-52.

Hortaçsu, A., and C. Syverson (2007). "Cementing Relationships: Vertical Integration, Foreclosure, Productivity and Prices," *Journal of Political Economy* 115, 250-301.

Hummels, D., J. Ishii, and K. Yi (2001). "The Nature and Growth of Vertical Specialization in World Trade," *Journal of International Economics* 54, 75-96.

Joskow, P. (1987). "Contract Duration and Relationship-Specific Investments: Empirical Evidence from Coal Markets," *American Economic Review* 77, 168-185.

Kaufmann, D., A. Kraay, and M. Mastruzzi (2004). "Governance Matters III: Governance Indicators for 1996, 1998, 2000, and 2002," *World Bank Economic Review* 18, 253-287.

Klapper, L., L. Laeven, and R. Rajan (2006). "Entry Regulation as a Barrier to Entrepreneurship," *Journal of Financial Economics* 82, 591-629.

Klein, B., R. G. Crawford, and A. Alchian (1978)."Vertical Integration, Appropriable Rents and the Competitive Contracting Process," *Journal of Law and Economics*, 21, 297-326.

Lafontaine, F., and M. Slade (2007). "Vertical Integration and Firm Boundaries: The Evidence" *Journal of Economic Literature*, 45, 629-685.

Legros, P., and A. F. Newman (2008). "Competing for Ownership," *Journal of the European Economic Association* 6, 1279-1308.

_____(2013). "A Price Theory of Vertical and Lateral Integration," *Quarterly Journal of Economics* 128, 725-770.

_____(2014). "Contracts, Ownership, and Industrial Organization: Past and Future," *Journal of Law Economics and Organization* 30(S1), i82-i117.

Macchiavello, R. (2012), "Financial Development and Vertical Integration: Theory and Evidence," *Journal of the European Economic Association* 10, 255-289.

McLaren, J. (2000). "Globalization and Vertical Structure," *American Economic Review* 90, 1239-1254.

Melitz, M. J. (2003). "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity," *Econometrica* 71, 1695-1725.

Melitz, M. J., and S. J. Redding (2014). "Heterogeneous Firms and Trade," in *Handbook of International Economics*, Amsterdam: North-Holland.

Mitra, D. (1999). "Endogenous Lobby Formation and Endogenous Protection: A Long-Run Model of Trade Policy Determination," *American Economic Review* 89, 1116-1134.

Nunn, N. (2007). "Relationship-Specificity, Incomplete Contracts, and the Pattern of Trade," *Quarterly Journal of Economics* 122, 569-600.

Ornelas, E., and J. Turner (2008). "Trade Liberalization, Outsourcing, and the Hold Up Problem," *Journal of International Economics* 74, 225-241.

Ordover, J. A., G. Saloner, and S. C. Salop (1990). "Equilibrium Vertical Foreclosure," *American Economic Review* 80, 127-142.

Rajan, R., and L. Zingales (1998). "Financial Dependence and Growth," *American Economic Review* 88, 559-586.

Ramondo, N., V. Rappoport, and K. Ruhl (2015). "Horizontal versus Vertical Foreign Direct Investment: Evidence from U.S. Multinationals," *Journal of International Economics*, forthcoming.

Rauch, J. (1999). "Networks Versus Markets in International Trade," *Journal of International Economics* 48, 7-35.

Riordan, M. H. (2008). "Competitive Effects of Vertical Integration," in P. Buccirossi (ed.), *Handbook of Antitrust Economics*, MIT Press.

Salinger, M. A. (1988). "Vertical Mergers and Vertical Foreclosure," *Quarterly Journal of Economics* 103, 345-356.

Syverson, C. (2008). "Markets: Ready-Mixed Concrete," *Journal of Economic Perspectives* 22, 217-234.

Slade, M. E. (1998). "Beer and the Tie: Did Divestiture of Brewer-Owned Public Houses Lead to Higher Beer Prices?," *Economic Journal* 108, 1-38.

Stuckey, J. A. (1983). *Vertical Integration and Joint Ventures in the Aluminium Industry*, Harvard University Press.

Topkis, D. (1998). *Supermodularity and Complementarity*, Princeton University Press.

Vives, X. (2000). *Oligopoly Pricing: Old Ideas and New tools*, MIT Press.

Williamson, O. (1971). "The Vertical Integration of Production: Market Failure Considerations," *American Economic Review* 61, 112-123.

_____(1975). *Markets and Hierarchies: Analysis and Antitrust Implications*, Free Press.

Woodruff, C. (2002). "Non-contractible Investments and Vertical Integration in the Mexican Footwear Industry," *International Journal of Industrial Organization* 20, 1197-1224.

Appendix

A-1 Descriptive statistics

Table A-1: Main sample

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	

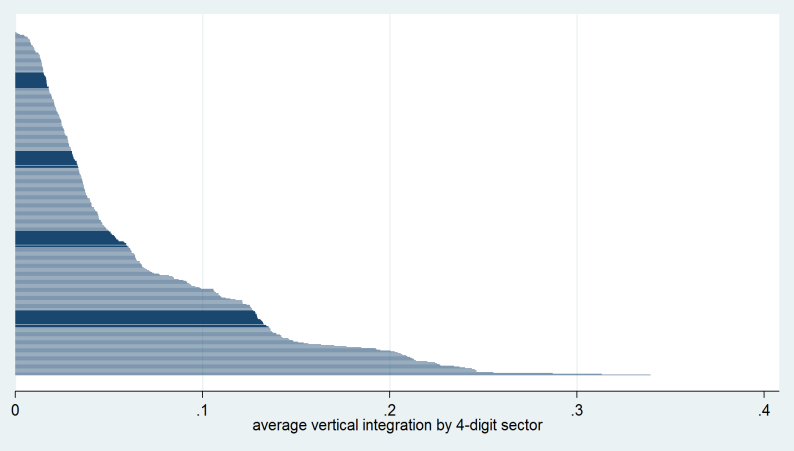
Notes: The sample includes all firms in the 2004 WorldBase dataset by Dun & Bradstreet, which are located in WTO member countries and have primary activities in manufacturing sectors. It excludes firms with less than 20 employees and multinationals.

Table A-2: Summary statistics

Sample				N
Plants				225,212
Connected plants				29,214
Multi-plant firms				6,830
Single-plant firms				189,756
Firms				196,586
Variables	Median	Mean	Std. Dev.	N
Vertical Integration Index$_f$	0.044	0.063	0.063	196,586
Domestic$_f$	0	0.233	0.423	196,586
Size$_f$	38.000	98.936	472.395	196,586
Productivity$_f$	11.506	11.446	1.082	178,448
Tariff$_{k,c}$	2.480	4.849	7.253	196,586
MFN Share$_{k,c}$	0.564	0.545	0.351	196,586
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	386
Input Tariff$_{k,c}$	2.546	3.994	4.954	154,915
Foreign Tariff$_{k,c}$	5.654	6.611	5.039	185,630
Concentration$_{k,c}$	0.053	0.132	0.188	178,199
Declining$_{k,c}$	1	0.531	0.499	139,211
Import-competing$_{k,c}$	0.093	0.241	1.442	173,138
Financial Development$_c$	0.332	0.554	0.479	80
Financial Dependence$_k$	-0.078	-0.253	5.248	386
Legal Quality$_c$	0.545	0.583	0.209	80

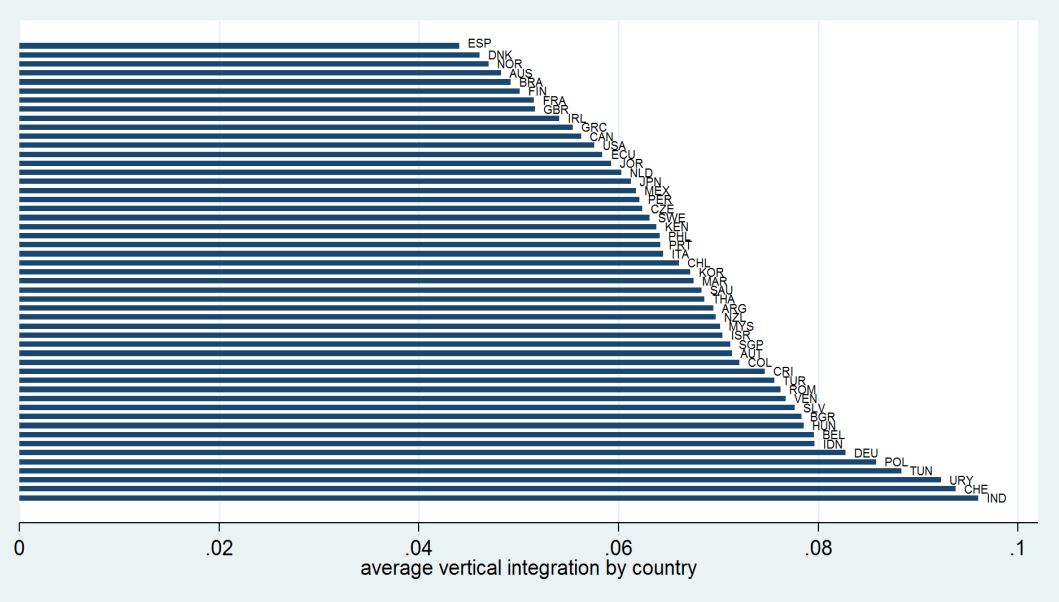
Sources: Vertical Integration Index$_f$, *Size$_f$*, *Productivity$_f$*, *Domestic$_f$* and *Concentration$_{k,c}$* constructed using plant-level data from 2004 WorldBase, Dun & Bradstreet. Sample includes manufacturing firms with at least 20 employees and excludes multinationals. *Tariff$_{k,c}$* from the World Integrated Trade Solution (WITS); *Input Tariff$_{k,c}$*, *Foreign Tariff$_{k,c}$*, *MFN Share$_{k,c}$*, and *Import competing$_{k,c}$*constructed using data from WITS and the UN Comtrade database. *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. *Declining$_{k,c}$* from UNIDO employment data. *Financial Development$_c$* from Beck, Demigurc-Kunt and Levine (2000). *Financial Dependence$_k$* from Compustat. *Legal Quality$_c$* from Kaufmann, Kraay, and Mastruzzi (2004). *Vertical Integration Index$_f$*, *Tariff$_{k,c}$*, *Input Tariff$_{k,c}$*, *Foreign Tariff$_{k,c}$*, *Size$_f$*, *Concentration$_{k,c}$*, and *MFN Share$_{k,c}$* are in levels; all other variables (with the exception of indicator variables) are in logs.

Figure A-1: Average vertical integration index by 4-digit SIC industry



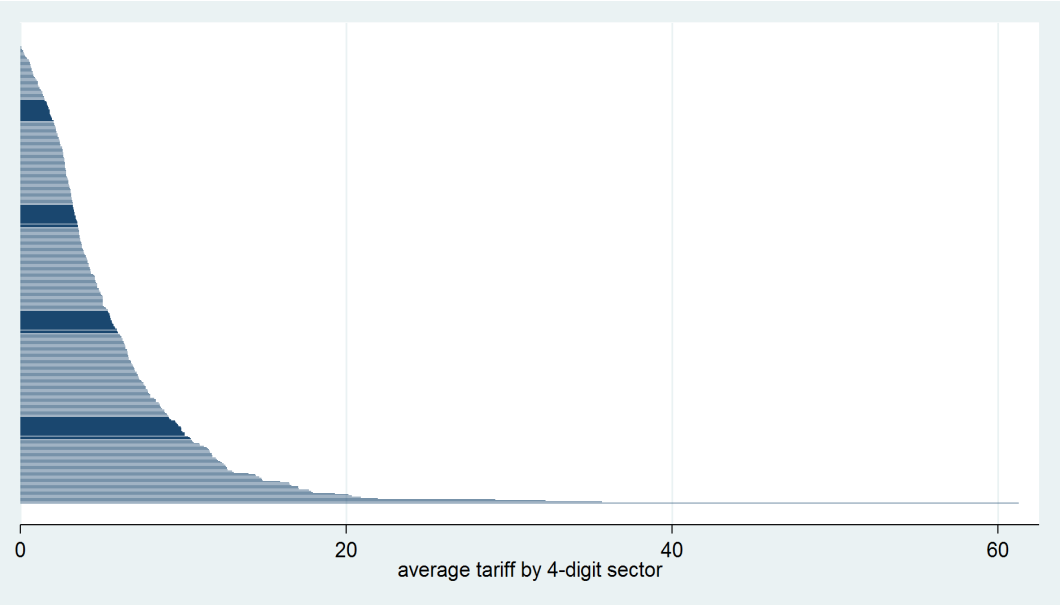
Notes: The figure shows average vertical integration indices by 4-digit SIC industry. The five most vertically integrated industries are: SIC 3331 (Primary copper), $\bar{V}_k = 0.339$; SIC 3334 (Primary aluminum), $\bar{V}_k = 0.313$; SIC 2062 (Cane sugar refining), $\bar{V}_k = 0.287$; SIC 2813 (Industrial gases), $\bar{V}_k = 0.255$, and SIC 2865 (Cyclic crudes and intermediates), $\bar{V}_k = 0.246$. The five least vertically integrated industries are SIC 2083 (Malt), $\bar{V}_k = 0$; SIC 2895 (Carbon black), $\bar{V}_k = 0$; SIC 2296 (Tire cord and fabrics), $\bar{V}_k = 0.0007$; SIC 3489 (Ordnance and accessories, n.e.c), $\bar{V}_k = 0.0017$; and SIC 2111 (Cigarettes), $\bar{V}_k = 0.0023$.

Figure A-2: Average vertical integration index by country



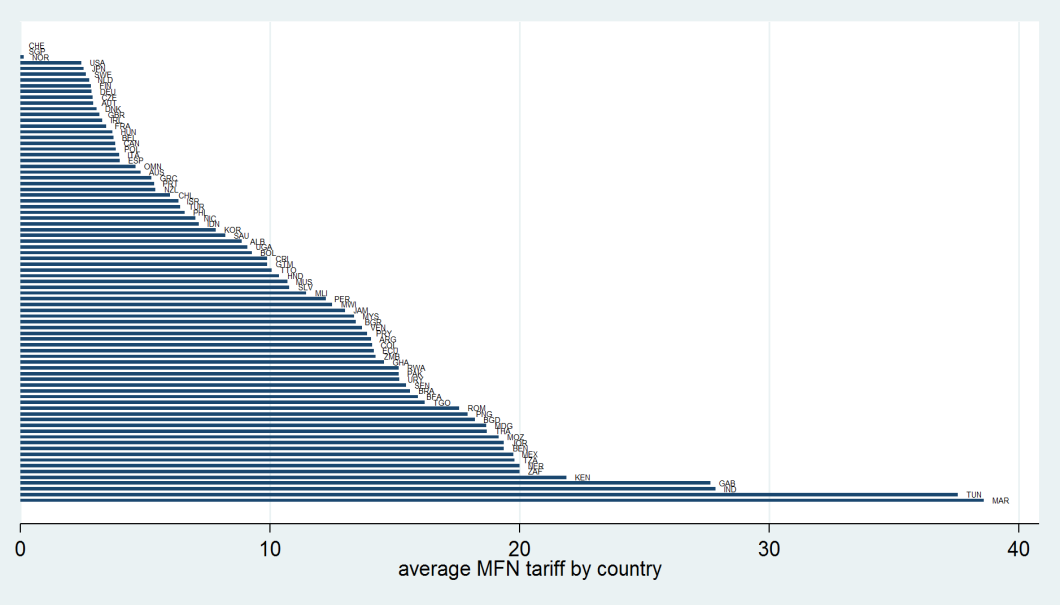
Notes: The figure shows average vertical integration indices by country. The five countries with the most vertically integrated firms are: India (IND), Switzerland (CHE), Uruguay (URY), Tunisia (TUN), Poland (POL). The five countries with the least vertically integrated firms are: Spain (ESP), Denmark (DNK), Norway (NOR), Australia (AUS), Brazil (BRA).

Figure A-3: Average applied MFN tariffs by 4-digit SIC industry



Notes: The figure shows average applied MFN tariffs by 4-digit SIC industry. The sectors with the highest tariffs are: SIC 2084 (Wines, brandy and brandy spirits), 61.742%; SIC 2131 (Chewing and smoking tobacco), 48.408%; SIC 2141 (Tobacco stemming and redrying), 42.568%; SIC 2111 (Cigarettes), 33.129%; and SIC 2043 (Cereal breakfast products), 27.343%. The five sectors with the lowest tariffs are: SIC 3572 (Computer storage devices), 0.250%; SIC 2711 (Newspapers), 0.641%; SIC 3674 (Semiconductors and related devices), 0.694%; SIC 2491 (Wood preserving), 1.066%; and SIC 2611 (Pulp mills), 1.075%.

Figure A-4: Average applied MFN tariff by country



Notes: The figure shows average applied MFN tariffs by country. The 5 countries with the highest tariffs are: Morocco (MAR), Tunisia (TUN), India (IND), Gabon (GAB), and Kenya (KEN). The 5 countries with the lowest tariffs are: Switzerland (CHE), Singapore (SGP), Norway (NOR), United States (USA), and Japan (JPN).

A-2 Vertical integration and productivity

The empirical results presented in Sections 5-7 are in line with the predictions of our theoretical model: higher output tariffs in a country-sector lead firms in that country-sector to become more vertically integrated; the effect is larger for firms that serve only the domestic market and when a smaller fraction of imports are exempt from the tariff. These findings provide strong support for the view that output prices are a key determinant of firm boundary choices.

One of the key assumptions of the theory is that vertical integration enhances productivity. As discussed in the introduction, the literature on firm boundaries puts forward various mechanisms through which integration may increase productive efficiency, e.g. technological synergies, better multitasking incentives, improved coordination. There is also a sparse but influential empirical literature providing evidence for this effect in specific industries. For example, Hortaçsu and Syverson (2007) show that vertically integrated ready-mixed concrete plants are more productive than non-integrated plants, even those in the same market. Forbes and Lederman (2010) find that integrated airlines perform systematically better than non-integrated airlines.

Table A-3: Vertical integration and productivity

	(1)	(2)	(3)	(4)
Vertical Integration$_f$	0.103***	0.100***	0.102***	0.098***
	(0.006)	(0.006)	(0.006)	(0.006)
Size$_f$		0.022***		0.027***
		(0.005)		(0.005)
# Observations	178,448	178,448	178,448	178,448
# Sectors	386	386	386	386
R^2	0.371	0.371	0.003	0.004
Sector Fixed Effects	YES	YES	NO	NO
Country Fixed Effects	YES	YES	NO	NO
Sector-Country Fixed Effects	NO	NO	YES	YES

Notes: Robust standard errors clustered at the sector-country level in parentheses denoting $***$ 1%, $**$ 5%, and $*$ 10% significance. The sample includes firms $\geq$ 20 employees in the manufacturing sector, excluding multinationals. The dependent variable is *Labor productivity*$_f$, measured as sales per worker of firm f (in logs). *Vertical Integration*$_f$ 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. *Size*$_f$ measures a firm's employment (in logs).

In Table A-3 we examine the relationship between productivity (measured as sales per employee) and the degree of vertical integration in our main sample of firms.[42] In the specifications

[42]We have also assessed the validity of assumption (i) of our model exploiting time variation in vertical inte-

of columns 1-2, we include country and sector fixed effects, to account for country and industry characteristics that may affect firm productivity. Columns 3-4 include sector-country fixed effects, which allow us to control for product prices and other sector-country variables.

In all specifications, the coefficient on vertical integration is positive and highly significant. This finding is consistent with assumption (i) of our model, according to which vertical integration has a positive impact on productivity. However, interpreting the coefficient of *Vertical Integration*$_f$ as the magnitude of the effect of integration on productivity should be done with caution, for as suggested at the end of Section 3, some exogenous sources of productivity variation could be driving selection into integration. Nevertheless, this selection effect can only be operative if vertical integration actually increases productive efficiency: if assumption (i) does not hold, there is no selection of this kind and no reason for a positive correlation between integration and productivity.

gration and productivity for firms that we observe in different years of the WorldBase dataset (1999, 2004 and 2009). In line with the regressions of Table A-3, we find that productivity increases when firms become more integrated. The results of these estimations are available upon request.