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Alyson C. Ma and Ari Van Assche

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ABSTRACT

The core idea behind the paper is that trade policy matters for the organization of global value chains, a notion largely neglected by economists but which has important implications for our understanding of trade and the international transmission of trade policy shocks. We develop a theoretical model in which a firm's ability to spatially separate manufacturing from headquarter services gives them the flexibility to circumvent economy-specific tariff changes by switching their assembly location abroad. We show that tariff shirking increases the elasticity of bilateral trade to economy-specific tariff hikes due to an extra extensive margin effect. Furthermore, we show that tariff shirking affects the vulnerability of headquarter services and manufacturing to trade policy shocks in opposite ways. While tariff shirking dampens the vulnerability of headquarter services to trade policy shocks, it amplifies the vulnerability of manufacturing to trade policy shocks. Using firm-level and province-level export data from the People's Republic of China, we provide evidence in line with the theoretical model.

Keywords: vertical specialization, extensive margin, antidumping, tariff shirking, People's Republic of China

JEL Classification: F12, F13, F14

I. INTRODUCTION

The organization of production has changed in the past few decades. Groundbreaking advances in transportation and communications technology have enabled firms to separate value chain tasks in space and time (Grossman and Rossi-Hansberg 2008). Recent studies have extensively investigated how this added organizational flexibility allows firms to arbitrage factor cost and institutional differences across economies, leading to the emergence of global value chains (see Van Assche [2012] for an overview).

An additional benefit related to the slicing up of value chains, which has received less attention, is that it allows firms to more easily circumvent trade policy barriers. To avoid an economy-specific trade barrier, a company no longer has to relocate its entire value chain to another economy, but only a single value chain stage, often final assembly. Fung, Fung, and Wind (2007, pp. 58–59), for example, describe how the trading company Li & Fung scrambled to restructure its value chain in response to an unexpected trade policy shock:

“[O]n a Friday in early September 2006, the South African government announced that it would be imposing strict quotas on Chinese imports in two weeks. Li & Fung had orders already in production for South African retailers that would be affected by these changes. Managers began to look at contingency plans to move production to factories in different countries and even to move the last stage of existing orders to different end countries to satisfy non-[People’s Republic of] China country-of-origin rules.”

The trading company’s urge to restructure its value chain to circumvent trade barriers implies that tariff shirking may be a powerful force affecting trade patterns. A firm’s ability to circumvent trade policy, in turn, may have important implications for the effectiveness of trade policy to protect domestic firms and for the transmission of trade policy shocks along different parts of the value chain.

In this paper, we present an analytical framework that allows us to investigate the effects of tariff shirking on trade. We build on the heterogeneous firm models by Melitz (2003) and by Chaney (2008), but allow Northern firms to manufacture their goods either in their home economy (local value chain) or in the South (global value chain). We show that this added organizational flexibility makes it profitable for some Northern firms (at the margin) to circumvent economy-specific tariff hikes by relocating its manufacturing. For example, if tariffs increase on Southern exports, some Northern firms will reshore their manufacturing to their home economy, leading to an extensive margin effect. Several strong results emerge from the model. First, tariff shirking reduces the effectiveness of trade policy to protect a domestic industry since it provides foreign companies with an extra tool to circumvent economy-specific tariffs. Second, vertical specialization increases the elasticity of bilateral exports to economy-specific tariff hikes. Third, Southern exports that are part of global value chains are more sensitive to an economy-specific tariff hike than Southern exports that are part of local value chains. Fourth, the effect of trade policy is distributed unevenly along the value chain. While tariff shirking dampens the vulnerability of headquarter services to trade policy shocks, it amplifies the vulnerability of manufacturing to trade policy shocks.

Guided by the theory, we empirically investigate the prediction that Southern exports that are part of global value chains are more sensitive to an economy-specific tariff hike than Southern exports that are part of local value chains. For this purpose, we draw on both firm-level and provincial-level data from the customs statistics of People’s Republic of China (PRC).

We do so by making a distinction between Chinese exports under two separate customs regimes: processing trade and ordinary trade. As both Kee and Tang (2013) and Koopman, Wang, and Wei (2012) have illustrated, processing exports are predominantly part of global value chains, while ordinary exports more extensively use domestic value chains. In line with our theoretical predictions, we find strong evidence that processing exports are more sensitive to the imposition of antidumping measures than ordinary exports. This is mostly due to the extensive margin effect identified in the theoretical model.

The rest of the paper is organized as follows. In section II, we survey the related literature on trade policy and global value chains. In section III, we present the theoretical model and discuss our central predictions. Section IV presents the data and methods used for our empirical analysis. Section V talks about the implications for policy and we finally conclude.

II. VERTICAL SPECIALIZATION AND TRADE POLICY

The growing ability of companies to separate value chain tasks in space and time is intrinsically related to the modularization of product architectures. Ulrich (1995) defines a product as a combination of components—or modules—that interact with one another according to the design rules of its product architecture. Products architectures can vary on a continuum from integral to modular depending on the number of interdependencies between modules (Schilling 2000). If the product architecture is integral, modules are highly interdependent and require constant monitoring and tacit interactions. In that case, geographically separating value chain activities is hard to do since it requires significant coordination efforts (Fort 2011). In contrast, if the product architecture is modular, then the modules interact through codified (and often digitized) interfaces, which make them relatively independent from one another. In that case, modules can be geographically separated at a relatively low coordination cost.

The emergence of e-mail, the Internet and common communications protocols, as well as the increased availability of high-capacity computing power, has made it easier for firms to modularize their product architecture. Currently, many companies rely on sophisticated computer-aided design (CAD) technologies and business-to-business (B2B) systems to share codified information between geographically separated locations. These technologies allow them to perform tasks in geographically dispersed locations with limited risk of miscommunication and with a relatively modest cost of monitoring (Blinder 2006, Leamer and Storper 2001, and Levy and Murnane 2003). Indeed, Fort (2011) estimates that United States (US) companies that use CAD technology to coordinate shipments have fragmented their international production processes more extensively than companies without CAD technology.

A vast literature in international trade has investigated how the added organizational flexibility related to the modularization of product architectures allows firms to arbitrage cost differences across economies. Beyond the traditional sources of comparative advantage such as technological differences and relative endowments, scholars have pinpointed new sources of comparative advantage for task trade. Focusing on the fact that global value chains often involve multiple companies that sign contracts with each other, one stream of literature has identified the quality of an economy's judiciary system can act as a source of comparative advantage (Acemoglu, Antràs, and Helpman 2007; Costinot 2009; Levchenko 2007; and Nunn 2007). Other studies have focused on the quality of an economy's transportation infrastructure (Gamberoni, Lanz, and Piermartini 2010) and labor markets (Helpman and Itskhoki 2010) as a source of comparative advantage.

Less attention has been paid to trade policy barriers as a cost factor that can be arbitrated through the restructuring of the value chain.¹ The literature has largely considered trade policy barriers as a factor that reduces a firm's incentive to slice up its value chains. Focusing on worldwide tariffs, Yi (2003) shows that they have a higher impact on the cost of trade within global value chains as compared with regular trade (i.e., trade of final goods fully produced in a single economy), since the same component needs to cross borders multiple times. As a result, he predicts that a relatively small rise in worldwide tariffs or other trade barriers will deter many firms from fragmenting production internationally, therefore leading to a large drop in trade.²

In Yi's (2003) model, the ability to fragment production internationally does not provide firms with added flexibility to circumvent tariffs, since tariffs worldwide are assumed to uniformly move up or down. The literature on tariff jumping, then again, provides insights into the effect of tariff changes on the spatial structure of production. Belderbos and Sleuwaegen (1998) and Blonigen (2002) provide evidence that many firms react to an economy-specific tariff increase or antidumping measure by moving their production to the destination economy, therefore avoiding the trade barrier. Blonigen, Tomlin, and Wilson (2004) show that such tariff jumping foreign direct investment (FDI) reduces the effectiveness of trade policy to protect domestic firms.

Surprisingly, the international trade literature has paid limited attention to tariff shirking as a strategy to avoid economy-specific changes in trade policy. Distinct from tariff jumping where the firm moves production to the destination economy or region, a firm under tariff shirking would try to circumvent the trade policy barrier by moving manufacturing to a third economy that does not face the trade policy barrier.³ Arguably, vertical specialization has made tariff shirking easier since firms only need to move a part of their value chain instead of their entire value chain. In the next section, we move to set up a theoretical model that allows us to analyze the mechanism of tariff shirking and the effect on trade.

III. MODEL

Our model builds on the firm heterogeneity models of Melitz (2003) and Chaney (2008), but allows firms to manufacture their final goods either in their home economy (local value chain) or in a Southern economy (global value chain). Consider a world with many small Northern economies and a small Southern economy. In each economy j , households spend the fixed amount $Y^j > 0$ on a specific differentiated goods sector. The demand function for a variety v in this sector produced in economy i and sold in economy j equals:

$$y^{ij}(v) = A^j p^{ij}(v)^{-\varepsilon}, \quad (1)$$

¹ Konings and Vandenbussche (2013) provide evidence that antidumping measures on imported inputs negatively affect firms' exports. However, they do not analyze whether firms react to this through tariff shirking.

² Escaith and Diakantoni (2012) and Miroudot and Rouzet (2013) use international input-output matrices to estimate the effective protection rates when components cross borders multiple times.

³ There is a recent literature on export platform FDI that investigates the drivers of a firm's decision to conduct FDI in a third economy (Ekholm, Forslid, and Markusen 2007; Grossman, Helpman, and Szeidl 2006; Ito 2013; Mrázová and Neary 2013). However, these studies have mainly focused on the effect of uniform changes in trade costs across economies, and not on the effect of economy-specific changes in trade costs, therefore ruling out tariff shirking. Furthermore, they have not considered the implications for the effectiveness of trade policy.

where $\varepsilon = \frac{1}{1-\alpha} > 1$ is the elasticity of substitution between any pair of differentiated goods and the demand level A^i is exogenous from the point of view of the individual firm and the individual economy (due to the small economy assumption).⁴

Exports from economy i to economy j are subject to an *ad valorem* tariff t^{ij} , where $\tau^{ij} = 1 + t^{ij}$. Tariffs are economy-specific and vary across economies. The tariff implies that the consumer price in economy j is higher than the domestically charged price (i.e., in economy i):

$$p^{ij}(v) = p^i(v)(1 + t^{ij}) = p^i(v)\tau^{ij}, \quad (2)$$

where $p^i(v)$ is the domestic price.

In each economy, a continuum of firms has the know-how to produce a single variety. We assume that each firm draws a productivity φ from a cumulative Pareto distribution $G(\varphi)$ with shape parameter $z > \varepsilon - 1$ (Helpman, Melitz, and Yeaple 2004):

$$G(\varphi) = 1 - \varphi^{-z}. \quad (3)$$

An inverse measure of the heterogeneity in a sector is given by z . If z is high, firms are more homogeneous, in the sense that more output is concentrated among the smallest and least productive firms. We assume that all economies face an identical Pareto distribution function.

The value chain of a product consists of three stages: knowledge-intensive headquarters service production, labor-intensive manufacturing and final sale. A firm is required to produce its headquarter services in its home economy. Manufacturing, in contrast, is footloose and can be conducted either in a Northern economy at a fixed unit labor cost of ω^N or in South at a fixed unit labor cost of ω^S . If manufacturing is not co-located with headquarters services, the firm faces a fixed cost g of coordinating its global value chain activities across borders. Finally, to sell its product variety to consumers in the destination economy j , a firm faces a fixed cost f .

In our model, we assume that wages are fixed and are lower in South than in the Northern economies, $\omega^S < \omega^N$. Furthermore, we assume that the following condition holds:⁵

$$\left(\frac{\omega^N}{\omega^S}\right)^{\varepsilon-1} \left(\frac{\tau^N}{\tau^S}\right)^{\varepsilon} > 1. \quad (4)$$

Under this condition, any firm has a marginal cost advantage of manufacturing its products in the South compared to the North. In other words, the wage advantage of manufacturing in the South is sufficiently large to outweigh a potential tariff advantage of exporting the final good from the North.

Without loss of generality, we will focus on the strategies of firms from a single Northern economy $l = N$ and from South $l = S$ that sell their products to a specific Northern destination

⁴ As is well known from previous studies, $A^i = Y^i / [\int_0^{n_i} p^i(v)^{1-\varepsilon} dv]$, where n_i is the measure of varieties available in economy i and $p^i(v)$ is the price of variety v in economy i . Firms treat A^i as fixed since they are too small to individually affect A^i .

⁵ Under this condition, the marginal profit of manufacturing a unit in the South exceeds the marginal profit of manufacturing a unit in the North. One can obtain this condition by using equation (6).

economy j . For notational clarity, we will drop the subscript j that identifies the destination economy.

We solve the model in two steps. In section III.A, we analyze the benchmark scenario of “no vertical specialization” where Northern and Southern firms are required to spatially co-locate headquarter services and manufacturing. In section III.B, we then study the scenario of “vertical specialization” where it becomes optimal for some Northern firms to slice up their value chain and offshore their manufacturing to a Southern economy. By comparing the equilibrium outcomes of both scenarios we can investigate how the extra organizational ability of slicing up the value chain affects the elasticity of exports to economy-specific tariff changes.

A. No Vertical Specialization

Consider the benchmark case where g approaches infinity so that all firms are better off co-locating manufacturing with headquarter services.⁶ This is in line with the scenario where the product architecture is integral so that it is difficult to spatially disperse value chain activities. From equations (1) and (2), firms from $l \in \{N, S\}$ choose y to maximize $\pi^l = \left(p^l - \frac{\omega^l}{\varphi}\right)y^l - f$. It is straightforward to check that this program yields the optimal price $p^l = \frac{\omega^l}{\alpha\varphi}$, the optimal firm-specific exports:

$$x^l = \frac{B}{1-\alpha} \left(\frac{\varphi}{\omega^l}\right)^{\varepsilon-1} \tau^{l-\varepsilon}, \quad (5)$$

and the optimal firm-specific profit:

$$\pi^l = \left(\frac{\varphi}{\omega^l}\right)^{\varepsilon-1} \tau^{l-\varepsilon} B - f, \quad (6)$$

where $B = (1 - \alpha)A\alpha^{\varepsilon-1}$. Intuitively, equations (5) and (6) suggest that a firm's exports and profits decline with the rise of its home economy l 's wages ω^l and the economy-specific tariffs it faces τ^l .

Not all firms are able to generate enough profits to cover the fixed cost f of exporting to the destination economy. Define φ^l as the threshold productivity at which $\pi^l = 0$. Using equation (6), the cut-off productivity coefficient for firms in economy l equals:

$$\varphi^l = \omega^l \left(\frac{f}{B}\right)^{\frac{1}{\varepsilon-1}} \tau^{l\frac{\varepsilon}{\varepsilon-1}}. \quad (7)$$

From equation (6), it is clear that less productive firms with $\varphi < \varphi^l$ do not export to the destination economy, while firms with $\varphi > \varphi^l$ become exporters.

Economy l 's aggregate exports to the destination economy equal the sum of exports by firms with $\varphi > \varphi^l$. Using the firm-level export equation (5), the aggregate export equation equals:

⁶ Alternatively, we could cut off the productivity at a maximum value.

$$X^l = \int_{\varphi^l}^{\infty} x^l(\varphi) dG(\varphi) = \frac{B}{1-\alpha} \tau^{l-\varepsilon} \int_{\varphi^l}^{\infty} \left(\frac{\varphi}{\omega^l}\right)^{\varepsilon-1} dG(\varphi). \quad (8)$$

We can use equation (8) to investigate the elasticity of aggregate exports X^l with respect to an economy-specific tariff change τ^l . As illustrated by Chaney (2008), the effect can be decomposed into two different margins:

$$-\frac{dX^l/d\tau^l}{X^l/\tau^l} = -\frac{\tau^l}{X^l} \left(\int_{\varphi^l}^{\infty} \frac{\partial x^l(\varphi)}{\partial \tau^l} dG(\varphi) \right) + \frac{\tau^l}{X^l} \left(x^l(\varphi^l) G'(\varphi^l) \frac{\partial \varphi^l}{\partial \tau^l} \right), \quad (9)$$

where the first term is the intensive margin and the second is the extensive margin. The intensive margin determines by which amount existing exporters (or incumbents) change the size of their exports. The extensive margin defines the amount that aggregate exports change due to firm entry and exit. In Appendix A, we solve equation (9) to obtain the elasticity of an economy's exports to an economy-specific tariff change:

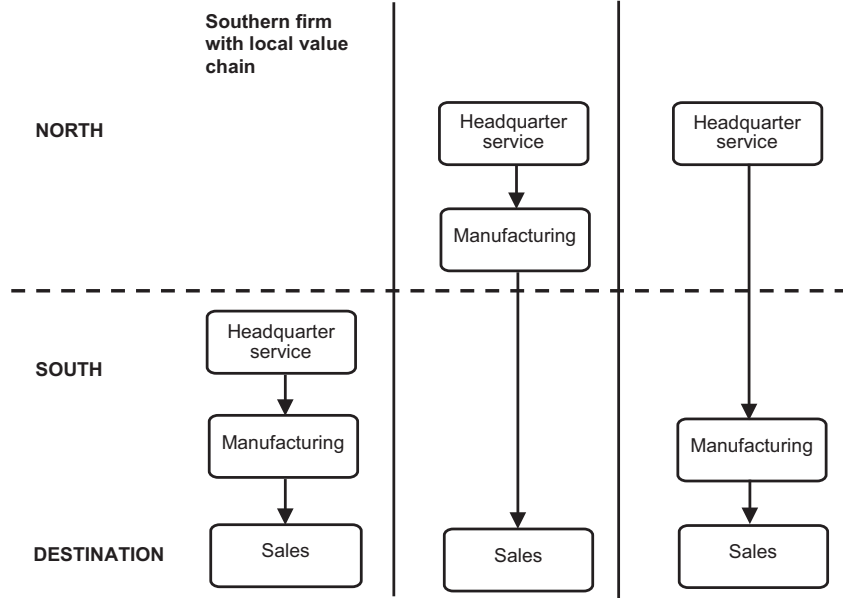
$$-\frac{dX^l}{X} \frac{\tau^l}{d\tau^l} = \varepsilon + (z - (\varepsilon - 1)) \frac{\varepsilon}{\varepsilon - 1}. \quad (10)$$

There are two important aspects to note about this elasticity. First, the elasticity differs from Chaney (2008) because we model trade barriers as ad valorem tariffs and not as iceberg transport costs. As Cole (2011) shows, the use of ad valorem tariffs implies that, unlike in Chaney (2008), the elasticity of trade with respect to trade barriers is a function of the elasticity of substitution between product varieties. It is important to emphasize, however, that the central predictions of our model would be unaffected if we had used iceberg transport costs. Second, due to our assumption that the productivity dispersion is identical across economies, the elasticity of aggregate exports with respect to an economy-specific tariff change is the same for both Northern economies and South. In the remainder of the paper, we will use equation (10) as a benchmark to investigate how vertical specialization alters the impact of economy-specific trade policy shocks on trade.

B. Vertical Specialization

Consider next the scenario where the fixed coordination costs g are within the parameter range $f \left[\left(\frac{\tau^N}{\tau^S} \right)^{\varepsilon} \left(\frac{\omega^N}{\omega^S} \right)^{\varepsilon-1} - 1 \right] < g < +\infty$. In that case, it is only optimal for the most productive Northern firms to locate their manufacturing in the South.⁷ As Figure 1 illustrates, three organizational forms coexist in the industry under this condition: (i) Southern firms with local value chains, (ii) Northern firms with local value chains, and (iii) Northern firms with global value chains. In the remainder of this section, we estimate the elasticity of exports with respect to economy-specific tariffs for these three organizational forms.

⁷ If $g < f \left[\left(\frac{\tau^N}{\tau^S} \right)^{\varepsilon} \left(\frac{\omega^N}{\omega^S} \right)^{\varepsilon-1} - 1 \right]$, it is optimal for all Northern firms to manufacture in the South. In this unrealistic case, there will be no extra extensive margin effect and the elasticity of bilateral exports with respect to a country-specific tariff change reverts to that of the case of no vertical specialization.

Figure 1: Types of Organizational Forms Exporting to the Destination Economy

Source: Authors' depiction

C. Southern Firms

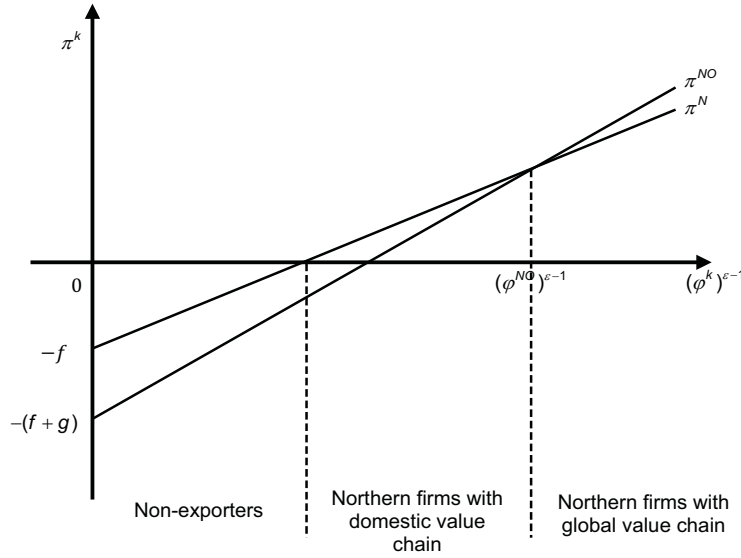
Due to the marginal cost advantage of manufacturing in the South, there is no benefit for Southern firms to manufacture their goods in the North. As a result, all Southern firms continue to co-locate manufacturing with headquarter services in the South and the analysis is identical to section III.A. The elasticity of Southern firms' exports with respect to an economy-specific tariff change thus equals:

$$-\frac{dX^S}{X^S} \frac{\tau^S}{d\tau^S} = \varepsilon + (z - (\varepsilon - 1)) \frac{\varepsilon}{\varepsilon - 1}. \quad (11)$$

D. Northern Firms

As illustrated in Figures 1 and 2, two types of Northern firms sell their products to the destination economy: less productive firms ($\varphi^N < \varphi < \varphi^{N0}$) which manufacture in the North and more productive firms ($\varphi > \varphi^{N0}$) which manufacture in the South. We consider their optimization problems in turn.

For Northern firms with a *domestic value chain* ($\varphi^N < \varphi < \varphi^{N0}$), the profit maximization problem is identical to section III.A. Firm-specific profits amount to $\pi^N = \left(\frac{\varphi}{\omega^N}\right)^{\varepsilon-1} \tau^{N-\varepsilon} B - f$, which imply that firms with a productivity below $\varphi^N = \omega^N \left(\frac{f}{B}\right)^{\frac{1}{\varepsilon-1}} \tau^{N\frac{\varepsilon}{\varepsilon-1}}$ do not export to the destination economy. Firm-specific exports amount to $x^N = \frac{B}{1-\alpha} \left(\frac{\varphi}{\omega^N}\right)^{\varepsilon-1} \tau^{N-\varepsilon}$.

Figure 2: Productivity and Northern Firms' Organizational Form

Source: Authors' calculations

Northern firms with a *global value chain* ($\varphi > \varphi^{NO}$) perform their manufacturing in the South and choose y to maximize $\pi^{NO} = \left(p - \frac{\omega^S}{\varphi}\right)y - f - g$. For these firms, their optimal price equals $p^{NO} = \frac{\omega^S}{\alpha\varphi}$, their firm-specific exports equal:

$$x^{NO} = \frac{B}{1-\alpha} \left(\frac{\varphi}{\omega^S}\right)^{\varepsilon-1} \tau^{S-\varepsilon}, \quad (12)$$

and their firm-specific profits equal:

$$\pi^{NO} = \left(\frac{\varphi}{\omega^S}\right)^{\varepsilon-1} \tau^{S-\varepsilon} B - f - g. \quad (13)$$

Using equations (5) and (13), the threshold at which $\pi^N(\varphi^{NO}) = \pi^{NO}(\varphi^{NO})$ equals:

$$\varphi^{NO} = \left(\frac{g}{B(\omega^{S^{1-\varepsilon}} \tau^{S-\varepsilon} - \omega^{N^{1-\varepsilon}} \tau^{N-\varepsilon})} \right)^{\frac{1}{\varepsilon-1}}. \quad (14)$$

The Northern firms with a productivity $\varphi > \varphi^{NO}$ manufacture in the South, while firms with a productivity $\varphi^N < \varphi < \varphi^{NO}$ manufacture in the North.

1. Aggregate Exports by Firm Type

Aggregate exports from North by firms with domestic value chains, X^N , equals the integral of firm-level exports x^N for firms with a productivity $\varphi^N < \varphi < \varphi^{NO}$. Using equation (5):

$$X^N = \int_{\varphi^N}^{\varphi^{NO}} x^N(\varphi) dG(\varphi). \quad (15)$$

Aggregate exports from South by Northern firms with global value chains, X^{NO} , equals the integral of firm-level exports x^{NO} for Northern firms with a productivity $\varphi > \varphi^{NO}$. Using equation (12):

$$X^{NO} = \int_{\varphi^O}^{\infty} x^{NO}(\varphi) dG(\varphi). \quad (16)$$

We can use these aggregate export equations to investigate if vertical specialization affects the elasticity of exports with respect to economy-specific tariffs.

2. Impact of an Increase in τ^S on X^{NO}

We first investigate the impact of an *ad valorem* bilateral tariff increase τ^S on X^{NO} . In Appendix B, we use equation (16) to calculate that the elasticity of X^{NO} with respect to τ^S equals:

$$-\frac{dX^{NO}/d\tau^S}{X^{NO}/\tau^S} = \varepsilon + (z - (\varepsilon - 1)) \frac{\varepsilon}{\varepsilon - 1} \chi, \quad (17)$$

$$\text{where } \chi = \frac{\left(\frac{\omega^N}{\omega^S}\right)^{\varepsilon-1} \left(\frac{\tau^N}{\tau^S}\right)^{\varepsilon}}{\left(\frac{\omega^N}{\omega^S}\right)^{\varepsilon-1} \left(\frac{\tau^N}{\tau^S}\right)^{\varepsilon} - 1} > 1.$$

Due to our assumption in equation (4) that there is a marginal cost advantage of manufacturing in the South compared to the North, $\chi > 1$. As a result, if we compare to equation (10), Northern firms' exports from South, X^{NO} , are more elastic with respect to an increase in τ^S than their exports were under no vertical specialization. This result is driven by an extra extensive margin effect related to tariff shirking. If τ^S increases, it induces an extra number of firms to stop exporting from economy S since they move assembly back to N to circumvent the tariff hike. Note that the extra elasticity denoted by χ is larger if the marginal cost advantage of manufacturing in the South is smaller. In other words, the smaller the marginal cost advantage of manufacturing in the South, the more X^{NO} would be affected by tariff shirking.

Compared to equation (11), Northern firms' exports from South, X^{NO} , is also more elastic than Southern firms' exports from South, X^S , with respect to an increase in τ^S . This is once again because some Northern firms (at the margin) have the extra flexibility to circumvent the tariff increase by reshoring manufacturing back to the North. An implication of the difference in elasticities between Southern exports conducted by Northern and Southern firms is that an increase in τ^S will reduce the share of Southern exports conducted by Northern firms. Define s^{NO} as the share of Southern exports conducted by Northern firms:

$$s^{NO} = \frac{X^{NO}}{X^{NO} + X^S}. \quad (18)$$

By taking the derivate of equation (18) and using the elasticities in equations (11) and (17), it is straightforward to show that the share s^{NO} is negatively affected by a rise in τ^S :

$$\frac{\partial s^{NO}}{\partial \tau^S} = -\frac{1}{\tau^S} s^{NO} (1 - s^{NO}) (z - (\varepsilon - 1)) \frac{\varepsilon}{\varepsilon - 1} (\chi - 1) < 0. \quad (19)$$

In our empirical analysis, we will further investigate this specific prediction of the model.

3. Impact of an Increase in τ^N on X^N

We next investigate the effect of an *ad valorem* bilateral tariff increase τ^N on X^N . In Appendix B, we use equation (15) to calculate that the elasticity equals:

$$-\frac{dX^N/d\tau^N}{X^N/\tau^N} = \varepsilon + (z - (\varepsilon - 1)) \frac{\varepsilon}{\varepsilon - 1} \left(1 + \frac{X^{NO}}{X^N} * \frac{1}{\left(\frac{\omega^N}{\omega^S}\right)^{\varepsilon-1} \left(\frac{\tau^N}{\tau^S}\right)^{\varepsilon} - 1} \right). \quad (20)$$

If we compare to the scenario of no vertical specialization in equation (10), it is clear that X^N is more elastic with respect to τ^N under vertical specialization than under no vertical specialization since $\frac{X^{NO}}{X^N} * \frac{1}{\left(\frac{\omega^N}{\omega^S}\right)^{\varepsilon-1} \left(\frac{\tau^N}{\tau^S}\right)^{\varepsilon} - 1} > 0$. This result is once again due to an extra extensive margin effect. The logic is the following. Compared to *no vertical specialization*, a tariff hike not only induces a number of Northern firms to become non-exporters, but also causes a number of firms to divert their exports through the South in order to circumvent the tariff increase. This extra tariff shirking effect at the extensive margin, which is driven by the ability to fragment assembly from input production, increases the elasticity of X^N with respect to τ^N .

The extra elasticity once again depends on the size of the marginal cost advantage of manufacturing in the South. The smaller this marginal cost advantage is, the more sensitive is X^N to an economy-specific tariff hike.

4. Sensitivity of Production Stages to Trade Policy Shocks

Finally, we investigate whether vertical specialization affects the impact of a tariff increase differentially along the two vertical stages of the value chain: (non-footloose) headquarters services and (footloose) manufacturing.

It is straightforward to show that vertical specialization *reduces* the vulnerability of sectorwide headquarter services in the North to an economy-specific tariff increase τ^N or τ^S . The intuition is the following. Since a number of companies (at the margin) are able to dampen the effect of the tariff hike by relocating their manufacturing, the demand for products sold by firms from N is less affected by the tariff hike than under the no-vertical-specialization scenario. As a result, non-footloose headquarters service production in economy N is also less vulnerable to the tariff hike.

In contrast, vertical specialization *increases* the vulnerability of manufacturing activities in both economy N and S to an economy-specific tariff increase τ^N or τ^S . As Northern companies (at the margin) relocate their manufacturing to circumvent tariffs, footloose manufacturing activities become particularly vulnerable to trade policy shocks. Manufacturing in economy N , for example, is extra vulnerable to an increase in τ^N since it induces a number of firms to cease manufacturing in N and offshore it to S . Similarly, manufacturing in economy S is extra vulnerable to an increase in τ^S since it induces a number of Northern firms to cease production in S and reshore it to economy N .

IV. EMPIRICAL ANALYSIS

A key prediction from the model is that Southern exports that are part of global value chains are more elastic with respect to an economy-specific tariff hike than Southern exports that are part of local value chains. As a result, an economy-specific tariff hike should reduce the share of exports that are part of global value chains. In this section, we draw on both province-level (1997–2009) and firm-level (2000–2006) data from PRC customs statistics to investigate this claim.

To classify PRC exports that are part of global versus local value chains, we distinguish between two customs regimes: processing trade and ordinary trade. These two trade forms differ in terms of tariff treatment and the ability of firms to sell in the domestic market:

- Under the *processing trade regime*, firms enjoy the right of duty-free imports of intermediate goods and capital equipment that are used in their export processing activity, but face restrictions in selling to the domestic market.
- Under the *ordinary trade regime*, firms need to pay import duties on imported inputs but can sell their output locally.

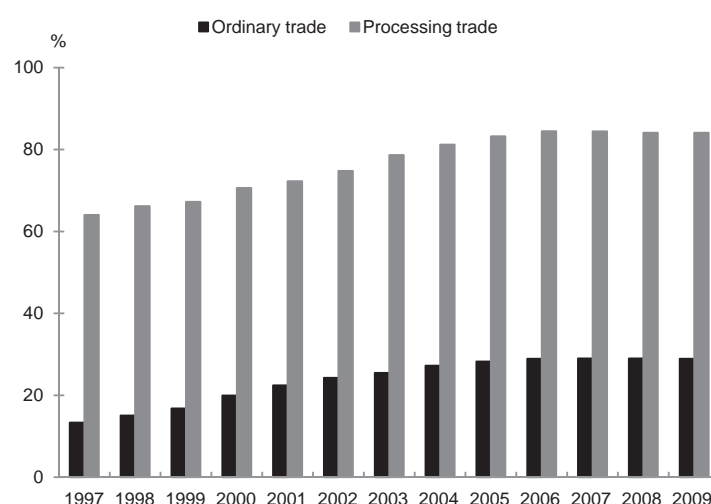
Due to these distinct characteristics the processing trade regime is used primarily by exporting firms that are part of a global value chain, while the ordinary trade regime is used by exporting firms that have more extensive domestic value chains. Two stylized facts back this up. First, recent estimates suggest that processing exports embody less than half as much domestic value added than ordinary exports (Kee and Tang 2013; Koopman, Wang, and Wei 2012). Second, as is shown in Figure 3, foreign-owned firms play a much more dominant role in the processing trade regime than in the ordinary trade regime. Between 1997 and 2009, the share of processing exports conducted by foreign-owned enterprises increased from 64% to 85%. In comparison, this share throughout the sample period remained under 30% in the ordinary trade regime. We use this distinction to evaluate the theoretical prediction that exports are more sensitive to economy-specific trade policy shocks under the processing trade regime than under the ordinary trade regime.

As our measure of economy-specific trade policy shocks, we use antidumping cases against the PRC as identified in the Global Antidumping Database (GAD) published by the World Bank (Bown 2009). The benefit of using antidumping as a measure for an economy-specific trade policy shock is that it is generally imposed by an economy on firms of a specific economy, and not across the board. The GAD has detailed information on each antidumping case, such as product information (6-digit HS codes), the investigating economy, the target economy, the preliminary determination date and the year it was revoked. For our analysis, we collect information on all antidumping cases against the PRC during the period 1997–2009. We match the GAD data with the PRC customs data at the HS6 digit level, the most disaggregated level at which the two datasets are comparable.

From 1997 to 2009 there were a total of 1,042 cases of which 1,011 were in the manufacturing sector. We focus our study on the manufacturing sector, which is more in line with the theory presented on vertical specialization. Over the 12-year period in the data set, the average number of cases was 78 per year with a median of 61 cases. The antidumping charges were imposed on \$131 billion of PRC exports, which represented 1.75% of total PRC exports in manufacturing. Table 1 shows that the number of cases increased by 162% from 55 to 144 between 2000 and 2001. The number of cases also spiked in 2006 with 127 cases (up by 22%)

and again in 2008 and 2009 with 110 and 158 cases, respectively. The table also shows that the US held the most antidumping charges against the PRC with about a quarter of the total number of cases. The next three largest initiators are India, the European Union, and Canada with 15%, 12%, and 10%, respectively.

Figure 3: Share of the People's Republic of China's Exports Conducted by Foreign-owned Enterprises, by Customs Regime, 1997–2009 (%)



Source: Authors' calculations using data from the People's Republic of China's Customs Statistics

Table 1: Summary Statistics of Preliminary Anti-dumping Decisions Imposed against the People's Republic of China, by year and economy

	Year of Preliminary Anti-dumping Decision													Total
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	
India	1	8	3	9	21	8	24	2	9	11	6	11	36	149
Indonesia	8	3	0	0	0	0	0	0	0	0	0	0	0	11
Israel	0	0	2	0	0	0	0	0	1	3	4	0	0	10
Malaysia	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Pakistan	0	0	0	0	0	0	0	0	1	4	0	0	4	9
Philippines	0	0	0	1	0	0	0	0	0	0	0	0	0	1
Republic of Korea	3	2	0	1	0	0	9	2	2	3	4	7	0	33
Turkey	0	0	0	0	0	2	0	0	0	0	0	0	0	2
Taipei, China	0	0	0	0	0	0	0	0	0	14	0	0	0	14
South Africa	13	4	0	1	2	1	0	1	3	4	2	3	1	35
European Union	11	20	2	6	3	1	3	2	20	20	5	7	21	121
Argentina	8	0	2	0	11	6	1	4	1	5	2	17	38	95
Brazil	0	2	0	0	0	0	0	0	0	5	3	2	16	28
Colombia	0	0	0	0	0	0	0	2	1	47	2	7	3	62
Mexico	1	1	1	0	5	1	3	1	2	2	2	3	0	22
Peru	0	1	6	0	11	4	1	1	0	0	0	0	0	24
Trinidad and Tobago	0	0	0	1	0	0	0	6	0	0	0	0	0	7
Venezuela	0	0	13	0	0	0	0	0	0	0	0	0	0	13
Canada	2	0	0	11	43	2	3	8	1	2	1	10	17	100
United States	13	0	2	25	46	50	5	42	3	5	5	42	15	253
Australia	1	0	0	0	2	3	0	3	1	2	0	1	7	20
New Zealand	0	0	0	0	0	0	0	1	0	0	0	0	0	1
Total	61	41	31	55	144	79	49	75	45	127	36	110	158	1,011

Source: Authors' calculations using the Global Anti-Dumping Database

A. Province-level Analysis

In a first step, we use more aggregate province-level data for the time period 1997–2009 to investigate if antidumping disproportionately affects processing exports compared to ordinary exports. In our analysis, our dependent variable is the share in value of bilateral exports that is organized through processing trade in a specific HS 6-digit industry and year:

$$Share_{ijkt} = \frac{PX_{ijkt}}{PX_{ijkt} + OX_{ijkt}}, \quad (21)$$

where PX_{ijkt} is the value of Chinese processing exports from province i to economy j in industry k and year t , and OX_{ijkt} is the value of Chinese ordinary exports from province i to economy j in industry k and year t . To test the prediction of the theoretical model, we estimate the following regression equation:

$$Share_{ijkt} = \alpha_i + \alpha_k + \alpha_t + \beta * AD_{jkt} + \varepsilon_{ijkt}, \quad (22)$$

where α_i , α_k and α_t are province, industry and year fixed effects; AD_{jkt} is a dummy variable that takes on a value of 1 when a HS 6-digit export industry k faces an anti-dumping measure imposed by economy j in a year t and 0 otherwise; and ε_{ijkt} is an error term. There will be evidence that an anti-dumping measure disproportionately affects processing trade if the OLS estimate $\hat{\beta}$ is negative and significant.

The results of the benchmark analysis are presented in Column 1 of Table 2. The negative and significant coefficient on the antidumping indicator suggests that the share of processing exports declines after the imposition of antidumping duties. Specifically, an antidumping imposition reduces the share of processing exports by 7.6%. We can infer from this that processing exports are considerably more sensitive to the imposition of antidumping duties than ordinary exports.

Table 2: Province-level Estimation Results

	Dependent Variable: $Share_{ijkt}$		
	Benchmark (1)	Foreign PT/Domestic OT (2)	Foreign PT/Domestic OT/only AD sectors (3)
AD	−7.590*** (0.606)	−8.371*** (0.720)	−11.118*** (0.736)
Year FE	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes
Province FE	Yes	Yes	Yes
Observations	931,293	713,761	410,630
R^2	0.16	0.19	0.18

AD = anti-dumping, FE = fixed effects, OT = ordinary trade regime, PT = processing trade regime.

Note: Coefficients are reported with robust standard errors that are clustered at the province level. Standard errors are given in parentheses. The individual coefficient is statistically significant at the *10%, **5%, or ***1% level.

Source: Authors' calculations using the Global Anti-Dumping Database and data from the People's Republic of China's Customs Statistics

In Column 2 of Table 2, we test whether the results are sensitive to excluding Chinese firms that conduct processing exports and foreign firms that conduct ordinary exports. This restriction aligns the empirical estimation better to the theory that Southern exports within global value chains are conducted by Northern firms, while Southern exports within local value chains are conducted by Southern firms. The results are similar to the benchmark analysis, with a slightly larger reduction of 8.4% in the share of processing exports.

In Columns 3 of Table 2, we, as an additional robustness test, exclude all industries from our data sample in which no antidumping was imposed during the entire sample period (1997–2009). The results are once again similar to the benchmark analysis, with a larger reduction of 11.1%.

B. Firm-level Analysis

The province-level data do not allow us to examine the impact of antidumping impositions on the intensive and extensive margin separately. To distinguish these two effects, we therefore utilize more disaggregated firm level data from Chinese customs statistics that are only available for the subsample 2000 to 2006.

We define *intensive margin* as exports by incumbent firms. To be considered as an incumbent, a firm must have at least one year of positive exports in an industry affected by anti-dumping prior to the imposition of the antidumping charges and at least one year of positive exports after the imposition. For example, a firm exporting a girl's 16 inch bike to the US in years 2001–2004 would be considered an incumbent if the US imposed an antidumping charge on the PRC for the item in year 2002.⁸

We define *extensive margin* as exports by non-incumbent firms (Morrow and Brandt 2013). In other words, the extensive margin captures exports by firms that did not export in a year prior to the imposition of antidumping charges or did not export in a year after the imposition of antidumping charges.

To investigate if antidumping disproportionately affects processing exports compared to ordinary exports at the intensive margin, we use the following dependent variable:

$$Share_Int_{jkt} = \frac{PX_Int_{jkt}}{PX_Int_{jkt} + OX_Int_{jkt}}, \quad (23)$$

where PX_Int_{jkt} is the value of processing exports to economy j by incumbents in industry k and year t , and OX_Int_{jkt} is the value of ordinary exports to economy j by incumbents in industry k and year t . Similar to above, we test our central prediction by estimating the following regression equation:

$$Share_Int_{jkt} = \alpha_k + \alpha_t + \beta * AD_{jkt} + \varepsilon_{jkt}, \quad (24)$$

where α_k and α_t are industry and year fixed effects; AD_{jkt} is a dummy variable that takes on a value of 1 when a HS 6-digit export industry k faces an anti-dumping measure imposed by economy j in a year t and 0 otherwise; and ε_{jkt} is an error term. There will be evidence that an

⁸ Given our definition of an incumbent, firms would not be considered in this category for years 2000 and 2006. As such, we dropped these years in our estimation.

anti-dumping measure disproportionately affects processing trade at the intensive margin if the OLS estimate $\hat{\beta}$ is negative and significant.

To investigate if antidumping disproportionately affects processing trade compared to ordinary trade at the extensive margin, we use the following dependent variable:

$$Share_Ext_{jkt} = \frac{PX_Ext_{jkt}}{PX_Ext_{jkt} + OX_Ext_{jkt}}, \quad (25)$$

where PX_Ext_{jkt} is the value of processing exports to economy j by non-incumbents in industry k and year t , and OX_Ext_{jkt} is the value of ordinary exports to economy j by non-incumbents in industry k and year t . Similar to above, we estimate the following regression equation:

$$Share_Ext_{jkt} = \alpha_k + \alpha_t + \beta * AD_{jkt} + \varepsilon_{jkt}. \quad (26)$$

There will be evidence that an anti-dumping measure disproportionately affects processing exports at the extensive margin if the OLS estimate $\hat{\beta}$ is negative and significant.

In Columns 1–3 of Table 3, we present the benchmark results for the share of processing exports in total Chinese exports. The results for the pooled estimation, intensive margin, and extensive margin are provided in Columns 1, 2, and 3, respectively. All three specifications include year and sector fixed effects. We find that antidumping has a negative impact on the share of processing exports across all three specifications, although it is only significant at the 10% level for the intensive margin. When incumbent and non-incumbent firms are pooled together, antidumping reduces the share of processing exports by 3.1%. When only incumbents are considered (intensive margin), antidumping reduces the share of processing exports by 2.1%. For non-incumbents (extensive margin), antidumping reduces the share of processing exports by 2.4%.

Table 3: Firm-level Estimation Results and Decomposition using Value of Exports

	Dependent: Share of Processing Exports in Total Value of Export								
	Benchmark			Domestic OT/Foreign PT		Domestic OT/Foreign PT/Import Cut off		Domestic OT/Foreign PT/Import Cut off/AD	
	Pooled (1)	Intensive (2)	Extensive (3)	Intensive (4)	Extensive (5)	Intensive (6)	Extensive (7)	Intensive (8)	Extensive (9)
AD	-3.13*** (0.834)	-2.07* (1.147)	-2.41** (1.176)	-3.247** (1.402)	-3.271** (1.361)	-4.021** (1.420)	-3.569** (1.373)	-2.451* (1.468)	-4.449*** (1.401)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	370,871	91,692	279,179	76,637	217,223	76,250	216,889	28,029	124,457
R ²	0.28	0.44	0.32	0.44	0.33	0.44	0.33	0.46	0.34

AD = anti-dumping, FE = fixed effects, OT = ordinary trade regime, PT = processing trade regime.

Note: Coefficients are reported with robust standard errors that are clustered at the FIRM level. Standard errors are given in parentheses. The individual coefficient is statistically significant at the *10%, **5%, or ***1% level.

Source: Authors' calculations using the Global Anti-Dumping Database and data from the People's Republic of China's Customs Statistics

Similar to the provincial-level estimation, we also conducted a number of robustness tests of our firm-level results. First, in Columns 4–5 of Table 3, we solely considered processing exports conducted by foreign-owned firms and ordinary exports by Chinese-owned firms. The results are similar to the benchmark findings, but with larger negative magnitudes of 3.2% and 3.3% at the intensive and extensive margin, respectively.

The decision to impose antidumping could be considered endogenous since the foreign firms that originate from the imposing economy may actively lobby for or against their imposition. To address this possible endogeneity, we have therefore as a robustness test eliminated from our data sample any firms that import more than 5% of its imports from an economy that imposes antidumping.⁹ The findings in Columns 6–7 of Table 3 suggest that it leads to slightly larger decreases in exports.

Finally, in Columns 8–9, we exclude all industries from our data sample in which no antidumping was imposed during the entire sample period. In this case, we find that the coefficient on the antidumping indicator for the intensive margin is negative as in the benchmark but at only the 10% significance level. The result predicts that the share of processing exports in total exports by incumbents decreases by 2.5% in the presence of an antidumping measure. The coefficient on the antidumping indicator for the extensive margin is highly significant and with a larger magnitude than the benchmark. Specifically, the share of processing exports at the extensive margin is reduced by 4.5% in reaction to antidumping.

In Table 4, we estimate our empirical specification using quantities instead of values. In other words, we use as our dependent variable the share of processing exports in the total quantity exported for years 2001 to 2005. The results confirm the previous results that antidumping charges negatively affect the share of processing exports in total exports, both at the intensive and extensive margin.

Table 4: Firm-level Estimation Results and Decomposition Using Quantity of Exports

Dependent: Share of Processing Exports in Total Quantity of Exports									
	Benchmark			Domestic OT/Foreign PT		Domestic OT/Foreign PT/Import Cut off		Domestic OT/Foreign PT/Import Cut off/AD	
	Pooled	Intensive	Extensive	Intensive	Extensive	Intensive	Extensive	Intensive	Extensive
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
AD	−2.83*** (0.819)	−2.00* (1.146)	−2.36** (1.186)	−3.072** (1.393)	−2.746** (1.365)	−3.651** (1.415)	−2.459* (1.366)	−3.217** (1.484)	−3.724** (1.391)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	370,224	91,571	278,653	76,537	216,691	76,156	216,358	27,994	124,167
R ²	0.28	0.45	0.32	0.45	0.33	0.45	0.33	0.47	0.34

AD = anti-dumping, FE = fixed effects, OT = ordinary trade regime, PT = processing trade regime.

Note: Coefficients are reported with robust standard errors that are clustered at the FIRM level. Standard errors are given in parentheses. The individual coefficient is statistically significant at the *10%, **5%, or ***1% level.

Source: Authors' calculations using the Global Anti-Dumping Database and data from the People's Republic of China's Customs Statistics

⁹ We would like to thank Laura Puzzello for suggesting this robustness test. The results are similar for other cut off levels.

V. CONCLUDING REMARKS

The core idea behind the paper is that trade policy matters for the organization of global value chains, a notion that seems to have been neglected by trade economists, but has major implications for our understanding of trade and the international transmission of trade policy shocks. To gain new insights into this research area, we have developed a theoretical model in which a firm's ability to spatially separate manufacturing from headquarter services gives them the flexibility to circumvent an economy-specific tariff increase by relocating their manufacturing elsewhere, a phenomenon that we have termed tariff shirking. We have illustrated a number of general equilibrium implications of tariff shirking. First, we have shown that it increases the elasticity of exports within global value chains to economy-specific trade policy shocks by creating an extra extensive margin effect. Second, we have illustrated that tariff shirking differentially affects the vulnerability of headquarters services and manufacturing to economy-specific trade policy shocks. Whereas tariff shirking dampens the vulnerability of headquarters services to trade policy shocks, it amplifies the vulnerability of manufacturing to trade policy shocks. This last result is complementary to Bergin, Feenstra, and Hanson's (2011) finding that offshored assembly activities in Mexico are more vulnerable to US business cycle shocks than corresponding US industries.

We used firm-level and province-level export data from the PRC to see if there is evidence that Chinese exports that are part of global value chains are more sensitive to antidumping measures than Chinese exports that rely on domestic value chains. The answer is yes: *processing exports* that rely heavily on imported inputs are consistently more sensitive to antidumping duties than *ordinary exports*. This result is found to be primarily driven by an extensive margin effect.

While our empirical results apply only to the PRC, the economic logic is broader and suggests that tariff shirking may be an important driver of trade and the international organization of production, and an important determinant of the effectiveness of trade policy. The policy implications of our analysis are complex. Policymakers may be inclined to try to prevent tariff shirking and restore the effectiveness of economy-specific trade policy barriers by linking them to rules of origin. Such a move, however, would further increase the administrative complexity of trade and may even end up being detrimental for an economy. As Deardorff (2013) shows, rules of origin can reduce or even eliminate completely the gains from trade. A policy reaction that would be more in line with the spirit of the World Trade Organization would be to step away from discriminatory trade policy barriers, which are less effective due to tariff shirking, and to focus on non-discriminatory trade policy barriers that limit the potential of tariff shirking.

APPENDIX A: NO VERTICAL SPECIALIZATION

The elasticity of aggregate exports X^l with respect to economy-specific tariff τ^l under no vertical specialization can be separated into an intensive and an extensive margin effect:

$$-\frac{dX^l/d\tau^l}{X^l/\tau^l} = -\frac{\tau^l}{X^l} \left(\int_{\varphi^l}^{\infty} \frac{\partial x^l(\varphi)}{\partial \tau^l} dG(\varphi) \right) + \frac{\tau^l}{X^l} \left(x^l(\varphi^l) G'(\varphi^l) \frac{\partial \varphi^l}{\partial \tau^l} \right). \quad (\text{A-1})$$

Using the definition of equilibrium individual exports from equation (5) and using the assumption that economy l is small enough so that a change in τ^l does not affect B , we get:

$$\frac{dx^l(\varphi)}{d\tau^l} = -\varepsilon \frac{x^l}{\tau^l}.$$

Inserting this into (A-1) and rearranging, we obtain:

$$-\frac{dX^l/d\tau^l}{X^l/\tau^l} = \varepsilon + \frac{x^l(\varphi^l) G'(\varphi^l) \varphi^l}{X^l} * \frac{\tau^l}{\varphi^l} \frac{\partial \varphi^l}{\partial \tau^l}. \quad (\text{A-2})$$

Using the definition of the distribution of productivity shocks $G'(\varphi) = z\varphi^{-z-1}$ from equation (3) and the definition of firm-level exports from equation (5), we can rewrite aggregate exports in the following way:

$$\begin{aligned} X^l &= \int_{\varphi^l}^{\infty} x^l(\varphi) dG(\varphi) = \\ &= \int_{\varphi^l}^{\infty} \frac{B}{1-\alpha} \left(\frac{\varphi}{\omega^l} \right)^{\varepsilon-1} \tau^l{}^{-\varepsilon} z\varphi^{-z-1} d\varphi \\ &= \frac{1}{z-(\varepsilon-1)} * x^l(\varphi^l) G'(\varphi^l) \varphi^l. \end{aligned}$$

Inserting this into (A-2), we obtain:

$$-\frac{dX^l/d\tau^l}{X^l/\tau^l} = \varepsilon + (z - (\varepsilon - 1)) * \frac{\tau^l}{\varphi^l} \frac{\partial \varphi^l}{\partial \tau^l}. \quad (\text{A-3})$$

From equation (7), we can derive that $\frac{\tau^l}{\varphi^l} \frac{\partial \varphi^l}{\partial \tau^l} = \frac{\varepsilon}{\varepsilon-1}$ so that:

$$-\frac{dX^l}{X^l} \frac{\tau^l}{d\tau^l} = \varepsilon + (z - (\varepsilon - 1)) \frac{\varepsilon}{\varepsilon-1} = \frac{z\varepsilon}{\varepsilon-1}. \quad (\text{A-4})$$

APPENDIX B: VERTICAL SPECIALIZATION

1. Elasticity of aggregate exports X^{NO} with respect to tariff τ^S

We first calculate the elasticity of aggregate exports by Northern firms that manufacture in South, X^{NO} , with respect to tariff τ^S . The elasticity can once again be separated into an intensive and an extensive margin effect:

$$-\frac{dX^{NO}/d\tau^S}{X^{NO}/\tau^S} = -\frac{\tau^S}{X^{NO}} \left(\int_{\varphi^{NO}}^{\infty} \frac{\partial x^{NO}(\varphi)}{\partial \tau^S} dG(\varphi) \right) + \frac{\tau^S}{X^{NO}} \left(x^{NO}(\varphi^{NO}) G'(\varphi^{NO}) \frac{\partial \varphi^{NO}}{\partial \tau^S} \right). \quad (B-1)$$

Using equation (12) and using the assumption that economy l is small enough so that a change in τ^S does not affect B , we get:

$$\frac{dx^{NO}(\varphi)}{d\tau^S} = -\varepsilon \frac{x^{NO}}{\tau^S}.$$

Inserting this into (B-1) and rearranging, we obtain:

$$-\frac{dX^{NO}/d\tau^S}{X^{NO}/\tau^S} = \varepsilon + \frac{x^{NO}(\varphi^{NO}) G'(\varphi^{NO}) \varphi^{NO}}{X^{NO}} * \frac{d\varphi^{NO}}{\varphi^{NO}} \frac{\tau^S}{d\tau^S}. \quad (B-2)$$

We can use the definition of firm-level exports from equation (12) and the definition of the distribution of productivity shocks in equation (3) to rewrite aggregate exports in the following way:

$$X^{NO} = \int_{\varphi^{NO}}^{\infty} x^{NO}(\varphi) dG(\varphi) = \frac{1}{z - (\varepsilon - 1)} * x^{NO}(\varphi^{NO}) G'(\varphi^{NO}) \varphi^{NO}. \quad (B-3)$$

Inserting (B-3) into (B-2), we obtain:

$$-\frac{dX^{NO}/d\tau^S}{X^{NO}/\tau^S} = \varepsilon + (z - (\varepsilon - 1)) * \left(\frac{\tau^S}{\varphi^{NO}} \frac{\partial \varphi^{NO}}{\partial \tau^S} \right). \quad (B-4)$$

We can use equation (14) to derive the elasticity of the cutoff condition φ^{NO} with respect to tariffs:

$$\frac{d\varphi^{NO}}{\varphi^{NO}} \frac{\tau^S}{d\tau^S} = \frac{\varepsilon}{\varepsilon - 1} \chi \text{ where } \chi = \frac{\left(\frac{\omega^N}{\omega^S} \right)^{\varepsilon - 1} \left(\frac{\tau^N}{\tau^S} \right)^{\varepsilon}}{\left(\frac{\omega^N}{\omega^S} \right)^{\varepsilon - 1} \left(\frac{\tau^N}{\tau^S} \right)^{\varepsilon} - 1}.$$

Inserting this elasticity into (B-4) gives:

$$-\frac{dX^{NO}/d\tau^S}{X^{NO}/\tau^S} = \varepsilon + (z - (\varepsilon - 1)) \frac{\varepsilon}{\varepsilon - 1} \chi. \quad (B-5)$$

2. Elasticity of aggregate exports X^N with respect to tariff τ^N

We can next calculate the elasticity of aggregate exports X^N with respect to tariff τ^N under vertical specialization. The elasticity can once again be separated into an intensive and an extensive margin effect:

$$-\frac{dX^N/d\tau^N}{X^N/\tau^N} = -\frac{\tau^N}{X^N} \left(\int_{\varphi^N}^{\varphi^{NO}} \frac{\partial x^N(\varphi)}{\partial \tau^N} dG(\varphi) \right) + \frac{\tau^N}{X^N} \left[x^N(\varphi^N) G'(\varphi^N) \frac{\partial \varphi^N}{\partial \tau^N} - x^N(\varphi^{NO}) G'(\varphi^{NO}) \frac{\partial \varphi^{NO}}{\partial \tau^N} \right]$$

Using the definition of equilibrium individual exports from equation (4) and using the assumption that economy l is small enough so that a change in τ^N does not affect B , we get:

$$\frac{dx^N(\varphi)}{d\tau^N} = -\varepsilon \frac{x^N}{\tau^N}.$$

Inserting this into the above equation and rearranging, we obtain:

$$-\frac{dX^N/d\tau^N}{X^N/\tau^N} = \varepsilon + \left(\frac{x^N(\varphi^N) G'(\varphi^N) \varphi^N}{X^N} * \frac{\partial \varphi^N}{\partial \tau^N} \frac{\tau^N}{\varphi^N} - \frac{x^N(\varphi^{NO}) G'(\varphi^{NO}) \varphi^{NO}}{X^N} * \frac{\partial \varphi^{NO}}{\partial \tau^N} \frac{\tau^N}{\varphi^{NO}} \right). \quad (B-6)$$

We have shown above that $\frac{\partial \varphi^N}{\partial \tau^N} \frac{\tau^N}{\varphi^N} = \frac{\varepsilon}{\varepsilon-1}$. Furthermore, it is straightforward to derive from equation (14) that:

$$\frac{\partial \varphi^{NO}}{\partial \tau^N} \frac{\tau^N}{\varphi^{NO}} = -\frac{\varepsilon}{\varepsilon-1} (\chi - 1) < 0, \text{ where } \chi = \frac{\left(\frac{\omega^N}{\omega^S}\right)^{\varepsilon-1} \left(\frac{\tau^N}{\tau^S}\right)^{\varepsilon}}{\left(\frac{\omega^N}{\omega^S}\right)^{\varepsilon-1} \left(\frac{\tau^N}{\tau^S}\right)^{\varepsilon} - 1} > 1.$$

Inserting these cut-off elasticities into (B-6) and rearranging:

$$-\frac{dX^N/d\tau^N}{X^N/\tau^N} = \varepsilon + \frac{\varepsilon}{\varepsilon-1} \left(\frac{x^N(\varphi^N) G'(\varphi^N) \varphi^N - x^N(\varphi^{NO}) G'(\varphi^{NO}) \varphi^{NO}}{X^N} \right) \\ \left(\frac{x^N(\varphi^N) G'(\varphi^N) \varphi^N - x^N(\varphi^{NO}) G'(\varphi^{NO}) \varphi^{NO}}{X^N} + \chi * \frac{x^N(\varphi^{NO}) G'(\varphi^{NO}) \varphi^{NO}}{X^N} \right) \quad (B-7)$$

Using the definition of firm-level exports from equation (5) and the definition of the distribution of productivity shocks in equation (3), we can rewrite aggregate exports in the following way:

$$X^N = \int_{\varphi^N}^{\varphi^{NO}} x^N(\varphi) dG(\varphi) = \frac{1}{z-(\varepsilon-1)} * [x^N(\varphi^N) G'(\varphi^N) \varphi^N - x^N(\varphi^{NO}) G'(\varphi^{NO}) \varphi^{NO}].$$

Inserting this equation into (B-7) and rearranging, we obtain:

$$-\frac{dX^N/d\tau^N}{X^N/\tau^N} = \varepsilon + (z - (\varepsilon - 1)) \frac{\varepsilon}{\varepsilon - 1} \\ \left(1 + \chi * \frac{x^N(\varphi^{NO})}{x^{NO}(\varphi^{NO})} * \frac{x^{NO}(\varphi^{NO}) G'(\varphi^{NO}) \varphi^{NO}}{x^N(\varphi^N) G'(\varphi^N) \varphi^N - x^{NO}(\varphi^{NO}) G'(\varphi^{NO}) \varphi^{NO}} \right). \quad (B-8)$$

Inserting equations (5), (12), (B-3) and the definition of χ into (B-8), we can rearrange the equation to:

$$-\frac{dX^N/d\tau^N}{X^N/\tau^N} = \varepsilon + (z - (\varepsilon - 1)) \frac{\varepsilon}{\varepsilon - 1} \left(1 + \frac{X^{NO}}{X^N} * \frac{1}{\left(\frac{\omega^N}{\omega^S}\right)^{\varepsilon-1} \left(\frac{\tau^N}{\tau^S}\right)^{\varepsilon} - 1} \right). \quad (B-9)$$

REFERENCES

- Acemoglu, D., P. Antràs, and E. Helpman. 2007. Contracts and Technology Adoption. *The American Economic Review* 97(3): 916–943.
- Belderbos, R., and L. Sleuwaegen. 1998. Tariff Jumping DFI and Export Substitution: Japanese Electronics Firms in Europe. *International Journal of Industrial Organization* 16(5): 601–638.
- Bergin, P. R., R. C. Feenstra, and, G. H. Hanson. 2011. Volatility Due to Offshoring: Theory and Evidence. *Journal of International Economics* 85(2): 163–173.
- Blinder, Alan S. 2006. Offshoring: The Next Industrial Revolution. *Foreign Affairs* 85(2): 113–128.
- Blonigen, Bruce A. 2002. Tariff-jumping Antidumping Duties. *Journal of International Economics* 57(1): 31–49.
- Blonigen, B. A., K. Tomlin, and W. W. Wilson. 2004. Tariff-jumping FDI and Domestic Firms' Profits. *Canadian Journal of Economics/Revue Canadienne d'Économique* 37(3): 656–677.
- Bown, C.P. 2009. Global Antidumping database (Current Version 5.0). Brandeis University mimeo.
- Chaney, T. 2008. Distorted Gravity: The Intensive and Extensive Margins of International Trade. *The American Economic Review* 98(4): 1707–1721.
- Cole, M. T. 2011. Not All Trade Restrictions Are Created Equally. *Review of World Economics* 147(3): 411–427.
- Cole, M. T., and R. B. Davies. 2011. Strategic Tariffs, Tariff Jumping, and Heterogeneous Firms. *European Economic Review* 55(4): 480–496.
- Costinot, A. 2009. On the Origins of Comparative Advantage. *Journal of International Economics* 77(2): 255–264.
- Deardorff, A. V. 2013. Rue the ROOs: Rules of Origin and the Gains (or Losses) from Trade Agreements. University of Michigan mimeo.
- Ekholm, K., R. Forslid, and J. R. Markusen. 2007. Export-platform Foreign Direct Investment. *Journal of the European Economic Association* 5(4): 776–795.
- Escaith, Hubert, and A. Diakantoni. 2012. Reassessing Effective Protection Rates in a Trade in Tasks Perspective: Evolution of Trade Policy in “Factory Asia”. World Trade Organization Economic Research and Statistics Division, Staff Working Paper ERSD-2012-13. Geneva: World Trade Organization.
- Fort, T. 2011. ‘Breaking Up is Hard to Do: Why Firms Fragment Production across Locations. University of Maryland mimeo.

- Fung, V. K., W. K. Fung, and Y.R. Wind. 2007. *Competing in a Flat World: Building Enterprises for a Borderless World*. Upper Saddle River: Pearson Prentice Hall.
- Gamberoni, E., R. Lanz, and R. Piermartini. 2010. Timeliness and Contract Enforceability in Intermediate Goods Trade. World Bank Policy Research Working Paper Series 5482. Washington: World Bank.
- Grossman, G. M., E. Helpman, and A. Szeidl. 2006. Optimal Integration Strategies for the Multinational Firm. *Journal of International Economics* 70(1): 216–238.
- Grossman, G. M., and E. Rossi-Hansberg. 2008. Trading Tasks: A Simple Theory of Offshoring. *American Economic Review* 98(5): 1978.
- Helpman, E., and O. Itskhoki. 2010. Labour Market Rigidities, Trade and Unemployment. *The Review of Economic Studies* 77(3): 1100–1137.
- Helpman, E., M. J. Melitz, and S.R. Yeaple. 2004. Export versus FDI with Heterogeneous Firms. *The American Economic Review* 94(1): 300–316.
- Ito, T. 2013. Export-platform Foreign Direct Investment: Theory and Evidence. *The World Economy* 36(5): 563–581.
- Kee, H. L., and H. Tang. 2013. Domestic Value Added in Chinese Exports: Firm-level Evidence. Johns Hopkins University mimeo.
- Konings, J., and H. Vandenbussche. 2013. Anti-dumping Protection Hurts Exporters: Firm-level Evidence. *Review of World Economics* 149(2): 295–320.
- Koopman, R., Z. Wang, and S-J. Wei. 2012. Estimating Domestic Content in Exports when Processing Trade is Pervasive. *Journal of Development Economics* 99(1): 178–189.
- Leamer, E. E., and M. Storper. 2001. The Economic Geography of the Internet Age. National Bureau of Economic Research Working Paper No. 8450. Cambridge: National Bureau of Economic Research.
- Levchenko, A. A. 2007. Institutional Quality and International Trade. *The Review of Economic Studies* 74(3): 791–819.
- Levy, F., and R. J. Murnane. 2003. The Skill Content of Recent Technological Change: An Empirical Exploration. *The Quarterly Journal of Economics* 118(4): 1279–1333.
- Melitz, M. J. 2003. The Impact of Trade on Intra-industry Reallocations and Aggregate Industry Productivity. *Econometrica* 71(6): 1695–1725.
- Miroudot, S., and D. Rouzet. 2013. The Cumulative Impact of Trade Barriers along the Value Chain: An Empirical Assessment Using the OECD Inter-country Input–Output Model. OECD mimeo.
- Morrow, P., and L. Brandt. 2013. Tariffs and the Organization of Trade in [the People’s Republic of] China. University of Toronto mimeo.

- Mrázová, M., and J. Neary. 2013. Selection Effects with Heterogeneous Firms. University of Oxford mimeo.
- Nunn, N. 2007. Relationship-specificity, Incomplete Contracts, and the Pattern of Trade. *The Quarterly Journal of Economics* 122(2): 569–600.
- Schilling, M. A. 2000. Toward a General Modular Systems Theory and its Application to Interfirm Product Modularity. *Academy of Management Review* 25(2): 312–334.
- Ulrich, K. 1995. The Role of Product Architecture in the Manufacturing Firm. *Research Policy* 24(3): 419–440.
- Van Assche, A. 2012. Global Value Chains and Canada's Trade Policy: Business As Usual or Paradigm Shift? *Institute for Research on Public Policy* No. 32. Montréal: Institute for Research on Public Policy.
- Yi, K-M. 2003. Can Vertical Specialization Explain the Growth of World Trade? *Journal of Political Economy* 111(1): 52–102.

Vertical Specialization, Tariff Shirking and Trade

We develop a theoretical model in which vertical specialization gives firms the flexibility to circumvent country-specific tariff changes by switching their assembly location abroad. Using firm-level and province-level export data from the People's Republic of China, we provide evidence in line with the theoretical model.

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