Global Value Chains and Trade Policy*

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Abstract

How do global value chain linkages modify countries' incentives to impose import protection? Are these linkages empirically important determinants of trade policy in practice? To address these questions, we develop a new value-added approach to modeling tariff setting with GVCs, in which optimal policy depends on the nationality of value-added content embedded in home and foreign final goods. Theory predicts that discretionary tariffs will be decreasing in the domestic content of foreign-produced final goods and (provided foreign political interests are not too strong) the foreign content of domestically-produced final goods. Using theory as a guide, we estimate the influence of GVC linkages on trade policy with newly assembled data on bilateral applied tariffs, temporary trade barriers, and value-added contents for 14 major economies over the 1995-2009 period. Our empirical findings indicate that GVCs already play an important role in shaping trade policy. Governments set lower tariffs and curb their use of temporary trade protection (particularly against China) where GVC linkages are strongest.

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Global value chains are transforming the nature of production. In the modern global economy, final goods are increasingly made by combining foreign and domestic inputs via supply networks that traverse both country borders and the traditional boundaries of the firm. This GVC revolution has attracted widespread interest among both business leaders and policy makers. The World Trade Organization is exploring how trade policy institutions can be modernized to suit this new reality. At the same time, value chain concerns figure prominently in debates about the UK's exit from the European Union and the re-design of the North American Free Trade Agreement.[1] This policy emphasis seems to reflect a tacit expectation that GVC linkages alter the conventional calculus of trade protection. It stands to reason that by knitting together the interests of firms and workers across national boundaries, GVCs are reshaping the consequences of tariffs and other border barriers, and hence the objectives of government policy.

Despite the attention afforded by practitioners, GVCs are largely absent in existing theoretical and empirical analyses of trade policy. One reason is that GVCs are a relatively new phenomenon, and data sources and methods to measure GVC linkages have only recently been developed. A second reason is that GVCs take many different forms: some are sequential in nature, others are are not; some are organized within firms, others at arms length; some feature bilateral bargaining over prices, others allow for market-determined prices; some are primarily bilateral, others involve many countries; and so on. This variety in the structure of GVCs frustrates policy analysis, since these important modeling details make it difficult to obtain general lessons or predictions for policy.

In this paper, we develop a new approach that leverages a value-added view of the production process to advance both the theory and empirics of trade policy with GVCs. We build on the idea that final goods are "made in the world" by combining domestic and foreign primary factors via GVCs. Thus, GVCs are ultimately vehicles for trade in factor services.[2] Developing this insight, we show that government objectives over final goods tariffs can be characterized in terms of two basic GVC features: the underlying pattern of trade in factor services, which defines the value-added content of final goods, and the system of pass-through elasticities that determine how prices of final goods are linked to payoffs for

[1]For the WTO, see the Made in the World Initiative and the 2014 World Trade Report [WTO (2014)]. See also Baldwin (2012) and Hoekman (2014). See Financial Times (2017) for discussion of supply chain consequences of Brexit, and Blanchard (2017) on NAFTA. Lobbying materials by the TPP Apparel Coalition on the (now defunct) Trans-Pacific Partnership and Wall Street Journal (2013) illustrate how business interests reflect value chain motivations in the high profile dispute between Nike and New Balance concerning United States import tariffs.

[2]Our approach is conceptually related to task trade approach of Grossman and Rossi-Hansberg (2008), in that we abstract from trade in physical inputs at intermediate stages of processing. Adão, Costinot and Donaldson (2017) also advocate for models of factor exchange.

agents engaged throughout the value chain. This value-added approach reduces a complex trade policy problem to a tractable, intuitive one. It also capitalizes on recent advances in measuring the value-added content of final goods to connect theory with trade policy empirics.

Embedding this production structure into a workhorse model of trade policy with political economy, we show that the structure of optimal final goods tariffs depends on the nationality of the value-added content embodied in home and foreign final goods. Specifically, final goods tariffs will be decreasing in both the domestic content of foreign-produced final goods and also (provided foreign political interests are not too strong) the foreign content of domestically-produced final goods. We then assemble rich new data on bilateral applied tariffs, temporary trade barriers (TTBs), and value-added contents, and estimate the influence of GVC linkages on trade policy outcomes for 14 major economies over the 1995-2009 period. Our empirical findings support the key mechanisms underlying the theory. By erasing the distinction between final goods made at home versus those made abroad, global value chains are already reshaping the contours of trade policy.

Our framework and results contribute to the trade policy literature in several ways. The first contribution is to extend the canonical theory of trade policy to include global value chain linkages. To highlight the essential mechanics, we note that the use of foreign value added in production drives a wedge between national income and the value of final goods produced in each country: some revenue from domestic final goods production ultimately accrues to foreigners via GVC linkages, while some foreign final goods revenue is paid to home residents. This re-conceptualization of the production process changes the mapping from prices to income, and hence welfare, relative to standard models. This value-added approach captures crucial aspects of GVCs while remaining agnostic about non-essential micro-economic details of GVC relationships.[3] This flexibility offers two important advantages: first, it implies that the fundamental mechanism we emphasize is implicitly embedded in all existing models of GVCs; second, it allows us to investigate the influence of GVCs empirically without imposing stringent, difficult-to-quantify microeconomic assumptions.[4]

[3]While our value-added (factor exchange) approach distills the governments tariff problem for final goods, it is not appropriate for studying optimal input tariffs. In particular, optimal input tariffs depend on many (difficult-to-measure) micro-economic details, on which the factor exchange approach is silent. Thus, we must set aside complementary theoretical questions concerning optimal input tariffs, which is a cost of our approach. From an empirical perspective, our focus on final goods tariffs turns into a benefit. Multilateral input tariffs are low, both in absolute terms and relative to final goods tariffs [Bown and Crowley (2016)], and bound at this level via GATT/WTO committments. Thus, governments exercise little discretion via this instrument in practice. We therefore focus our theory of how GVCs influence discretionary policy on instruments (final goods tariffs) that governments actually use in discretionary ways. For further discussion of input tariffs, see Section 1.2.3.

[4]Our model features a terms-of-trade motive for protection. However, the basic insights are portable to

We develop the theory in several steps. We first present the main argument in a streamlined many-country, many-good framework with political economy motives, drawing on and extending canonical partial equilibrium models with specific factors [Grossman and Helpman (1994); Helpman (1997)]. We characterize unilaterally-optimal bilateral tariffs for final goods and discuss the intuition behind the key drivers of policy in this baseline model. We then advance the analysis in three dimensions. First, we describe how two important institutional features of the world trading system – the GATT most-favored-nation (MFN) rule and Article XXIV regional trade agreements – may lead applied tariffs to deviate from the unconstrained, unilaterally-optimal policy. The resulting framework for bilateral trade policy analysis in the presence of institutional constraints offers an ancillary contribution of the theory that can be used for a variety of empirical applications. Second, we characterize optimal tariffs in a more general version of our baseline model, in which we drop specific factors assumptions to allow for the endogenous reorganization of value chains in response to tariffs. Third, we discuss the role of input tariffs in our framework, with an eye toward explaining the theoretical and empirical context that motivates our focus on how GVCs influence protection for final goods.

In all variants of the model, final goods tariffs deviate from the standard "inverse export supply elasticity rule" for three reasons. First, domestic content embodied in foreign final goods dampens a country's incentive to manipulate its terms of trade. Put simply, tariffs push down the prices that foreign producers receive, which hurts upstream domestic producers who supply value added to foreign producers. Thus, all else equal, a country will set lower tariffs against imports that embody more of its own domestic value-added content.

Through a second channel, foreign content embodied in domestic final goods also reduces the government's incentive to impose tariffs. Intuitively, when import-competing sectors use foreign inputs, some of the protectionist rents from higher tariffs accrue to foreign upstream suppliers, which dampens the government's motivation to apply import protection. Importantly, this effect of foreign value-added content on tariffs arises even if the government has no ability (or motive) to manipulate its terms of trade; this channel thus constitutes a distinct international externality that travels through domestic prices.

Political economy (distributional) concerns are a third source of deviations from the inverse elasticity rule. If the government affords additional political weight to domestic suppliers of value added embodied in foreign final goods, the tariff liberalizing effect via the first channel will be stronger. Conversely, if the government affords political weight to suppliers of foreign value added embodied in domestic goods, these political concerns may

alternative environments, including the recent class of models that feature extensive margin adjustments and de-location effects in addition to (or instead of) conventional terms-of-trade motives.

weaken (or even overturn) the second channel. In addition to these new results concerning the political economy of value-added content, the model also features the standard result that politically optimal tariffs rise if the government favors domestic producers of final goods, which is important for taking theory to data [Goldberg and Maggi (1999); Gawande and Bandyopadhyay (2000)].

We combine data on bilateral import protection and value-added contents to estimate the influence of value-added content on tariff-setting in practice. Our analysis focuses on dimensions of policy over which governments have scope to implement discretionary levels of protection.[5] We first examine bilateral applied tariffs where countries offer preferential tariffs to selected partners. We then examine the use of temporary trade barriers (antidumping, safeguards, and countervailing duties) in a separate, complementary set of exercises. Throughout, we measure value-added contents using input-output methods and data from the World Input-Output Database. We use instrumental variables to identify the causal effect of value-added content on trade policy, and thus test the predictions of the theory.

Theory motivates the empirical specifications we adopt and our choice of controls. In a first specification, we focus on identifying the role of domestic value added in foreign production, using fixed effects to control for export supply elasticities, political economy, and foreign value-added effects. We then turn to a second set of specifications that leverage additional implications of the theory to identify the role of foreign value added in domestic production.

In both sets of analysis, we attend to the institutional environment in which policy is set. Recognizing that some tariff preferences are set via regional trade agreements, in which terms-of-trade concerns may be neutralized by cooperation [Grossman and Helpman (1995*b*); Bagwell and Staiger (1999)], we study how the sensitivity of applied tariffs to value-added content differs inside versus outside regional trade agreements. We also account for censoring of discretionary bilateral applied tariffs (relative to unconstrained, optimal tariffs) due to the MFN rule.

Summarizing our results, we find first that higher domestic value added in foreign final goods results in lower applied bilateral tariffs. This result holds across alternative specifications that control for confounding factors using both observable proxies and fixed effects. Further, this liberalizing effect of domestic value added holds for tariffs set outside of RTAs, but not for those set within RTAs. The estimated influence of domestic value added on tariffs becomes stronger when we instrument for domestic value-added content and correct

[5] Our study is thus in the tradition of earlier work examining unconstrained dimensions of policy, including Trefler (1993), Goldberg and Maggi (1999), Gawande and Krishna (2003), Broda, Limão and Weinstein (2008), Bown and Crowley (2013), and Blanchard and Matschke (2015), among others.

for censoring of applied bilateral tariffs induced by the MFN rule. Second, we find that higher foreign value added in domestic final goods results in lower applied bilateral tariffs. This effect again strengthens when we correct for censoring and holds most strongly inside RTAs.

Finally, we show that bilateral TTB coverage ratios respond to value-added content in much the same way as bilateral applied tariffs. These results both corroborate our findings for tariffs and extend our analysis to include these increasingly important discretionary trade policy instruments. Refining the analysis further, we find the role of domestic value added in foreign production to be strongest for TTB-use against China, where antidumping and other TTBs were most actively deployed during the 1995-2009 period. The data suggest that governments are most likely to curb protectionist application of TTBs where value chain linkages are strongest, particularly when China is the target.

Our study is related to several recent contributions to the theory of trade policy. Our framework complements work by Ornelas and Turner (2008, 2012) and Antràs and Staiger (2012), who analyze how bilateral bargaining among value chain partners alters the mapping from tariffs to prices, and therefore optimal trade policy for both final goods and inputs. In contrast to this approach, we are agnostic about the nature of price determination within global value chains; our results obtain even if prices are determined by market clearing conditions, as in conventional models.

Our theory is also related in spirit to Blanchard (2007, 2010), who shows that foreign direct investment and international ownership alter the mapping from prices to income, and thus optimal tariffs. In contrast to this work on ownership concerns, our theory here links observable input trade patterns to bilateral tariffs. In this way, it hones in on arguably the most important dimension of GVC activity – the input linkages that accompany GVCs. Because these input linkages are both pervasive and large quantitatively – foreign value added accounts for 20 percent of the value of final manufacturing output in many countries, and more than 50 percent in some countries and sectors – the role of input linkages is fruitful yet previously unexplored territory for both theoretical and empirical analysis.

Our results also contribute to the empirical literature on trade policy. Our evidence linking the domestic value-added content in foreign production to preferential tariffs and TTBs fits into a prominent literature studying terms-of-trade motives for protection [Broda, Limão and Weinstein (2008); Bagwell and Staiger (2011); Ludema and Mayda (2013); Bown and Crowley (2013); Soderbery (2017); Nicita, Olarreaga and Silva (forthcoming)]. We are the first (to our knowledge) both to demonstrate the relevance of terms-of-trade concerns for *bilateral* tariff policy, and to document that tariffs set via RTAs behave in a manner consistent with the neutralization of terms-of-trade motives. Our empirical findings are also consistent with recent work on the influence of multinational firms. Blanchard and Matschke (2015) show that the United States is more likely to offer preferential market access to destinations that host affiliates of US multinational firms, and Jensen, Quinn and Weymouth (2015) find that US multinationals refrain from filing antidumping disputes against countries with which they conduct substantial intrafirm trade.

Finally, this paper contributes to a recent literature that applies input-output methods to measure the value-added content of trade [Johnson and Noguera (2012); Koopman, Wang and Wei (2014); Los, Timmer and de Vries (2015)]. Drawing on this work, we examine the implications of value-added contents for a particular set of economic policies.

The paper proceeds as follows. Section 1 presents the theoretical framework. Section 2 outlines our empirical strategy for taking the theory to data. Section 3 describes the data. Sections 4 and 5 include the empirical results, and Section 6 concludes.

1 Theoretical Framework

This section develops a many-country, many-good model with political economy concerns in which final goods are produced by combining home and foreign factors of production, as in a global value chain.

We first derive the optimal bilateral tariff under the assumption that factor inputs are supplied inelastically and locked into the value chain for particular final goods. This "specific-factors in the value chain" approach intentionally mimics and extends canonical models of endogenous trade policy with sector-specific factors, which underpin the existing empirical trade policy literature. It allows us to demonstrate cleanly the direct role that value chain linkages play in modifying optimal policy, separate from potential general equilibrium contaminants. It also facilitates comparisons between our theory and well-known results in the existing theoretical and empirical literatures. Specifically, we show that value-added content influences the structure of tariffs on final goods, in addition to standard terms-of-trade and political economy influences.

Broadening the analysis, we then discuss several variations on this baseline model. We describe how two important institutional features of the world trading system – the most-favored national rule and regional trade agreements – can be incorporated into the analysis. We also present a generalization of the model in which we relax the specific-factors assumption to incorporate general equilibrium effects. Finally, we discuss the role of input tariffs in the model, and the specific empirical context that motivates our theoretical focus on final goods tariffs.

1.1 Optimal Bilateral Tariffs and Value Added Content

In this section, we introduce global value chains into a specific-factors style model with quasi-linear preferences and a numéraire sector, in the spirit of Grossman and Helpman (1994), Broda, Limão and Weinstein (2008), Ludema and Mayda (2013) and others. Each country produces and trades potentially many final goods. The set of countries is given by $\mathcal{C} = \{1, ..., C\}$, where C may be large. There are $S + 1$ final goods, where the numéraire final good is indexed by 0, and all other (non-numéraire) goods are indexed by the set $\mathcal{S} = \{1, ..., S\}$. Final goods prices in each country are denoted by p_s^c, where c designates the location and s the final goods sector. The numéraire is freely traded, so that $p_0^c = 1$ for all countries $c \in \mathcal{C}$. We use $\vec{p}^c = (p_1^c, ..., p_S^c)$ to denote the vector of (non-numéraire) final goods prices in country c, $\vec{p}_s = (p_s^1, ..., p_s^C)$ to denote the vector of sector s prices in each country, and $\vec{p} = (\vec{p}^1, ..., \vec{p}^C)$ to represent the complete $(1 \times SC)$ vector of non-numéraire final goods prices in every country world-wide.[6]

Each country is populated by a continuum of identical workers with mass normalized to one. Consumers' preferences are identical and quasi-linear, given by the aggregate utility function:

$$U^c = d_0^c + \sum_{s \in \mathcal{S}} u_s(d_s^c) \qquad \forall c \in \mathcal{C}, \tag{1}$$

where d_s^c represents consumption of final goods in sector s in country c and sub-utility over the non-numéraire goods is differentiable and strictly concave. Consumption is chosen to maximize utility subject to the budget constraint, $d_0^c + \sum_s p_s^c d_s^c \leq I^c$, where I^c is national (aggregate) income in country c, measured in the numéraire.

Production Each country is endowed with two types of factors. The first is a homogeneous factor (e.g., undifferentiated labor), which is perfectly mobile across sectors within each country but cannot move across countries. The numéraire good is produced under constant returns to scale using the homogeneous factor, which normalizes the homogeneous-factor wage to one in all countries. The second is a set of specific factors, which we refer to as "value-added inputs."[7] With global value chains, each country's value-added inputs may be used in production of final goods both at home and abroad. For now, assume that these

[6] It often proves useful to partition price vectors into domestic and foreign components [Bagwell and Staiger (1999)]. From the perspective of a given home country i, let $\vec{p} \equiv (\vec{p}^i, \vec{p}^*)$, where $\vec{p}^*$ is the $(1 \times S(C-1))$ vector of prices in every country other than i. Likewise, let $\vec{p}_s \equiv (p_s^i, \vec{p}_s^*)$ where $\vec{p}_s^*$ is the $(1 \times (C-1))$ vector of prices on s in every country other than i.

[7] These value-added inputs are simply bundles of specific primary factors. One could replace the term value-added inputs everywhere with "specific capital" or "specific human capital" (or any other composite of specific primary factors) and generate the same results. We prefer the value-added nomenclature because it is tied to what we measure in the data.

value-added inputs are specific to the destination country and sector in which they are used to produce final goods.

Final goods in non-numéraire sector s in country c are produced using the homogeneous factor, domestic value-added inputs, and foreign value-added inputs:

$$q_s^c = f_s^c(l_s^c, \nu_{sc}^c, \vec{\nu}_{s*}^c) \quad \forall s \in \mathcal{S}, c \in \mathcal{C}, \tag{2}$$

where q_s^c is quantity of final goods produced, l_s^c is the quantity of homogeneous factor used, ν_{sc}^c is the quantity of the home (country c) value-added input used, and $\vec{\nu}_{s*}^c$ is the $(1 \times (C-1))$ vector of (all) foreign value-added inputs used by sector s in country c.[8] As a notational convention, superscripts denote the country-location of production, and subscripts denote the production-sector and country-origin of value-added inputs.

As is standard, the specific value-added inputs capture all residual profit (quasi-rents) from production, so the prices paid to the specific value-added inputs vary endogenously with final goods prices. The quasi-rent associated with production by sector s in country i (π_s^i) is given by:

$$\pi_s^i(p_s^i) = p_s^i q_s^i(p_s^i) - w l_s^i(p_s^i) = \sum_{c \in \mathcal{C}} r_{sc}^i \nu_{sc}^i, \tag{3}$$

where r_{sc}^i denotes price of value-added inputs from each source country $c \in \mathcal{C}$ used in production of s in country i. Value-added input prices r_{sc}^i depend on final goods output prices and the vector of value-added inputs in production: $r_{sc}^i \equiv r_{sc}^i(p_s^i; \vec{\nu}_s^i)$ $\forall i, j, s$.

This view of the production process captures two essential features of global value chains. First, in a global value chain, output is produced using both home and foreign factors of production. Second, global value chains often feature a high degree of input specificity and lock-in between buyers and suppliers, as emphasized by Antràs and Staiger (2012). In our model, where output is a reduced form function of factor inputs, this lock-in is manifest as factor specificity.

The model we develop here captures both of these ideas in a reduced form, without taking a stand on the underlying production structure by which factors are transformed into final goods.[9] This representation of the value chain allows us to proceed in the analysis without specifying the exact division of quasi-rents across the different value added components. We assume only that the mapping from final goods prices to the vector of quasi-rents is well-

[8] It proves helpful to partition the $(1 \times C)$ vector of value-added inputs, $\vec{\nu}_s^c \equiv (\nu_{sc}^c, \vec{\nu}_{s*}^c)$, into local value-added inputs, ν_{sc}^c, and the $(1 \times (C-1))$ vector of foreign value-added inputs, denoted by an asterisk, $\vec{\nu}_{s*}^c$.

[9] A simple interpretation of the model is that intermediate inputs are produced at home (from domestic factors) and shipped abroad to be combined with foreign factors and assembled into final goods. More complicated value chains spread over multiple countries, in which inputs cross borders many times, are also compatible with our reduced-form representation of the production process in (2).

defined and can be represented by elasticity terms ε_{sc}^{ri}, which denote the elasticity of the return to each country c's value added embodied in production of each sector s in a given country i with respect to changes in the local price of final goods in sector s in country i. These elasticities describe how changes in the price of a final good are passed through to value-added inputs, and thus implicitly depend on various supply side primitives (production structure, market frictions, market power, etc.). A key advantage of our approach is that we do not need to directly specify these primitives in order to characterize optimal policy, or to study the predictions of our theory empirically.

National Income National income equals the sum of tariff revenue and payments to the homogeneous factor and value-added inputs:

$$I^i = R(\vec{p}, I^i; \vec{\nu}) + 1 + \sum_{s\in\mathcal{S}} r_{si}^i \nu_{si}^i + \sum_{s\in\mathcal{S}} \sum_{c\neq i\in\mathcal{C}} r_{si}^c \nu_{si}^c, \tag{4}$$

where tariff revenue is $R(\vec{p}, I^i; \vec{\nu}) \equiv \sum_{s\in\mathcal{S}} \sum_{c\neq i\in\mathcal{C}} (p_s^i - p_s^c) M_{sc}^i(\vec{p}, I^i; \vec{\nu})$, M_{sc}^i is country i's imports of good s from country c, and labor income of the homogeneous factor is 1 due to normalization. Using (3), we can rewrite (4) as:

$$I^i = 1 + \vec{p^i} \cdot \vec{q^i}(\vec{p^i}, \vec{\nu^i}) + R(\vec{p}, I^i; \vec{\nu}) - \underbrace{\sum_{s\in\mathcal{S}} \sum_{c\neq i\in\mathcal{C}} r_{sc}^i \nu_{sc}^i}_{\equiv FVA^i(\vec{p^i})} + \underbrace{\sum_{s\in\mathcal{S}} \sum_{c\neq i\in\mathcal{C}} r_{si}^c \nu_{si}^c}_{\equiv DVA_i(\vec{p}^*)} . \tag{5}$$

The first three components of Equation (5) mirror traditional models, in which national income equals final goods output plus tariff revenue. There are two adjustments to the standard definition of income due to global value chain linkages. First, some of the revenue from domestic final goods production is paid to foreign factors of production (foreign value-added inputs). Henceforth, we refer to these payments to foreign factors as FVA, or *foreign value added in domestic final goods*. Second, the home country earns income by supplying home value-added inputs to foreigners. We refer to these payments as DVA, or *domestic value added in foreign final goods*. Foreshadowing the key mechanisms, note that DVA and FVA depend on final goods prices via the endogenous return to value-added. Because tariffs influence these prices, trade policy affects income in a non-standard way in the presence of GVCs.

Political Economy Let the government's objective function be given by the sum of national income, consumer surplus, and the weighted sum of quasi-rents in production:

$$G^i = I^i + \zeta(\vec{p}^i) + \sum_s [\delta^i_s \pi^i_s(p^i_s) + \delta^i_{s*} FVA^i_s(p^i_s) + \delta^*_{si} DVA_{si}(\vec{p}^*_s)], \tag{6}$$

where $\zeta(\vec{p}^i) \equiv \sum_s [u_s(d_s) - p^i_s d_s]$ is consumer surplus and $\{\delta^i_s, \delta^i_{s*}, \delta^*_{si}\}$ are political economy weights (relative to aggregate welfare) attached to various sources of rents.[10]

This objective function augments standard political economy assumptions to recognize the potential political influence of foreign and domestic value chain interests. The first two terms in (6) measure the indirect utility of the representative consumer (aggregate welfare). The remaining terms capture political economy influences: δ^i_s is the weight that the government puts on total rents from domestic final goods production, δ^i_{s*} is the weight placed on rents from domestic production that accrue to foreign value-added inputs (FVA^i_s), and δ^*_{si} is the weight placed on rents accruing to domestic value-added inputs used in foreign final goods production (DVA_{si}). We do not impose a priori restrictions on the weights, but standard arguments would imply positive values for politically active constituencies.[11]

Optimal Bilateral Tariffs Country i's bilaterally optimal tariff on final goods in sector x against a given trading partner $j \in \mathcal{C}$ maximizes Equation (6) subject to a standard no arbitrage condition: $p^i_x = \tau^i_{xj} p^j_x$, where $\tau \equiv (1 + t^i_{xj})$ and t^i_{xj} is the ad-valorem tariff. Given the pattern of value-added content, and every other country's tariff schedules, a country i's unilaterally optimal tariff on imported good x from country j is given by:

$$\tau^i_{xj} = argmax\ G^i \quad \text{s.t.} \quad p^i_x = \tau^i_{xj} p^j_x, \tag{7}$$

[10] Helpman (1997) discusses how this type of objective function may be obtained from standard micro-founded political economy models. As in Ludema and Mayda (2013), we choose to not model the policy-making process and adopt this more direct approach to characterizing government objectives.

[11] These weights reflect a range political economy forces. The restriction $\delta^i_s = \delta^i_{s*} = \delta^*_{si} = 0$ yields a national welfare maximizing government. Standard protection-for-sale lobbying would imply $\delta^i_x > 0$ for a politically active industry [Grossman and Helpman (1994)]. Similarly, δ^*_{xi} would be positive if domestic value-added input suppliers advocate for better market access on behalf of their foreign downstream buyers. To the extent that the government responds to the interests of foreign value-added input suppliers, δ^i_{s*} would also be positive. For instance, foreigners could lobby directly over trade policy [Gawande, Krishna and Robbins (2006)]. Alternatively, foreign value-added inputs suppliers could be represented in domestic politics by their downstream buyers, as in tariff jumping foreign investors that earn "political goodwill" [Bhagwati et al. (1987)] and advocate on behalf of their upstream affiliates located abroad. Finally, we implicitly assume that the home government affords zero consideration to foreign value-added inputs in foreign production, though this assumption could also easily be relaxed.

with the associated first order condition:

$$G^i_{\tau^i_{xj}} = \frac{dM^i_x}{d\tau^i_{xj}} t^i_{xj} p^j_x - M^i_{xj}\frac{dp^j_x}{d\tau^i_{xj}} + \delta^i_x q^i_x \frac{dp^i_x}{d\tau^i_{xj}} + \Omega^{Ri}_{xj} - (1-\delta^i_{x*})\frac{dFVA^i_x}{d\tau^i_{xj}} + (1+\delta^*_{xi})\frac{dDVA_{xi}}{d\tau^i_{xj}} = 0. \quad (8)$$

The first two terms of this expression capture the standard terms-of-trade motive, and the third term represents the (familiar) effect of domestic protectionist political pressure.[12] The term $\Omega^{Ri}_{xj} \equiv \sum_{c\neq i,j} \frac{dR^i_{xc}}{d\tau^i_{xj}}$ captures the potential for trade diversion to change country i's tariff revenue from trade with countries other than j.[13] The last two terms capture the politically-weighted influence of trade in value-added inputs on the optimal tariff.

Consider first the role of foreign value added embodied in domestic final goods (FVA). The bilateral tariff raises the local final goods price (p^i_x), which in turn increases the returns to foreign value-added inputs embodied in domestic production ($r^i_{xc}(p^i_x)$). We decompose this effect as follows:

$$\frac{dFVA^i_x}{d\tau^i_{xj}} = \sum_{c\neq i}\left[\frac{r^i_{xc}\nu^i_{xc}}{p^i_x}\underbrace{\left(\frac{dr^i_{xc}}{dp^i_x}\frac{p^i_x}{r^i_{xc}}\right)}_{\equiv\varepsilon^{ri}_{xc}\geq 0}\right]\frac{dp^i_x}{d\tau^i_{xj}} = \varepsilon^{ri}_{x*}\sum_{c\neq i}\frac{r^i_{xc}\nu^i_{xc}}{p^i_x}\frac{dp^i_x}{d\tau^i_{xj}} = \varepsilon^{ri}_{x*}\frac{FVA^i_x}{p^i_x}\frac{dp^i_x}{d\tau^i_{xj}}. \quad (9)$$

The term $\varepsilon^{ri}_{xc} \equiv \frac{dr^i_{xc}}{dp^i_x}\frac{p^i_x}{r^i_{xc}}$ is the elasticity of foreign value-added input prices with respect to local final goods prices. We assume this elasticity is positive: a higher price on a final good implies higher returns to the value-added used in its production. In preparation for the empirical application, we further assume that this elasticity is the same across all foreign input sources, so that $\varepsilon^{ri}_{xc} = \varepsilon^{ri}_{x*}\ \forall c \neq i \in \mathcal{C}$ (as reflected the second equality above).

Turning to the role of domestic value added in foreign final goods (DVA), the bilateral tariff alters foreign final goods prices, which feed back into the price of domestic value-added inputs. We decompose the direct and indirect price effects of the tariff as follows:

$$\frac{dDVA_{xi}}{d\tau^i_{xj}} = \frac{r^j_{xi}\nu^j_{xi}}{p^j_x}\underbrace{\left(\frac{dr^j_{xi}}{dp^j_x}\frac{p^j_x}{r^j_{xi}}\right)}_{\equiv\varepsilon^{rj}_{xi}\geq 0}\frac{dp^j_x}{d\tau^i_{xj}} + \Omega^{DVAi}_{xj} = \underbrace{\varepsilon^{rj}_{xi}\frac{DVA^j_{xi}}{p^j_x}\frac{dp^j_x}{d\tau^i_{xj}}}_{\text{direct effect}} + \underbrace{\Omega^{DVAi}_{xj}}_{\text{indirect effect}}. \quad (10)$$

[12]Tariffs influence final goods prices in the usual way: an increase in country i's bilateral tariff on good x against a trading partner country j, τ^i_{xj}, causes the price of x to rise in the imposing country (i), and fall in trading partner j. That is, we rule out the Metzler and Lerner paradoxes such that: $\frac{dp^i_x}{d\tau^i_{xj}} \geq 0 \geq \frac{dp^j_x}{d\tau^i_{xj}}$.

[13]The price of x in other countries may respond to the tariff as a result of trade diversion. In general, the direction of third-country price movements are ambiguous absent additional modeling assumptions. Theoretical work has used various techniques to restrict the external price effects of bilateral tariffs, usually by adopting a 'competing exporters' framework [Bagwell and Staiger (1997)] or a small country assumption [e.g. Grossman and Helpman (1995*a*)].

The direct price effect captures how τ_{xj}^i impacts the price of i's value-added used by the country (j) on which the tariff is imposed. The indirect price effect encompasses how the tariff impacts the price of i's value-added inputs used in third countries. In what follows, we focus on the direct effects and collect the indirect effects in Ω_{xj}^{DVAi}.[14] The strength of this direct effect is governed by the elasticity $\varepsilon_{xi}^{rj} \geq 0$. As above, we assume that this elasticity is positive: a higher price of good x in country j implies a higher price for country i's value-added inputs used in production of that good.

Substituting Equations (9) and (10) into Equation (8), we solve for the (unconstrained) optimal bilateral tariff:

$$t_{xj}^i = \frac{1}{\epsilon_{xj}^i}\left(1 + \frac{\delta_x^i q_x^i}{|\lambda_{xj}^i| M_{xj}^i} - (1+\delta_{xi}^*)\varepsilon_{xi}^{rj}\frac{DVA_{xi}^j}{p_x^j M_{xj}^i} - \frac{(1-\delta_{x*}^i)\varepsilon_{x*}^{ri}}{|\lambda_{xj}^i|}\frac{FVA_x^i}{p_x^i M_{xj}^i} - \tilde{\Omega}_{xj}^i\right), \tag{11}$$

where $\lambda_{xj}^i \equiv \frac{dp_x^j}{d\tau}/\frac{dp_x^i}{d\tau} < 0$, $\epsilon_{xj}^i \equiv \frac{dE_{xi}^j}{dp_x^j}\frac{p_x^j}{E_{xi}^i} > 0$ represents the bilateral, sector-specific export supply elasticity, and $\tilde{\Omega}_{xj}^i \equiv \frac{\Omega_{xj}^{Ri}+\Omega_{xj}^{DVAi}}{(dp_x^j/d\tau_{xj}^i)M_{xj}^i}$ captures any potential third-country effects of trade diversion.[15]

Discussion Equation (11) and traces out the role of value chain linkages and political economy in shaping bilaterally optimal tariffs. There are four key elements in this expression.

The first two elements are well-understood. They are the inverse export supply elasticity ($\frac{1}{\epsilon_{xj}^i}$) and the inverse import penetration ratio ($\frac{\delta_x^i q_x^i}{|\lambda_{xj}^i| M_{xj}^i}$). The inverse export supply elasticity captures the familiar terms-of-trade, cost-shifting motive for tariffs [Johnson (1951-1952)]. The inverse import penetration ratio captures the influence of domestic political economy concerns, whereby the government trades off the interests of import-competing domestic producers of good x against social welfare.

The third element is new and captures the the role of domestic value added in foreign production. When DVA_{xi}^j is high, the government optimally sets a lower bilateral tariff, because lowering the tariff raises the price of foreign final goods and some of this price increase is passed back to the home country in the form of higher prices for domestic value-added inputs. This mechanism drives down the optimal tariff even when the domestic govern-

[14] $\Omega_{xj}^{DVAi} \equiv \frac{dDVA_{xi}^{-j}}{d\tau_{xj}^i} = \sum_{c\neq i,j}\frac{dDVA_{xi}^c}{dp_x^c}\frac{dp_x^c}{d\tau_{xj}^i} = \sum_{c\neq i,j}\varepsilon_{xi}^{rc}\frac{DVA_{xi}^c}{p_x^c}\frac{dp_x^c}{d\tau_{xj}^i}$. The consequences of any third-country effects are ambiguous and plausibly inconsequential (e.g. when trade diversion is minimal; see e.g. Freund and Ornelas (2010)).

[15] This bilateral tariff expression describes country i's non-cooperative equilibrium response as a function of all other countries' tariff policies, which are implicitly captured in the trade volume, elasticity, price, and λ terms. Country i's Nash equilibrium tariff is then given by (11) evaluated at the world tariff vector for which every country's tariff reaction curves intersect.

ment values only national income ($\delta^*_{xi} = 0$); the effect is reinforced when the government affords additional political consideration ($\delta^*_{xi} > 0$) to the interests of domestic value-added input suppliers. In effect, a large importing country internalizes some of the terms-of-trade externality when its value added is embodied in foreign final goods.

The fourth element is also new and captures the role of foreign value added in domestic production (FVA^i_x). Foreign value added influences the optimal tariff through a separate international cost-shifting margin. By reducing its tariffs, the government of country i lowers *domestic* prices. These lower domestic prices benefit domestic consumers at the expense of import-competing final goods producers. But when the import-competing sectors use foreign value-added inputs ($FVA^i_x > 0$), some of these losses can be passed upstream to foreign input suppliers.[16] Thus, the benefits to consumers of lower tariffs are shifted partly onto foreigners. This mechanism constitutes a distinct "domestic-price externality" that will also serve to drive down the optimal bilateral tariff, all else equal. When the government assigns positive political weight to the interests of foreign value-added input suppliers ($\delta^i_{x*} > 0$), this effect is attenuated. The more the government values foreign input suppliers, then the less it will be motivated to lower tariffs at their expense. As long as domestic consumer concerns dominate the interests of foreign value-added suppliers ($\delta^i_{x*} < 1$), bilateral tariffs nonetheless will be decreasing in FVA.[17]

Two final points are worth noting. First, the DVA and FVA terms are both scaled by bilateral imports (M^i_{xj}), just as in the import penetration ratio term. This scaling arises because the political and value-added terms act as counterweights to the standard terms-of-trade motive, the strength of which depends on the level of bilateral imports. The fact that imports induce bilateral variation in the strength of the FVA effect will play a role in our identification strategy below. Second, the influence of value added in shaping optimal tariffs is governed (in part) by the value-added elasticities, ε^{rj}_{xi} and ε^{ri}_{x*}, which capture the extent to which changes in final goods prices are ultimately passed through to value-added input prices. Empirically, the strength of these effects will be embedded in coefficient estimates together with political welfare weights and overall trade elasticities.

[16] Note that this effect is essentially multilateral, since any change in country i's local price of x is passed on to all foreign suppliers. We imposed a common pass-through elasticity above, which implies that only the multilateral value of foreign value added appears in the optimal tariff expression. Relaxing this assumption, one would replace this multilateral value with an elasticity-weighted average of foreign value added.

[17] We do not rule out the possibility that the government places greater value on the interests of foreign value-added owners than on its domestic consumers ($\delta^i_{x*} > 1$). If true, bilateral tariffs will be increasing with FVA. Our empirical strategy allows for this possibility, in that we estimate the relationship between FVA and tariffs without a priori sign restrictions. Nonetheless, we do not expect to find a positive relationship, given empirical evidence that governments value aggregate social welfare far more than even domestic political interests (e.g., see Goldberg and Maggi (1999) for the United States).

1.2 Extensions

Having identified the key mechanisms via which value-added content influences optimal policy, we now consider extensions of the model that incorporate institutional constraints on applied tariff setting, endogenous value-added content and general equilibrium effects, and input tariffs.

1.2.1 Trade Policy Institutions

We begin with the two institutional issues that figure prominently in our empirical investigation: the most-favored-nation (MFN) rule and bilateral (regional) free trade agreements.

The MFN Rule The most-favored-nation rule dictates that WTO members may not discriminate across their WTO-member trading partners, but for defined exceptions to this rule specified in GATT's Article XXIV and Enabling Clause. Further, any deviations from MFN under these auspices must involve *downward* adjustment in applied tariffs – i.e., countries may offer tariff preferences, but they may not impose higher-than-MFN discriminatory tariffs. As a result, MFN tariff rates serve as an upper bound on applied bilateral tariffs.[18]

We can readily incorporate this constraint into the model above, where we refine the government's *applied* tariff problem in (7) subject to the additional constraint that $t_{xj}^{i,\text{applied}} \leq t_x^{i,\text{MFN}}$, where $t_{xj}^{i,\text{applied}}$ is the bilateral applied tariff and $t_x^{i,\text{MFN}}$ denotes the MFN tariff. Adding this MFN constraint, the *applied* bilateral tariff then will be the lesser of the expression in (11) and the MFN tariff binding:

$$t_{xj}^{i,\text{applied}} = \min\{t_{xj}^i, t_x^{i,MFN}\}. \tag{12}$$

Following Grossman and Helpman (1995*a*), we take MFN tariffs as given when analyzing the politically optimal applied bilateral tariffs.[19] In our empirical application, there are two important reasons to focus on bilateral deviations from MFN, rather than MFN tariffs themselves. First, current MFN tariffs were set primarily under the Uruguay Round,

[18]Temporary trade barriers (anti-dumping, countervailing duties, and safeguards) are the key exception in which discretionary trade policy consists of *upward* deviations from MFN tariffs. We explore these alternative instruments of trade policy in Section 5.

[19]To justify this assumption, Grossman and Helpman (1995*a*) appeal to GATT Article XXIV, which prohibits countries that adopt bilateral agreements from raising their external (MFN) tariffs. Further consistent with this assumption, existing theoretical and empirical work finds that tariff preferences have an ambiguous impact on MFN tariffs. See Bagwell and Staiger (1997), McLaren (2002), Saggi (2009) for theoretical analysis. On the empirics, Limão (2006) finds that tariff preferences make subsequent MFN liberalization less likely, while Estevadeordal, Freund and Ornelas (2008) find the opposite.

which was completed in 1994.[20] Not only does this predate our sample period, but the MFN negotiations also largely predated the post-1990 rise in global value chain activity. In contrast, bilateral tariff preferences remained an active area of trade policy during the 1995-2009 period, and thus provide more fertile ground for empirical exploration. Second, our empirical setting exploits variation in tariff preferences across trade partners within a given importer and industry. Thus, we effectively difference away MFN tariffs (and their multilateral determinants) in all of our empirical specifications.

Regional Trade Agreements While most observed bilateral tariff preferences are unilateral, some are granted via bilateral or regional trade agreements (RTAs), under which governments may cooperate to set more efficient tariffs among signatory countries. The existing literature suggests that negotiated tariff setting may mitigate or even eliminate terms-of-trade cost-shifting externalities [Grossman and Helpman (1995*b*), Bagwell and Staiger (1999)]. If this is true in practice, then cooperation between RTA members could change the relationship between value-added content and applied tariffs within versus outside RTAs.

Specifically, if RTAs eliminate terms-of-trade motives for final goods, we would not expect to see the imprint of DVA on tariff preferences under RTAs. Since the effect of DVA works entirely through foreign local prices – and thus the bilateral terms of trade – an agreement that neutralizes terms-of-trade motives in tariff setting must also neutralize any (offsetting) influence of DVA. (See Appendix A.1 for formal treatment.) We therefore expect that the influence of DVA on observed tariffs may be weaker, or possibly non-existent, within RTAs. Looking forward, this possibility has two implications for empirical work. First, we can examine this prediction by testing for a differential relationship between DVA and tariffs for country pairs with versus without RTAs. Second, in light of this prediction, we will take care to document how DVA influences tariff preferences specifically among countries without RTAs in place.

The anticipated effect of FVA under an RTA is less clear, since the effect of FVA on the unilaterally optimal tariff works through a *domestic* (local) price externality. As far as we know, neither the theoretical nor empirical trade literature speaks to the potential for cooperative agreements to mitigate behind-the-border externalities.[21] If RTAs eliminate *all* cross-border externalities between countries, we might also expect the effect of FVA to disappear under cooperative agreements. Otherwise, we would expect the FVA effect to

[20] This is true for industrialized countries. As a legacy of the Uruguay round, MFN tariffs for these countries sometimes fall during our sample period due to extended phase-in schedules. Although MFN tariffs for several emerging markets were lowered during our sample period, either unilaterally or in conjunction with joining the WTO, our empirical strategy ensures that these MFN tariff changes do not drive the results.

[21] The sole exception is recent theoretical work by DeRemer (2016), who develops an augmented definition of reciprocity in the presence of local price externalities.

remain. Moreover, because the FVA effect reflects a *multilateral* externality, it is not clear how, if at all, a bilateral or regional trade agreement would mitigate the role of FVA.

Ultimately, we leave these open empirical questions to be answered by data. With both FVA and with DVA, we anticipate the potential for heterogeneous coefficients across RTA and non-RTA preferences and will allow for these differential effects in our empirical application.

1.2.2 General Equilibrium with Endogenous Value Chains

In this section, we generalize the model to endogenize the pattern of value added use across sectors and countries.[22] We outline the core assumptions and describe optimal tariffs in the generalized model here, and reserve the derivation for Appendix A.2.

In place of the specific-factors structure used in Section 1.1, we now assume that the quantities of value-added inputs used in production respond to prices. To distinguish effects that operate through prices versus quantities, we also assume that there are frictions that limit the substitutability of value-added inputs across end-use sectors or destinations, such that the equilibrium returns to value-added inputs may differ across countries and industries.[23] Notice that when value-added inputs are mobile across sectors and countries, input use generally depends on the *complete* vector of worldwide final goods prices: $\vec{\nu} \equiv \vec{\nu}(\vec{r}(\vec{p}; \vec{\nu})) \equiv \vec{\nu}(\vec{p})$, with payments to factors given by $\vec{r}(\vec{p}; \vec{\nu}(\vec{p})) \equiv \vec{r}(\vec{p})$.[24] In turn, the value added components of national income, DVA and FVA, will depend on the vector of final goods prices via both $\vec{r}$ via $\vec{\nu}$.

As before, we assume that national income is given by Equation 5 and the government maximizes the weighted sum of national income, consumer surplus, and politically-weighted producer influences. As shown in the appendix, country i's optimal bilateral tariff on good x from trading partner j may be written as:

$$t^i_{xj} = \frac{1}{\tilde{\epsilon}^i_{xj}} \left(1 + \frac{\delta^i_x q^i_x}{|\lambda^i_{xj}| M^i_{xj}} - (1+\delta^*_{xi})(\tilde{\varepsilon}^{rj}_{xi} + \tilde{\varepsilon}^{\nu j}_{xi}) \frac{DVA^j_{xi}}{p^j_x M^i_{xj}} - (1-\delta^i_{x*})(\tilde{\varepsilon}^{ri}_{x*} + \tilde{\varepsilon}^{\nu i}_{x*}) \frac{FVA^i_x}{p^i_x M^i_{xj}} - \tilde{\Omega}^i_{xj} \right), \quad (13)$$

[22] We maintain the assumptions on preferences – quasi-linear preferences with an outside good – used in Section 1.1. Combined with specific factors, these assumptions yield an essentially partial equilibrium model, which can be analyzed sector by sector. Relaxing the specific factors assumption alone (as we do here) re-introduces cross-sector general equilibrium spillovers. Thus, there is little additional cost of dropping the assumptions on preferences as well. Nonetheless, we proceed by retaining these preference assumptions, both to economize on notation and maintain our focus on factor markets.

[23] Absent frictions, the pass through from final goods prices to DVA and FVA would operate entirely through value-added input quantities. We allow for both price and quantity channels of adjustment.

[24] In this general equilibrium setting, a change in any given bilateral tariff thus may (potentially) disrupt the entire world vector of prices in all sectors, in every country. Though this complicates exposition, it does not not fundamentally alter the key mechanisms in the model. See the appendix for details.

where $\tilde{\epsilon}^i_{xj}$ is the general equilibrium analog to the bilateral export supply elasticity in the baseline version of the model and $\tilde{\Omega}^i_{xj}$ again captures indirect (third-country and cross-sector) effects of the tariff change.

Despite the potential complications of the general equilibrium setting, this optimal tariff looks essentially similar to the optimal tariff in the specific-factors version of the model in Equation (11).[25] Focusing on the direct bilateral, sector-x elements, the only substantive difference is that the *quantitative* effects of DVA and FVA on the optimal tariff depend on the elasticity of both value-added *prices* (via $\tilde{\varepsilon}^r$) and *quantities* (via $\tilde{\varepsilon}^\nu$) with respect to tariffs.

Thus, while a more flexible production structure introduces additional adjustment channels, these channels can still be summarized in terms of "pass through" elasticities, as in the specific-factors model. The predictions we emphasize require only that there exists *some* sensible mapping from tariffs to final goods prices, to the total return on value-added inputs, to national income. Although the exact form of this mapping depends on particular model assumptions, the essential structure of the government's problem does not. Thus, we conclude that our predictions for how value-added content modifies tariff setting are robust to relaxation of the specific-factors assumptions adopted above. Accordingly, our predictions would obtain in many models of global value chains, regardless of the particular institutions that govern input price determination.

1.2.3 Input Tariffs

Thus far, we have analyzed how final goods tariffs respond to value-added content, formalizing the idea that global value chains erode mercantilist motives for trade protection. For both theoretical and empirical reasons, we have abstracted from the simultaneous analysis of input tariffs. We pause here to explain why it is reasonable to relegate input tariffs to the background in analyzing discretionary final goods tariffs.

In government decisions about the optimal level of final goods tariffs, input tariffs may play two basic roles. First, they may influence the value-added content of final goods. Thus, a given choice of input tariffs will influence the optimal choice of final goods tariffs via its impact on DVA and FVA. By conditioning on observable patterns of DVA and FVA in the theory and empirics, our theory implicitly allows input tariffs to influence final goods tariffs

[25] For economy of notation with the more complex price relationships, Equation (13) uses augmented elasticity terms ($\tilde{\varepsilon}$) that collapse both the mapping from final goods prices to value added (the ε terms in equation (11)) and the mapping from tariffs to final goods prices (the λ terms in (11)). These augmented elasticities are defined to maintain the sign conventions in the baseline model (i.e. DVA^j_{xi} and FVA^i_x enter negatively); see Appendix A.2 for details.

via this channel.[26] In the opposite direction, one might be concerned about reverse causality: the possibility that final goods tariffs might influence the optimal choice of input tariffs and thus the pattern of value added use. As we discuss further below, we explicitly address concerns about reverse causality running from final goods tariffs to value-added contents directly in our empirical work.

Second, input tariffs may generate tariff revenue. This possibility could be important for the following reason: as the government alters final goods tariffs, it will change the amount of production taking place, the value of imported inputs being used, and hence the revenue from input tariffs. Notwithstanding this theoretical concern, these revenue effects are not a substantial concern in our empirical context. Input tariffs are low (near zero) for the countries and period that we study empirically, so input tariff revenue effects are plausibly negligible. Further, existing input tariffs are bound at these very low levels by WTO disciplines, leaving little room for government discretion, and so again may be plausibly taken as exogenous as we analyze how countries exercise bilateral discretion in final goods tariff setting. Thus, we abstract from them in our main body of theory.[27]

That said, we do also consider a variant on the baseline model with positive input tariffs in Appendix A.3. We consider a case where input tariffs are levied as a tax on foreign value-added content in production.[28] Re-deriving the optimal tariff on final goods in this case, we find that input tariffs attenuate the impact of foreign value-added content on the optimal tariff. The intuition for this result is tied to the general intuition for the local price externality: an increase in the final goods tariff generates producer gains that are partly captured by upstream foreign input suppliers. When the government taxes foreign inputs in production, it recaptures a part of this spillover and thus internalizes a portion of the local price externality. The important insight of this analysis for our empirical work is that the effects of input tariffs are potentially embedded in the empirical coefficients on foreign value added that we estimate, and would push the FVA effects toward zero without substantively changing the comparative static predictions of the model.

Finally, while this discussion focuses on how given input tariffs might influence the relationship between final goods tariffs and value-added content, we readily acknowledge a role

[26] Input tariffs have additional second-order effects that operate via price elasticities as well. These will be absorbed into our coefficient estimates, and thus they are not of interest to us for theoretical study.

[27] Bown and Crowley (2016) report that tariffs for final goods are typically 70-90 percent higher than tariffs on intermediate inputs for G20 countries. As an illustrative example, Canada eliminated manufacturing input tariffs across the board in 2015. Further, reported MFN rates likely overstate the true importance of input tariff revenue, as many countries implement preferential duty drawback schemes to rebate import tariff revenue for exporting firms.

[28] If the government does not have access to value-added tax instruments, this case may be interpreted as one in which gross imported inputs are produced abroad (exclusively using foreign factors) and the domestic government levies gross taxes on imported inputs.

for future work in studying the determination of input tariffs themselves. We have chosen to defer this issue for another paper for both empirical and theoretical reasons. First, as noted above, input tariffs (and their WTO bindings) are in practice very low, and therefore subject to limited government discretion. Empirically, there is little room to observe variation in input tariff setting. Second, input tariffs are contingent on a host of additional issues that are largely irrelevant in the study of final goods tariffs. In particular, optimal input tariffs generally will depend on particular microeconomic features of the production process including the stage (or stages) at which input tariffs are applied and whether value-chains are structured as 'snakes' or 'spiders', whether they span firm boundaries, and whether input prices are determined by market clearing conditions or bilateral bargaining. A signature strength of our value-added approach is that it side-steps these hard-to-quantify production details, and thus is amenable to direct econometric investigation.

2 Empirical Strategy

The value-added augmented tariff theory presented above guides our empirical strategy for identifying the influence of value-added content on policy. To organize the analysis, we start by focusing on the role of domestic value added in foreign production, treating the foreign value added and domestic political economy in Equation (11) as nuisance controls to be absorbed by fixed effects. This approach allows us to test the theory in a flexible way and facilitates discussion of the role of RTAs, MFN-censoring, and threats to identification (e.g., endogeneity concerns). To examine foreign value added and domestic political economy explicitly, we then adapt our empirical strategy to lean more strongly on the functional form of Equation (11). In this second specification, we include explicit measures of domestic value added, foreign value added, and final goods production (all scaled by imports) as regressors. Building on this specification, we examine how temporary trade barriers respond to value-added content in a third part of the analysis.

2.1 Domestic Value Added in Foreign Production

Following Equations (11) and (12), the unilateral applied bilateral tariff can be written as:

$$\begin{aligned} & t_{xjt}^{i,\text{applied}} = \min\{t_{xjt}^{i}, t_{xt}^{i,MFN}\} \\ & \text{with} \quad t_{xjt}^{i} = \frac{1}{\epsilon_{xj}^{i}} + \frac{\delta_{x}^{i} p_{xt}^{i} q_{xt}^{i} - (1-\delta_{x*}^{i})\varepsilon_{x*}^{ri} FVA_{xt}^{i}}{\epsilon_{xj}^{i} |\lambda_{xj}^{i}| p_{xt}^{i} M_{xjt}^{i}} + \beta_{ijxt} DVA_{xit}^{j}, \end{aligned} \tag{14}$$

where $\beta_{ijxt} \equiv -\frac{(1+\delta^*_{xi})\varepsilon^{rj}_{xi}}{\epsilon^i_{xj} p^j_{xt} M^i_{xjt}}$.[29] This expression highlights three concerns that we need to address to isolate the impact of DVA^j_{xit} on t^i_{xjt}.

First is the need to control for inverse export supply elasticities $(1/\epsilon^i_{xj})$. Our approach follows the literature by placing empirical restrictions on export supply elasticities. We assume that the inverse export supply elasticity can be decomposed into additive importer-industry-year and exporter-industry-year specific components, which will be absorbed by fixed effects.[30]

Second is the need to control for political economy and foreign value added effects on tariffs, both collected in the second term. Note that the term has both a multilateral component ($p^i_{xt} q^i_{xt}$ and FVA^i_{xt} in the numerator) and a bilateral component ($p^i_{xt} M^i_{xjt}$ in the denominator).[31] To control for these influences, we interact importer-industry-year fixed effects with bilateral, time-varying indicators for import volumes. Specifically, we divide the observed empirical distribution of imports into ten decile bins and form indicators $D_{xijt} \equiv \mathbf{1}(p^i_{xt} M^i_{xjt} \in D)$, where D indexes the set of import decile bins. We interact these decile indicators with the importer-industry-year fixed effects to form importer-industry-year-decile fixed effects.[32] (Later, we use these import ratios directly.)

The third concern is the potential for coefficient heterogeneity on DVA^j_{xit}, principally due to the presence of imports in the denominator of β_{ijxt}. We address this issue here by substituting $\ln(DVA^j_{xit})$ for DVA^j_{xit}. The logic is as follows. DVA^j_{xit} and bilateral final goods imports are strongly positively correlated in the data, with a raw correlation of 0.75. Because β_{ijxt} is inversely related to the level of bilateral final goods imports, we expect that a \$1 change in DVA^j_{xit} at low levels of DVA^j_{xit} to be more influential than a \$1 change in DVA^j_{xit} at high levels of DVA^j_{xit}. The log function is a convenient transformation of the data that captures this mechanism and so allows us to estimate a homogeneous coefficient for domestic value added.

Based on this discussion, the first specification that we take to the data is:

$$t^i_{xjt} = \Phi_{xit} \times D_{xijt} + \Phi_{xjt} + \beta \ln(DVA^j_{xit}) + e_{xijt}, \tag{15}$$

[29]As implied by this expression, we treat ε^{rj}_{xi}, ε^{ri}_{x*}, ϵ^i_{xj}, and λ^i_x as time-invariant parameters that will be absorbed in our coefficient estimates.

[30]Broda, Limão and Weinstein (2008) and Ludema and Mayda (2013) assume that export supply elasticities vary by importer and industry, but are identical across partners and through time: $\epsilon^i_{xjt} = \epsilon^i_x$. Our more general parametrization obviously nests this assumption.

[31]Heterogeneity in elasticities, etc. also generates both multilateral and bilateral components to this term. We abstract from this unobserved heterogeneity in the empirical work and focus exclusively on observables.

[32]These decile interactions also absorb residual variation in bilateral inverse export supply elasticities not picked up by the importer-industry-year or exporter-industry-year fixed effects alone.

where Φ_{xit} and Φ_{xjt} are importer-industry-year and exporter-industry-year fixed effects. The DVA sign prediction is $\beta < 0$.

2.1.1 Preferences under vs. outside RTAs

Thus far, our discussion has focused on unilateral tariffs. As discussed in Section 1.2.1, RTAs may nullify the influence of domestic value added on tariffs. This result depends on whether terms-of-trade externalities are fully eliminated, which may or may not obtain given the institutional design of particular bilateral trade negotiations. Little is known empirically about the extent to which bilateral or regional trade agreements actually neutralize bilateral terms-of-trade externalities. We therefore initially adopt an agnostic approach to the question of whether domestic value added effects are present in RTAs.

We start by pooling data on tariffs under and outside of RTAs, treating Equation (15) as describing all bilateral tariffs. We then (quickly) proceed to test whether domestic value added has similar effects on tariffs inside and outside RTAs. To do so, we augment Equation (15) to allow trade agreements to alter the responsiveness of tariffs to domestic value added, as well as shift the level of tariffs directly.[33] The augmented specification is:

$$\begin{aligned} t^i_{xjt} = \Phi_{xit} \times D_{xijt} + \Phi_{xjt} + RTA_{ijt} \\ + \beta_1[1 - RTA_{ijt}] \ln(DVA^j_{xit}) + \beta_2 RTA_{ijt} \ln(DVA^j_{xit}) + e_{xijt}, \quad (16) \end{aligned}$$

where RTA_{ijt} is an indicator for whether ij have a bilateral or regional trade agreement in force at date t. If RTAs neutralize bilateral terms-of-trade externalities, then we expect $\beta_2 = 0$. At a minimum, we expect β_2 to be less than β_1 if RTAs at least partially neutralize the bilateral terms-of-trade externality.

2.1.2 Censoring and Endogeneity Concerns

As emphasized in the theory, observed bilateral applied tariffs are effectively censored by each country's multilateral MFN tariff: $t^{i,\text{applied}}_{xjt} = \min\{t^i_{xjt}, t^{i,MFN}_{xt}\}$. In our empirical work, we initially ignore this censoring and estimate the response of tariffs to domestic value added via ordinary least squares. These OLS estimates measure the responsiveness of *applied* bilateral tariffs, rather than *optimal* bilateral tariffs, to domestic value added. As is standard, we expect MFN-censoring to attenuate estimates of β toward zero. To estimate the response of optimal tariffs to domestic value added, we correct for MFN-censoring using a Tobit specification.

[33]Level effects are implied by the discussion in Section 1.2.1, in that the additive inverse export supply elasticity term in the unilaterally optimal tariff may disappear under the RTA.

To establish the causal impact of domestic value added on tariffs, we also need to address the possibility that DVA^j_{xit} responds endogenously to final goods tariffs. The concern is that country i's domestic value added embodied in production of final goods in sector x in trading partner j may be decreasing in country i's tariff against imports of x from j. In the model, this would arise because the tariff pushes down the price of the value-added inputs country i supplies for production of x in j.[34] More generally (outside the model), lower tariffs might induce firms to offshore final production stages, leading to higher domestic content in foreign production. Both of these mechanisms induce a negative correlation between $\ln(DVA^j_{xit})$ and e_{ijxt}. We use an instrumental variables strategy to address these concerns, and we defer the specifics until we implement the strategy below.

2.1.3 A Note on Interpretation: Tariffs Levels vs. Tariff Preferences

Before proceeding, we emphasize one final important point of interpretation. In all specifications that include importer-industry-year fixed effects, including (15) or (16), these fixed effects absorb all variation in multilateral, industry-level MFN tariffs in the data. By construction, our empirical specifications therefore identify the role of domestic value added entirely from deviations between applied bilateral tariffs and MFN tariffs. Put another way, we exploit only bilateral tariff preferences – downward deviations from MFN – to identify the role of DVA on tariff policy. We define bilateral tariff preferences as the (negative) deviation from MFN tariffs, so that $t^{i,\text{applied}}_{xjt} - t^{i,MFN}_{xt} \leq 0$ is the tariff preference granted by country i to country j in sector x at date t. Under this sign convention, more generous bilateral tariff preferences are more *negative* and correspond equivalently to lower bilateral tariff levels.

2.2 Foreign Value Added in Domestic Production

Thus far, we have focused on identifying the influence of domestic value-added in foreign production on tariffs, absorbing all variation in foreign value-added in domestic production via fixed effects. Now we turn to an alternative empirical specification to study these foreign value-added effects directly.

Returning to the unilateral applied bilateral tariff in Equations (11) and (12), we can

[34] Relaxing the specific factors assumption would work in the same direction. Tariffs depress foreign final goods output, which may depress the quantity of value-added inputs used, as demonstrated in the general equilibrium extension of the model developed in the appendix.

re-write the optimal bilateral tariff expression as:

$$\begin{aligned} t^{i,\text{applied}}_{xjt} &= \min\{t^i_{xjt}, t^{i,MFN}_{xt}\} \\ \text{with} \quad t^i_{xjt} &= \frac{1}{\epsilon^i_{xj}} + \gamma^{IP}_{xij}\left(\frac{FG^i_{xt}}{p^j_{xt}M^i_{xjt}}\right) + \gamma^{FVA}_{xij}\left(\frac{FVA^i_{xt}}{p^j_{xt}M^i_{xjt}}\right) + \gamma^{DVA}_{xij}\left(\frac{DVA^j_{xit}}{p^i_{xt}M^i_{xjt}}\right), \end{aligned} \tag{17}$$

where $FG^i_{xt} \equiv p^i_{xt}q^i_{xt}$, $\gamma^{IP}_{xij} \equiv \frac{\delta^i_x}{\epsilon^i_{xj}|\lambda^i_{xj}|}$, $\gamma^{FVA}_{xij} \equiv -\frac{(1-\delta^i_{x*})\varepsilon^{ri}_{x*}}{\epsilon^i_{xj}|\lambda^i_{xj}|}$, and $\gamma^{DVA}_{xij} \equiv -\frac{(1+\delta^*_{xi})\varepsilon^{rj}_{xi}}{\epsilon^i_{xj}}$.

Equation (17) breaks up the domestic political economy and foreign value added terms and collects imports with other observables to form three ratios. The first is the ratio of domestic final goods production (FG) to bilateral imports, which we refer to as the inverse import penetration ratio (IP-Ratio for short). The second and third are the ratios of foreign value added and domestic value added to bilateral final goods imports, which we refer to as the FVA-Ratio and DVA-Ratio.[35] This ratio specification recognizes that the strength of domestic political economy and foreign value added forces varies bilaterally, due to variation in bilateral imports.

In taking Equation (17) to the data, we confront new econometric concerns. Each of the independent variables has imports in the denominator. Classical measurement error in imports then generates non-classical (multiplicative type) measurement error in the ratios. To deal with this problem, we replace the levels of each ratio with their logs.[36]

Because an important component of the effect of FVA operates at the multilateral level, we also relax the set of fixed effects to use time-series variation, in addition to cross-sectional variation. Specifically, we replace the importer-industry-year fixed effect with importer-industry, importer-year, and industry-year fixed effects. This change re-introduces cross-industry variation within importers over time, with industry trends differenced away, for identification. At the same time, however, a subtle threat to identification emerges. As discussed in Section 2.1.3, importer-industry-year fixed effects absorb all variation in MFN tariffs. To ensure that MFN tariff variation does not drive our results with this new fixed effects specification, the dependent variable is explicitly defined as tariff preferences in each

[35] A subtle point is that import quantities are evaluated at exporter prices in the first two ratios and at importer prices in the third. We suppress this distinction in our empirical work, as we are not able to measure imports at different prices in the same data set that we use to construct the numerators.

[36] Intuitively, classical measurement error in imports is particularly influential over the value of the ratio when imports are small (equivalently, the ratio is large). Taking logs of the ratios down-weights variation among these large, poorly-measured observations.

specification. Thus, we adopt the following specification:

$$t^i_{xjt} - t^{i,MFN}_{xt} = \Phi_{xi} + \Phi_{it} + \Phi_{xt} + \Phi_{xjt} + \gamma^{IP} \ln\left(\frac{FG^i_{xt}}{IM^i_{xjt}}\right) + \gamma^{DVA} \ln\left(\frac{DVA^j_{xit}}{IM^i_{xjt}}\right) + \gamma^{FVA} \ln\left(\frac{FVA^i_{xt}}{IM^i_{xjt}}\right) + e_{xijt}, \quad (18)$$

where the Φ terms again denote fixed effects and IM^i_{xjt} represents bilateral final goods imports. The sign predictions are $\gamma^{IP} \geq 0$, $\gamma^{DVA} < 0$, and $\gamma^{FVA} < 0$ (provided the political strength of foreign value added is not too high). As robustness check, we also estimate a variant of this specification with importer-industry-year fixed effects.

2.2.1 Preferences under vs. outside RTAs

In taking the specification in Equation (18) to data, we again confront concerns about tariffs inside vs. outside RTAs. While we expect that tariffs within bilateral or regional agreements will continue to respond to domestic political economy concerns, since they are independent of cross-border externalities, the effect of FVA is less clear cut. But since there is nothing in the existing literature to suggest directly that RTAs will eliminate *all* price externalities (beyond simply the terms of trade), we initially use all bilateral tariff variation, both within and outside of RTAs, to look for FVA effects. More subtly, the theory also suggests that the coefficients attached to the inverse penetration ratio and foreign value added may differ inside versus outside of RTAs. It also implies that within RTAs, the additive inverse supply elasticity term may disappear, due to neutralization of the term-of-trade externality.

In light of these differences, we analyze FVA effects outside and inside RTAs in several steps. First, we pool all tariffs and estimate a single set of (homogeneous) coefficients on IP-Ratio, DVA-Ratio, and FVA-Ratio. In this regression, we also include an indicator variable for RTAs, which absorbs level differences in tariffs inside versus outside agreements. Second, we break up the coefficients on each of the ratios, as we did in the previous section. Third, we re-estimate Equation (18) in the subsample of non-RTA tariffs only.

2.2.2 Censoring and Endogeneity Concerns

The censoring concerns in this specification mirror those outlined in Section 2.1.2, and so we implement the same Tobit correction. In contrast, new endogeneity concerns arise in this empirical specification. In addition to domestic value added, the levels of domestic production, imports, and foreign value added may be correlated with the residual variation in tariffs. Most importantly, foreign value added may increase with tariffs. In our model, the price of foreign value-added inputs rises mechanically with the tariff. Outside the model, one might (also) be concerned that foreign firms engage in "tariff jumping," shifting to local final production (using imported inputs) in high tariff sectors/countries.[37] If so, the coefficient estimate on the FVA-Ratio will be biased upwards, which could lead us to find a zero/positive coefficient erroneously.[38] We discuss this issue further when we turn to IV below.

3 Data

This section describes how we construct our data on the value-added content of production and bilateral trade policy. It also offers a first peek at the data.

3.1 Value-Added Content of Final Goods Production

To calculate our measures of the value-added content embodied in final goods production (DVA and FVA), we use data from the World Input-Output Database (WIOD).[39] It contains an annual sequence of global input-output tables for the 1995-2009 period covering 35 industries across 27 EU countries and 13 other major countries.

Following Los, Timmer and de Vries (2015), we use these data to compute the national origin of value added contained in the final goods that each country produces. Intuitively, the global input-output table enables one to trace backwards through the production process to assess the value and identify the national origin of the intermediate inputs used (both directly and indirectly) to produce each country's final goods. With this information, one can (for example) compute the amount of Canadian value added embodied in US-produced autos. We describe the exact calculations in Appendix B. We construct value-added contents for 14 "countries" (13 non-EU countries, plus the composite EU region) and 14 industries, which are listed in Table 1.[40]

[37] Alternatively, by protecting domestic producers and raising the level of domestic production, high tariffs could mechanically raise the total amount of foreign value added used by domestic industry. This is not a concern with the log specification we implement, since $\ln\left(FVA^i_{xt}/IM^i_{xjt}\right)$ is purged of $\ln\left(FG^i_{xt}/IM^i_{xjt}\right)$. To be explicit, let us write $FVA^i_{xt} = fva^i_{xt} FG^i_{xt}$, where fva^i_{xt} is the share of foreign value added in domestic production. Then, $\ln(FVA^i_{xt}/IM^i_{xjt}) = \ln(fva^i_{xt}) + \ln(FG^i_{xt}/IM^i_{xjt})$. Since we control for $\ln(FG^i_{xt}/IM^i_{xjt})$ directly, the FVA effect is identified entirely from variation in the share of foreign value added ($\ln(fva^i_{xt})$) over time. Tariff jumping could, however, influence this share.

[38] An alternative story that works in the opposite direction is that RTA tariff liberalization could induce higher FVA if these agreements create "regional factories" [Baldwin and Lopez-Gonzalez (2015)]. Our control for RTAs dampens this potential source of bias and our IV approach (discussed shortly) mitigates it further.

[39] The data is available at http://www.wiod.org and documented in Timmer (2012).

[40] We exclude two industries from the raw WIOD data: (1) Mining and Quarrying, which contains no final end use products, and (2) Coke, Refined Petroleum and Nuclear Fuel, which contains only one final end use

3.2 Bilateral Tariffs

We construct bilateral, industry-level tariffs on final goods for four benchmark years: 1995, 2000, 2005, and 2009. We briefly describe the data sources and procedure here; see Appendix B for details.

We start with national government, product-level tariff schedules collected by UNCTAD (TRAINS) and the WTO, which we obtain via the World Bank's WITS website [http://wits.worldbank.org]. Multilateral MFN applied tariffs are typically available in the WTO data, while bilateral applied tariffs are from TRAINS. Combining these sources and aggregating product lines yields a data set of bilateral tariffs at the Harmonized System (HS) 6-digit level.

To identify final goods tariffs in the data, we use the Broad Economic Categories (BEC) classification. We retain HS 6-digit categories classified as consumption and capital goods, discarding both mixed use and intermediate input categories.[41] We then concord these HS 6-digit final goods categories to WIOD industries using a cross-walk from HS categories to ISIC Revision 3 industries to the WIOD industry codes. We take simple averages across HS categories within each industry to measure industry-level applied bilateral and MFN tariffs.

3.3 Temporary Trade Barriers

We obtain data on temporary trade barriers (TTBs) — antidumping, safeguards, and countervailing duties — from the World Bank's Temporary Trade Barriers Database [Bown (2014)]. These data identify the importing country imposing the TTB, the countries and product lines on which the TTB is imposed, and the timing of when TTBs are imposed and removed.[42] Following Trefler (1993) and Goldberg and Maggi (1999), among others, we construct import coverage ratios to track TTB use over time. These coverage ratios measure the stock of accumulated bilateral TTBs imposed by each importer against individual exporters in each industry and year.[43]

As in the tariff data, we begin with TTB data at the product-level, aggregate to the

HS 6-digit category.

[41]Roughly 40 percent of the HS 6-digit codes in the raw data are classified as final goods, which corresponds to the value share of final goods in world trade.

[42]The data cover all countries in Table 1, except for Russia. In our analysis of TTBs, we exclude China and Taiwan because nearly all of their TTBs are imposed on intermediate inputs.

[43]In constructing these coverage ratios, we follow the approach described in Bown (2011). Coverage ratios are a convenient tool for aggregating TTBs across products and measuring their overall intensity, which avoids needing to convert heterogeneous TTB measures (e.g., ad valorem duties, specific duties, price undertakings, or quantitative restrictions) into ad valorem equivalents. For emphasis, the coverage ratio measures the stock of TTBs in force, not the flow of newly imposed TTBs. Further, the stock measure accounts for removal of TTBs as they expire.

HS 6-digit level, extract HS 6-digit categories that correspond to final goods using the BEC classification, and then aggregate to WIOD industries. The TTB coverage ratio is the (unweighted) share of HS 6-digit final goods products within a WIOD sector for which a given importing country has a TTB in effect against a particular trading partner. We construct TTB coverage ratios for each year separately (1995, 2000, 2005, and 2009), which allows for both the imposition of new TTBs and removal of existing TTBs over time.

3.4 First Peek at the Data

Before moving to formal analysis, we pause to introduce the bilateral tariff data, since their use is relatively new to the literature. We first review a few salient facts about bilateral tariff preferences, and then relate observed tariff variation to value-added content in an illustrative case to fix ideas.

Tariff Preferences Our identification strategy exploits differences between bilateral applied tariffs and applied MFN rates. Bilateral applied tariffs differ from MFN tariffs because countries offer preferential (lower-than-applied MFN) tariffs to selected partners under various preference schemes. We provide a summary description of these schemes and their relative importance here, with details provided in Appendix B.

There are four main sources of tariff preferences in our data. The first is the Generalized System of Preferences (GSP), which accounts for the majority of preferences. It is an explicitly unilateral preference scheme, in which developing countries receive preferential treatment from high-income importers.[44] An important feature of the GSP program is that each GSP-granting country unilaterally chooses the set of GSP-receiving countries to which and sectors in which it extends preferences, and these choices differ across GSP-granting countries and time.

Free trade agreements and customs unions, authorized under WTO Article XXIV, are a second source of preferences. These agreements embody a high degree of cooperation, in that bilateral preferences are both extensive in scope and meaningfully symmetric across partners. As a result, we treat all Article XXIV in our data as *potentially* cooperative bilateral or regional trade agreements. That said, two points about RTAs are worth emphasizing. The first is that carve-outs in Article XXIV agreements are pervasive.[45] Second, there are often

[44] In our data, GSP-granting countries include Australia, Canada, the EU, Japan, Russia, Turkey, and the United States; recipients include Brazil, China, India, Indonesia, South Korea, Mexico, Russia, Turkey, and Taiwan.

[45] As Estevadeordal, Freund and Ornelas (2008) put it: "Article XXIV is ... perhaps the least enforced article of the GATT, and in reality the complete elimination of internal tariffs is the exception, rather than the rule, in most operative RTAs." For analysis of RTA coverage by the WTO Secretariat, see WTO (2011).

asymmetric and prolonged phase-in periods, during which preferences are only partially implemented. As a result, many products/industries continue to face positive tariffs even after Article XXIV comes into force. In our data, about 50 percent of RTA tariffs are greater than zero.

The third source of preferences derives from trade agreements struck between developing countries under the auspices of the WTO's Enabling Clause. These include 'Partial Scope Agreements' (e.g., the Global System of Trade Preferences and the Asia-Pacific Trade Agreement), as well as some bilateral agreements.[46] Lastly, a handful of idiosyncratic programs and one-off preferences constitute the fourth and final source of preferences in our data.

In the data, there is significant variation in tariff preferences across country pairs and sectors and over time. Exporters receive preferential treatment in about one-third of our observations. Conditional on receiving preferences, the median difference between the applied bilateral tariff and the applied MFN tariff is about -2 percentage points, with a 10th-90th percentile range of $[-6.21, -0.13]$. We plot the distribution of preferences in Figure 1. Decomposing the sources of these preferences, GSP programs account for 69 percent of observed preferences, RTAs account for an additional 20 percent of preferences, and other unilateral tariff schemes account for the remaining 11 percent of preferences.

Tariff Preferences and Domestic Value Added Before putting the pieces together formally, we open with a simple scatter plot, which both illustrates the variation in the data and motivates a number of concerns that we address in the subsequent empirical analysis.

Figure 2 plots bilateral tariff preferences ($t^i_{xj} - t^{i,MFN}_x$) against (log) bilateral domestic value added in foreign production for high-income importers against emerging market exporters in 2005. The top panel focuses on the Textiles and Apparel industry, where both the scope for and use of tariff discretion is high. The bottom panel depicts the same correlation for manufacturing as a whole, where the y-axis is the simple mean preference across all manufacturing industries and the x-axis is total domestic value added in foreign manufacturing.

We note two key points about the figure.[47] First, there is a negative correlation between applied tariffs and $\ln(DVA)$, which is consistent with the prediction that importers grant larger preferences to countries that use a lot of domestic (importer) value added in production

[46] The agreements typically cover only a small share of products (roughly 4 to 500 HS 6-digit categories in our data). As such, these preferences appear highly discretionary.

[47] Two additional comments are as follows. A number of observations in the lower right area are cases where the country pair has a trade agreement in place, and this motivates our attention to RTAs below. Furthermore, looking at the upper right portion of the figure, it is evident that China receives relatively few preferences despite the high foreign content of its exports. This suggests that there may be un-modeled political economy forces that lead particular exporters (in particular, China) to receive fewer preferences than others; systematic exporter-level influences will be absorbed in the fixed effects in our estimation.

of their final goods. Roughly speaking, this is the correlation we are estimating below. Second, there is an obvious censoring problem in the figure, as indicated by the mass point at zero preference. The inability to raise tariffs above the MFN rate against countries in which domestic value added is low (the left end of the x-axis) will tend to bias the simple correlation toward zero.

4 Results I: Tariffs

Following the structure outlined in Section 2, we start by estimating how bilateral applied tariffs respond to domestic value added in foreign production. We then turn to an alternative specification to examine how foreign value added in domestic production influences tariffs.

4.1 Domestic Value Added in Foreign Final Goods

Table 2 presents benchmark OLS results based on Equation (15). Panel A of the table contains results with importer-industry-year-decile fixed effects, and Panel B includes importer-industry-year fixed effects. Both panels also include exporter-industry-year fixed effects.

We start in columns (1) and (5) by regressing all bilateral tariffs on the log of domestic value added in foreign final goods production, $\ln(DVA^j_{xit})$. The correlation is negative, indicating that applied bilateral tariffs are lower when bilateral DVA is high (consistent with the theoretical prediction). In columns (2) and (6), we add binary indicators for the existence of bilateral or regional trade agreements (RTAs). This RTA indicator absorbs systematic differences in both bilateral tariffs and bilateral DVA across country pairs with versus without RTAs. (Country pairs with an RTA tend to have both low tariffs and high DVA relative to non-RTA pairs.) Controlling for RTAs attenuates the DVA coefficient, but the estimated influence of domestic value added embodied in foreign production remains highly significant. Finally, comparing results across panels, note that estimates with alternative fixed effects are similar in magnitude, though estimates with importer-industry-year-decile fixed effects appear to be slightly more conservative.

To interpret the magnitudes, it is typical for $\ln(DVA^j_{xit})$ to vary by roughly 5 log points across bilateral partners within a given importer and industry.[48] The point estimate in column (2) is -0.5. Thus, moving from low to high DVA partners yields a reduction of 2.5 percentage points in *observed* applied tariffs. Since the median tariff is around 8 percent in our data, this represents about a 30 percent reduction in the typical tariff level.

[48] This is the median difference between maximum and minimum values across the 13 trading partners in each importer-industry-year cell. The inter-quartile range is roughly 3.6 log points.

Tariffs Within vs. Outside RTAs Recognizing that the theory makes distinct predictions for tariffs set inside versus outside RTAs, we estimate specifications with heterogeneous coefficients on DVA inside versus outside RTAs. In columns (3) and (7) of Table 2, we take an agnostic view, estimating separate coefficients inside versus outside RTAs. In columns (4) and (8), we *impose* the assumption that the inside-RTA coefficient is zero, as implied by theory if indeed RTAs eliminate all terms-of-trade motivations for final goods.

Looking at column (3), DVA is associated with lower applied bilateral tariffs set outside RTAs, while tariffs set inside RTAs are uncorrelated with DVA. Imposing the restriction that the correlation is exactly zero, in columns (4) and (8), has no appreciable impact on the DVA estimate outside RTAs. In Appendix B, we repeat this analysis using an alternative, broader definition of RTAs that includes some non-Article XXIV trade agreements. The results using this broader definition are essentially the same.

Based on these results, we focus exclusively on the non-RTA sample in the remainder of this section. Table 3, Panel A repeats the OLS estimation in the non-RTA sample of tariffs. The coefficients on DVA are again negative and significant.

Censoring and Endogeneity We now turn to estimates that correct for censoring of bilateral tariffs due to application of the MFN rule and that address endogeneity concerns.

The OLS estimates presented above describe how *applied* tariffs respond to DVA. They are likely to underestimate how strongly *optimal* tariffs respond to DVA, since the MFN rule prohibits upward deviations in bilateral tariffs. To examine the impact of this censoring, we estimate a one-sided Tobit model in column (3) of Table 3.[49] As expected, the coefficient on domestic value added rises (in absolute value), roughly tripling to -0.77. Given the 'typical' 5 log point spread in DVA across partners, this revised estimate implies that optimal tariffs are roughly 3.85 percentage points (48 percent of the median tariff) lower for partners with high versus low DVA.

As noted earlier, the possible endogenous response of DVA^i_{xjt} to t^i_{xjt} is a threat to causal identification. To address this endogeneity concern, we instrument for DVA in two different ways.

[49]Two details are worth noting. First, we estimate a Tobit with importer-industry-year fixed effects here, rather than importer-industry-year-decile fixed effects. As we showed previously, OLS estimates with the different sets of fixed effects are quite similar. Further, when we move to Tobit, we must drop observations that are perfectly predicted by the fixed effects, where the perfect prediction arises due to some importer-industry-year or exporter-industry-year cells having no tariff preferences. The Tobit sample is therefore smaller than the baseline (OLS) sample. Using importer-industry-year fixed effects (instead of importer-industry-year-decile fixed effects) minimizes this reduction in sample size. Second, while there is some additional censoring of tariffs at zero, it is not quantitatively important – the mass point of tariffs at the upper MFN rate dwarfs the mass point at zero. Two-sided Tobit estimates are typically slightly larger in absolute value than the one-sided estimates, so the one-sided estimates here are conservative.

We first instrument for $\ln(DVA^i_{xjt})$ using domestic value added from i used in the services sector in country j, which we denote $\ln(DVA^i_{zjt})$ and verbally refer to as DVA-in-Services. This instrument is relevant, since there are likely common supply-side factors that make i an attractive input supplier for j across many sectors. It is also valid, in that t^i_{xjt} has no direct influence over value-added input use by the service sector in country j, and so $\ln(DVA^i_{zjt})$ is plausibly uncorrelated with the tariff equation residual. As a concrete example, the identification assumption is that the amount of US value added used by India in the services sector is not determined by the US import tariff on textiles from India.

Results using this DVA-in-Services instrument are presented in Panel B of Table 3. Not only do the OLS results from Panel A hold up, but they are actually strengthened when when we instrument for domestic value-added content. This suggests that the mechanical endogeneity concerns described above are not inflating our estimates, and if anything that countervailing concerns – such as measurement error – may be biasing the non-IV results toward zero.

To corroborate this analysis, we examine the same set of IV-regressions for a second, alternative instrument: the level of domestic value added in foreign production in 1970, which we denote $\ln(DVA^i_{sj,1970})$ and verbally refer to as DVA-in-1970. This instrument is plausibly valid in that 1970 predates the introduction of all the preference schemes observed in our data; thus, DVA-in-1970 cannot mechanically be a function of contemporary tariff preferences.[50] We present IV results using this second instrument in Panel C of Table 3. Not only does the DVA coefficient remain and significant after instrumenting, the IV estimate is again is larger in absolute value than the OLS estimate.

As a final set of checks, we examine a series of alternative specifications with additional bilateral control variables, including distance, colonial history, common language, and a common border (contiguity).[51] These controls have been shown to predict the adoption of bilateral trade agreements (RTAs) in previous work by Baier and Bergstrand (2004) and

[50] Using the data set developed in Johnson and Noguera (forthcoming), we measure bilateral DVA-in-1970 for two composite sectors: agriculture and manufacturing. Due to missing data for Russia and Taiwan, the sample for which we can construct this instrument is roughly 30 percent smaller than our baseline sample. This is one cost of using this instrument. A second cost is that there is no time-variation in the instrument, in contrast to DVA-in-Services. On the other hand, this cost is counterbalanced by additional cross-industry variation in this instrument. In the end, this instrument isolates different exogenous variation than does the DVA-in-Services instrument.

[51] We obtain these variables from the CEPII GeoDistance Database: `http://www.cepii.org/CEPII/fr/bdd_modele/presentation.asp?id=6`. One complication is that these characteristics pertain to individual bilateral country pairs, but we have a composite non-country entity (the EU) in our data. We therefore define bilateral characteristics vis-a-vis the EU by taking GDP-weighted averages of bilateral characteristics defined for each individual EU country. This implies that colonial linkages, common language, and contiguity are not strict indicator variables, as their weighted averages can lie between zero and one when the EU is a trading partner.

Egger et al. (2011). While the tariff preferences under consideration here differ in important respects from those granted via RTAs (as discussed above), we think it prudent nonetheless to confirm that these bilateral characteristics are not driving our results. Table 4 presents OLS and IV results with these additional controls. While the DVA coefficient remains negative and significant, the coeffiecients on the control variables themselves are typically indistinguishable from zero.[52] Thus, we conclude that value-added content drives tariff preferences in a manner that is distinct from previously studied empirical determinants of RTA-based preferences.

All together, these results point to a causal relationship running from domestic value added in foreign production to preferential tariff treatment. We now turn to a deeper examination of whether the role of DVA differs depending on the nature of the tariff preference program under which tariffs are set.

Unpacking non-RTA Preferences As noted previously, the GSP program is an important source of bilateral tariff preferences in our data. It is also an especially useful source of variation, in that it is explicitly unilateral. According to theory, we should therefore expect to find that GSP-related preferences respond to DVA. On the other hand, it is less clear how other non-GSP preferences (some of which are more plausibly cooperative in nature, others of which are not) will respond to DVA.

To explain how we analyze GSP versus non-GSP preferences, we briefly review how the GSP program operates. By design, GSP operates only among a subset of country pairs – namely, between "advanced" importing countries that grant preferential access to "developing" exporting countries under the Enabling Clause. We define the set of potential *GSP-granting* countries as those that granted GSP access to at least one other country (at any time) in our sample. Likewise, we define the set of potential *GSP-eligible* countries as those that received GSP access from at least one other country (at any time) in our sample. Each GSP-granting country has discretion over the set of countries and sectors included in its GSP program, as well as the level of its tariff preferences.[53]

[52] One point of interpretation is worth emphasizing here. The gravity variables could influence DVA in two ways. First, they could have a direct effect, either because they influence tariffs for various unmodeled reasons, or because they proxy for omitted determinants of tariffs. Second, they could have an indirect effect, via DVA. That is, DVA_{xi}^{j} is high when i supplies inputs to j, and input sourcing is naturally correlated with trade costs.This potential correlation may explain why the DVA coefficient falls slightly when we add these additional bilateral controls. In effect, these controls mechanically remove some of the meaningful variation in DVA that drives tariffs and therefore diminish its observed effect. Given this interpretation concern, as well as the insignificant point estimates on the proxies, we omit them from our main specifications.

[53] In our data, we observe only a uniform tariff preference applied to all countries included in each importer's GSP program. In reality, countries have scope to vary tariff preferences bilaterally, via discretionary application of limits on GSP access (e.g., competitive needs limitations); see Blanchard and Hakobyan (2014). We do not observe these bilaterally targeted preferences, and so our data likely understate the true degree

To examine how the GSP program operates in our data, we define an indicator (in the non-RTA sample) that identifies which country pairs are potentially eligible for GSP preferences: $GSP_{ij} = \mathbf{1}\,(i \in \textit{GSP-granting}, j \in \textit{GSP-eligible})$. For country pairs with $GSP_{ij} = 1$, the GSP program itself accounts for essentially all observed preferences in our data. However, not all pairs with $GSP_{ij} = 1$ actually have lower-than-MFN tariffs, both because some potentially GSP eligible exporters and sectors are excluded by GSP-granting countries, and because program use varies over time.[54] For country pairs with $GSP_{ij} = 0$, non-GSP preference schemes are the source of observed tariff preferences.

In Table 5, we re-estimate our baseline DVA regressions allowing the coefficient on DVA to vary depending on whether the country-pair is potentially eligible for GSP. As it turns out, tariffs respond to domestic value added in both the GSP eligible and GSP ineligible samples. In the pooled sample with heterogeneous coefficients, DVA has a slightly stronger effect on observed tariffs for GSP-eligible pairs. This difference fades in Panels B and C when we split the sample, allowing the fixed effects to vary across groups.

The conclusion is that DVA influences tariffs throughout the non-RTA sample. We are reassured that DVA influences preferences granted under the GSP program, since we are confident that there is significant unilateral discretion over bilateral tariffs in this particular institutional context. At the same time, we also detect DVA effects in non-GSP preferences, which implies that other preference regimes (e.g., Partial Scope Agreements) also appear to enable countries to manipulate bilateral tariffs in response to terms-of-trade concerns.

4.2 Foreign Value Added in Domestic Final Goods

We now move to specifications based on Equation (18) in which ratios of final goods production, domestic value added, and foreign value added to bilateral imports appear separately on the right hand side to identify the influence of foreign value added in domestic production on bilateral tariffs.

In Table 6, we estimate Equation (18) using the sample of both RTA and non-RTA tariffs. This specification allows for the possibility that FVA effects may be found both inside and outside RTAs, even if DVA effects are not. This specification is also useful for comparison to Table 2. The baseline specification in column (1) includes the fixed effects specified in Equation (18), together with a RTA indicator to control for level differences in tariffs and value-added contents inside versus outside RTAs. We also estimate a supplemental

of discretion that countries exercise. As such, one might expect our results to be attenuated.

[54] For example, the US does not grant China preferences in its GSP program, while the EU does. Therefore, while both $GSP_{\text{USA,CHN}} = 1$ and $GSP_{\text{EUN,CHN}} = 1$, we observe tariff preferences in only the EUN-CHN case. Additional variation comes from changed in the application of GSP preferences over time.

specification in column (2) with importer-industry-year fixed effects, which replaces $\Phi_{xi} + \Phi_{it} + \Phi_{xt}$ with Φ_{xit} in (18). With the importer-industry-year fixed effects, we can identify only γ^{DVA} and $(\gamma^{IP} + \gamma^{FVA})$, where $(\gamma^{IP} + \gamma^{FVA})$ is identified by variation in bilateral imports across partners. Columns (3) and (4) repeat the exercises in columns (1) and (2), correcting for MFN censoring via a Tobit regression.

Starting with DVA, we find a strong negative relationship between the log DVA-Ratio and applied tariffs, consistent across specifications, and similar in magnitude to those estimated previously in Table 2. The coefficient on the FVA-Ratio is negative in both the OLS and Tobit specifications. It is significant at the 5 percent level in the OLS specification and modestly insignificant at conventional levels in the Tobit specification. The coefficients on the inverse import penetration ratio are positive throughout, consistent with the existing literature on the political economy of trade policy [Goldberg and Maggi (1999) and Gawande and Bandyopadhyay (2000)].

Before proceeding, we pause to comment on endogeneity concerns in this specification. As noted in Section 2.2.2, the primary new concern is that foreign value added may depend positively tariffs, which would bias the FVA coefficient upward (toward zero/positive values). We generally find negative OLS coefficients on FVA. Therefore, the sign result we emphasize here is not plausibly explained by endogeneity; if anything, the magnitude of the OLS coefficient may be understated due to endogeneity. To examine endogeneity concerns more formally, we provide instrumental variables estimates of Equation (18) in Appendix B. We find that the IV estimate of the FVA coefficient is also negative and typically larger (in absolute value) than the OLS coefficient, consistent with this argument.

Recalling again the distinction between tariffs within versus outside RTAs, we re-estimate these two specifications allowing for coefficient heterogeneity across these groups and present the results in Table 7. Consistent with our previous results, we find that tariffs fall with DVA outside RTAs, but we cannot reject that the coefficient is zero inside these agreements. In contrast, the opposite pattern holds for the foreign value added results. FVA effects are strongest inside RTAs, and they are statistically indistinguishable from zero for tariffs set outside RTAs, both in the pooled sample and in Panel C where re-estimate Equation (18) in the non-RTA sample only. In Appendix B, we show that the FVA effect outside RTAs is estimated to be negative when we instrument for FVA, consistent with the potential attenuating effect of endogenous FVA.

We find it striking that FVA effects are so strong inside RTAs, despite our null results concerning DVA effects inside the same set of RTAs. Value-added content matters both inside and outside these agreements, although how it matters seems to differ in a manner that is roughly consistent with the neutralization of terms-of-trade motives for final goods.

Regarding magnitudes, it is worth pointing out that the FVA point estimates here are economically sensible. For example, the Tobit estimate is that a one log point change in FVA lowers tariffs inside RTAs by 5.38 percentage points. Historically, FVA grew by roughly 0.5 log points over the 1995-2009 period, therefore this implies a fall in optimal tariffs of about 2.7 percentage points (about one-third the size of the median bilateral tariff).

5 Empirical Results II: Temporary Trade Barriers

In addition to bilateral tariffs, governments use non-tariff barriers to restrict imports. In this section, we examine whether value-added content influences use of these policies as well. We focus on a specific class of non-tariff barriers, referred to collectively as temporary trade barriers (TTBs), which include antidumping, safeguards, and countervailing duties.

Temporary trade barriers are a natural testing ground for the value-added mechanisms indicated by theory. Countries have wide latitude under WTO rules to use TTBs, and they can be targeted at particular trading partners and products.[55] Moreover, for countries with low MFN tariffs, TTBs are one of the few WTO-consistent means by which to implement discriminatory trade policy, and accordingly their use has been rising over time [Bown (2011)]. Prior research has found that non-tariff barriers generally, and temporary trade barriers in particular, appear to respond to optimal tariff considerations, which suggests TTBs may offer fertile territory for exploring the effects of DVA in particular.[56]

In examining TTB use, our empirical specifications follow our earlier approach for bilateral tariffs. The principal modification is that we use lagged measures of value-added content in our regressions, since the TTB import coverage ratio (the dependent variable) measures the stock of TTBs in force, rather than the flow of new TTBs imposed/removed (Section 3.3). Because TTBs typically remain in effect for a number of years, many TTBs in effect at date t were actually imposed in previous periods. Therefore, lagged value-added content better captures the information that was relevant to policymakers at the time when barriers

[55] Antidumping and countervailing duties (CVDs) are explicitly partner- and product-specific. While safeguards are applied at the product level, they take on an exporter-specific dimension via country-level exclusions. As described in Bown (2011), antidumping and safeguards were the most heavily used of the policies for our countries during this sample period. Furthermore, in the handful of cases in which CVDs were utilized, they were typically applied concurrently (for the same products and exporters) with antidumping duties Bown (2011, pp. 1989-1990), so that our measures of TTBs would not be substantially affected by dropping CVDs.

[56] Broda, Limão and Weinstein (2008) find that US NTBs are higher in sectors with high inverse export supply elasticities. Bown and Crowley (2013) find that United States' use of antidumping and safeguards is consistent with the Bagwell and Staiger (1990) model of self-enforcing trade agreements and cooperative tariffs. Trefler (1993) also used US NTB data in studying endogenous trade policy, and Goldberg and Maggi (1999) and Gawande and Bandyopadhyay (2000) used US NTB data in their empirical examination of the protection-for-sale model [Grossman and Helpman (1994)].

currently in effect were actually adopted.

Table 8 presents ordinary least squares estimates for TTB coverage ratios.[57] Similar to previous tables, columns (1) and (3) include results with importer-year, industry-year, importer-industry, and exporter-industry-year fixed effects, while columns (2) and (4) include importer-industry-year and exporter-industry-year fixed effects. We find that both higher levels of domestic value added in foreign production and foreign value added in domestic production are associated with lower TTB coverage ratios. Governments appear to curb their protectionist TTB actions where value chain linkages are strongest. Further, the coefficient on the inverse import penetration ratio is positive. These results are broadly consistent with our results for tariffs.[58]

Finally, it would be remiss in any analysis of TTBs to overlook the outsize role played by China. In our data, China is the exporter in approximately 30 percent of the importer-exporter-industry-year cells in which TTBs are observed as being used (i.e., with nonzero coverage ratios), roughly three times as many as the next highest exporter. Further, it is very rare during this particular time period for countries to impose TTBs in a given sector without also including China among the set of exporters on which barriers are imposed [Bown (2010), Prusa (2010)]. At face value, these observations suggest that most of the TTB use during this period is aimed at China. Recognizing this possibility, we separately examine how value-added content influences TTB use depending on whether China is the exporting country. To this end, we interact the value-added content measures with indicators for whether China is the exporter, and then re-estimate the specifications from Panel A.[59]

The results are reported in Panel B of Table 8. The main finding is that TTB coverage ratios are roughly four times as sensitive to domestic value-added content when China is the exporter: while DVA discourages the use of protectionist TTBs against all exporters, it

[57] TTB coverage ratios have a mass point at zero. While we could use limited dependent variable methods to take this into account, we focus on OLS results for several reasons. First, TTBs are a rare event in the data, occurring in only 6 percent of our importer-exporter-industry-year observations. Standard binary outcome models (e.g., Probit and Logit) are biased in this context [King and Zeng (2001)]. Further, for Tobit models, the distribution of the rare positive outcomes is constrained to follow the extreme upper tail of the normal distribution, which is an untenable assumption in our context. Second, as a practical matter, presuming that zero TTB coverage ratios conform to our basic theoretical predictions, OLS would then understate the true role of value-added content in shaping TTBs (coefficients of interest would be biased toward zero). Thus, OLS is a robust and likely conservative approach to characterizing our data.

[58] One minor point is that we cluster in this table on importer-exporter-industry, in contrast to previous tables. The reason is that TTB policy decisions are independent across industries. This contrasts with tariff policy, where tariffs may be correlated across sectors for institutional reasons – e.g., due to signing bilateral trade agreements that cover multiple sectors, or due to the application of exporter-specific exemptions in the GSP program. The significance levels of our main results in columns (1) and (3) are robust to clustering by importer-exporter pair, as we did in previous tables.

[59] Note that we do not explicitly include an indicator variable for whether China is an exporter in the regression, since it is redundant given the exporter-industry-year fixed effects included in these regressions.

is particularly influential in shaping trade policy actions against China. At the same time, this effect is not limited to China: TTB use is also significantly negatively correlated with domestic value added for other exporters as well. In contrast to DVA, foreign value appears to be equally influential over TTB against China versus all other exporters. This is sensible: FVA effects operate at the multilateral level in theory, so it makes sense that their empirical influence manifests itself at the multilateral level.

6 Conclusion

This paper takes a first look at the role of global value chains in shaping trade policy. Fundamentally, GVCs erode the link between the location in which final goods are produced and the nationality of the value-added content embodied in those goods. Because import tariffs are by definition applied based on the location from which goods are imported, GVCs modify optimal tariff policy.

When domestic content in foreign final goods is high, governments have less incentive to manipulate the (final goods) terms-of-trade, leading to lower import tariffs. When foreign content in domestic final goods is high, some of the benefits of protection are passed back up the value chain to foreign suppliers. This mechanism further lowers optimal tariffs. We find evidence in support of both of these predictions in two distinct empirical settings: when countries discriminate across trading partners by lowering protection through bilateral tariff preferences, and when countries discriminate by raising protection through the adoption of temporary trade barriers, particularly against China. These results demonstrate the empirical importance of specific channels through which global value chains shape governments' trade policy choices in practice.

We conclude with a few thoughts about future work in this area. First, we have focused on how governments set protection on final goods, setting aside the issue of optimal input tariffs. In future work, we plan to address how governments could jointly set tariffs on final goods and intermediate inputs to protect and promote domestic value added.

Second, in our empirical analysis, we have focused on *bilateral* tariff preferences and TTB coverage ratios. This empirical setting distinguishes our work from the bulk of the empirical trade policy literature, which focuses primarily on *multilateral* tariffs and non-tariff barriers. We have demonstrated that bilateral protection is a fertile testing ground for the theory of trade protection; future work is also likely to benefit from this empirically rich bilateral context to test alternative theories of trade policy formation.

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Table 1: Industry and Country Coverage

Industries		Countries	
Name	No.	Name	Abbrev.
Agriculture, Hunting, Forestry and Fishing	1	Australia	AUS
Food, Beverages and Tobacco	3	Brazil	BRA
Textiles and Textile Products	4	Canada	CAN
Leather and Footwear	5	China	CHN
Wood and Products of Wood and Cork	6	European Union	EUN
Pulp, Paper, Paper, Printing and Publishing	7	India	IND
Chemicals and Chemical Products	9	Indonesia	IDN
Rubber and Plastics	10	Japan	JPN
Other Non-Metallic Mineral	11	Mexico	MEX
Basic Metals and Fabricated Metal	12	Russia	RUS
Machinery, NEC	13	South Korea	KOR
Electrical and Optical Equipment	14	Taiwan	TWN
Transport Equipment	15	Turkey	TUR
Manufacturing, NEC	16	United States	USA

Note: Industry numbers denote WIOD industries. We exclude Mining and Quarrying (WIOD industry 2) and Coke, Refined Petroleum and Nuclear Fuel (WIOD industry 8) in all our analysis.

Table 2: Bilateral Tariffs and Domestic Value Added in Foreign Production

Panel A: Importer-Industry-Year-Decile & Exporter-Industry-Year Fixed Effects				
	(1)	(2)	(3)	(4)
Log DVA: $\ln(DVA^j_{xit})$	-0.92***	-0.46***		
	(0.27)	(0.16)		
Log DVA Outside RTAs: $[1-RTA_{ijt}]\times\ln(DVA^j_{xit})$			-0.55***	-0.66**
			(0.19)	(0.32)
Log DVA Inside RTAs: $RTA_{ijt}\times\ln(DVA^j_{xit})$			0.26	
			(0.42)	
Reciprocal Trade Agreement: RTA_{ijt}		-3.68***	-7.86**	-7.00***
		(0.82)	(3.28)	(2.07)
Observations	8,853	8,853	8,853	8,853
R-Squared	0.988	0.990	0.991	0.991

Panel B: Importer-Industry-Year & Exporter-Industry-Year Fixed Effects				
	(5)	(6)	(7)	(8)
Log DVA: $\ln(DVA^j_{xit})$	-1.32***	-0.61***		
	(0.35)	(0.21)		
Log DVA Outside RTAs: $[1-RTA_{ijt}]\times\ln(DVA^j_{xit})$			-0.69***	-0.64***
			(0.22)	(0.24)
Log DVA Inside RTAs: $RTA_{ijt}\times\ln(DVA^j_{xit})$			-0.12	
			(0.46)	
Reciprocal Trade Agreement: RTA_{ijt}		-4.53***	-7.39***	-7.84***
		(0.91)	(2.80)	(1.71)
Observations	8,853	8,853	8,853	8,853
R-Squared	0.967	0.974	0.974	0.974

Note: The regression specification is based on Equation (15). The dependent variable in all columns is the applied bilateral tariff of country i in industry x against exporter j at time t: t^i_{xjt}. Log DVA ($\ln(DVA^j_{ijt})$) is domestic value added from the importing country(i) embodied in final production in industry x in the exporting country (j). Reciprocal Trade Agreement (RTA_{ijt}) is an indicator that takes the value one if i and j have a RTA in force in year t. Standard errors (in parentheses) are clustered by importer-exporter pair. Significance levels: * $p < .1$, ** $p < .05$, *** $p < .01$.

Table 3: Bilateral Tariffs and Domestic Value Added in Foreign Production: Censoring and Instrumental Variables Estimation in Non-RTA Sample

Panel A: OLS vs. Tobit			
	OLS		Tobit
	(1)	(2)	(3)
Log DVA: $\ln(DVA^j_{xit})$	-0.17**	-0.24***	-0.77***
	(0.068)	(0.079)	(0.23)
Observations	8,187	8,187	4,431
R-Squared	0.997	0.994	

Panel B: Instrumental Variables (DVA-in-Services)			
	Linear-IV		Tobit-IV
	(4)	(5)	(6)
Log DVA: $\ln(DVA^j_{xit})$	-0.21***	-0.28***	-0.80***
	(0.053)	(0.082)	(0.26)
Observations	8,187	8,187	4,431
R-Squared	0.997	0.994	

Panel C: Instrumental Variables (DVA-in-1970)			
	Linear-IV		Tobit-IV
	(7)	(8)	(9)
Log DVA: $\ln(DVA^j_{xit})$	-0.87***	-1.22***	-2.74***
	(0.16)	(0.26)	(0.93)
Observations	6,055	6,055	3,280
R-Squared	0.997	0.992	

Column Fixed Effects (all panels)			
Importer-Industry-Year-Decile	Y	N	N
Importer-Industry-Year	N	Y	Y
Exporter-Industry-Year	Y	Y	Y

Note: The regression specification is based on Equation (15). The dependent variable in all columns is the applied bilateral tariff of country i in industry x against exporter j at time t: t^i_{xjt}. Log DVA ($\ln(DVA^j_{ijt})$) is domestic value added from the importing country(i) embodied in final production in industry x in the exporting country (j). Sample includes only countries pairs and years with no reciprocal trade agreement in force. Standard errors (in parentheses) are clustered by importer-exporter pair. Significance levels: * $p < .1$, ** $p < .05$, *** $p < .01$.

Table 4: Bilateral Tariffs and Domestic Value Added in Foreign Production with Gravity Controls

	OLS				Linear IV			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log DVA: $\ln(DVA^{j}_{xit})$	-0.12*	-0.17**	-0.11*	-0.099	-0.16***	-0.21***	-0.16***	-0.13**
	(0.063)	(0.068)	(0.064)	(0.065)	(0.058)	(0.053)	(0.059)	(0.060)
Log Bilateral Distance	0.12		0.15	0.16	0.090		0.12	0.13
	(0.12)		(0.14)	(0.14)	(0.082)		(0.094)	(0.097)
Colony		0.021	0.18	0.19		0.045	0.17	0.18
		(0.25)	(0.30)	(0.31)		(0.16)	(0.19)	(0.19)
Common Language				-0.24				-0.24*
				(0.23)				(0.14)
Contiguity				0.33				0.32
				(0.38)				(0.24)
Observations	8,187	8,187	8,187	8,187	8,187	8,187	8,187	8,187
R-Squared	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997

Note: Dependent variable in all columns is the applied bilateral tariff of country i in industry x against exporter j at time t: t^{i}_{xjt}. Log DVA ($\ln(DVA^{j}_{ijt})$) is domestic value added from the importing country(i) embodied in final production in industry x in the exporting country (j). The Linear-IV specification uses the DVA-in-Services instrument. Sample includes only countries pairs and years with no reciprocal trade agreement in force. Bilateral distance, colony, language, and contiguity data from CEPII and aggregated using country-GDP weights for trade with the EU. Standard errors (in parentheses) are clustered by importer-exporter pair. Significance levels: * $p < .1$, ** $p < .05$, *** $p < .01$.

Table 5: Bilateral Tariffs and Domestic Value Added in Foreign Production: GSP Eligible vs. GSP Ineligible Country Pairs

Panel A: No RTA Sample				
	OLS		Linear-IV	
	(1)	(2)	(3)	(4)
Log DVA (GSP ineligible): $GSP_{ij} \times \ln(DVA^j_{xit})$	-0.13*	-0.19**	-0.14***	-0.18**
	(0.07)	(0.077)	(0.06)	(0.08)
Log DVA (GSP eligible): $[1-GSP_{ij}] \times \ln(DVA^j_{xit})$	-0.18**	-0.26***	-0.25***	-0.32***
	(0.07)	(0.09)	(0.06)	(0.09)
GSP eligible: GSP_{ijt}	-0.64***	-0.58**	-0.42**	-0.40
	(0.24)	(0.23)	(0.17)	(0.26)
R-Squared	8,187	8,187	8,187	8,187
Observations	0.998	0.994	0.998	0.994

Panel B: No RTA & GSP Eligible Sample				
	OLS		Linear-IV	
	(5)	(6)	(7)	(8)
Log DVA: $\ln(DVA^j_{xit})$	-0.15	-0.22*	-0.16***	-0.23**
	(0.11)	(0.11)	(0.06)	(0.10)
R-Squared	3,039	3,039	3,039	3,039
Observations	0.999	0.995	0.998	0.994

Panel C: No RTA & GSP Ineligible Sample				
	OLS		Linear-IV	
	(9)	(10)	(11)	(12)
Log DVA: $\ln(DVA^j_{xit})$	-0.18	-0.21*	-0.22***	-0.23**
	(0.11)	(0.12)	(0.07)	(0.11)
R-Squared	5,148	5,148	5,148	5,148
Observations	0.998	0.996	0.998	0.996

Column Fixed Effects (all panels)				
Importer-Industry-Year-Decile	Y	N	Y	N
Importer-Industry-Year	N	Y	N	Y
Exporter-Industry-Year	Y	Y	Y	Y

Note: The regression specification is based on Equation (15). The dependent variable in all columns is the applied bilateral tariff of country i in industry x against exporter j at time t: t^i_{xjt}. Log DVA ($\ln(DVA^j_{ijt})$) is domestic value added from the importing country(i) embodied in final production in industry x in the exporting country (j). See Section 4.1 for the definition of GSP Eligibility. No RTA Sample includes only countries pairs and years with no reciprocal trade agreement in force. Standard errors (in parentheses) are clustered by importer-exporter pair. Significance levels: * $p < .1$, ** $p < .05$, *** $p < .01$.

Table 6: Bilateral Tariffs and Value-Added Content

	OLS		Tobit	
	(1)	(2)	(3)	(4)
Log DVA-Ratio: $\ln(DVA^j_{xit}/IM^i_{xjt})$	-0.48***	-0.55***	-1.32***	-1.40***
	(0.18)	(0.21)	(0.43)	(0.46)
Log FVA-Ratio: $\ln(FVA^i_{xt}/IM^i_{xjt})$	-0.31**		-0.51	
	(0.15)		(0.36)	
Log Inv. IP-Ratio: $\ln(FG^i_{xt}/IM^i_{xjt})$	0.88***		1.95***	
	(0.30)		(0.70)	
Log IP-Ratio + Log FVA Ratio $(\gamma^{IP} + \gamma^{FVA})$		0.63***		1.53***
		(0.22)		(0.50)
Reciprocal Trade Agreement: RTA_{ijt}	-4.59***	-4.50***	-7.19***	-7.13***
	(0.89)	(0.90)	(1.34)	(1.33)
Observations	8,707	8,707	7,643	6,229
R-Squared	0.520	0.536		

Column Fixed Effects				
Importer-Year	Y	N	Y	N
Industry-Year	Y	N	Y	N
Importer-Industry	Y	N	Y	N
Importer-Industry-Year	N	Y	N	Y
Exporter-Industry-Year	Y	Y	Y	Y

Note: The regression specification is based on Equation (18). The dependent variable in all columns is the applied bilateral tariff of country i in industry x against exporter j at time t: t^i_{xjt}. Log DVA-Ratio ($\ln(DVA^j_{ijt}/IM^i_{xjt})$) is the ratio of domestic value added from the importing country (i) embodied in final production in industry x in the exporting country (j) to bilateral final goods imports for i from j in industry x. Log FVA-Ratio ($\ln(FVA^j_{xit}/IM^i_{xjt})$) is the ratio of foreign value added in final production in country i and industry x to bilateral final goods imports. Log IP-Ratio ($\ln(p^i_{xt}q^i_{xt}/IM^i_{xjt})$) is final production in country i and industry x to bilateral final goods imports. With importer-industry-year fixed effects, only the sum of the coefficients on the log FVA-Ratio and log IP-Ratio is identified. Reciprocal Trade Agreement (RTA_{ijt}) is an indicator that takes the value one if i and j have a RTA in force in year t. Standard errors (in parentheses) are clustered by importer-exporter pair. Significance levels: * $p < .1$, ** $p < .05$, *** $p < .01$.

Table 7: Bilateral Tariffs and Value Added Content Inside versus Outside RTAs

Panel A: Full Sample & Heteogeneous RTA Coefficients				
	OLS		Tobit	
	(1)	(2)	(3)	(4)
Log DVA-Ratio Outside RTA: $[1 - RTA_{ijt}] \times \ln(DVA^j_{xit}/IM^i_{xjt})$	-0.48***	-0.54***	-1.34***	-1.43***
	(0.18)	(0.20)	(0.42)	(0.45)
Log DVA-Ratio Inside RTA: $RTA_{ijt} \times \ln(DVA^j_{xit}/IM^i_{xjt})$	0.16	0.10	-0.23	-0.29
	(0.53)	(0.55)	(0.68)	(0.70)
Log FVA-Ratio Outside RTA: $[1 - RTA_{ijt}] \times \ln(FVA^i_{xt}/IM^i_{xjt})$	-0.17		0.025	
	(0.16)		(0.44)	
Log FVA-Ratio Inside RTA: $RTA_{ijt} \times \ln(FVA^i_{xt}/IM^i_{xjt})$	-2.87*		-5.38**	
	(1.49)		(2.38)	
Log Inv. IP-Ratio Outside RTA: $[1 - RTA_{ijt}] \times \ln(FG^i_{xt}/IM^i_{xjt})$	0.73***		1.39**	
	(0.28)		(0.67)	
Log Inv. IP-Ratio within RTA: $RTA_{ijt} \times \ln(FG^i_{xt}/IM^i_{xjt})$	3.16***		6.18***	
	(1.12)		(2.06)	
Log IP-Ratio + Log FVA-Ratio $(\gamma^{IP} + \gamma^{FVA})$		0.62***		1.51***
		(0.22)		(0.48)
Log FVA-Ratio Inside RTA − Outside RTA		-2.74*		-5.24**
		(1.56)		(2.55)
Log IP-Ratio Inside RTA − Outside RTA		2.48**		4.58**
		(1.09)		(2.15)
Reciprocal Trade Agreement: RTA_{ijt}	-8.33***	-8.32***	-14.3***	-13.7***
	(1.95)	(2.03)	(4.15)	(4.13)
Observations	8,707	8,707	7,643	6,229
R-Squared	0.536	0.552		

Panel B: No RTA Sample				
	OLS		Tobit	
	(5)	(6)	(7)	(8)
Log DVA-Ratio: $\ln(DVA^j_{xit}/IM^i_{xjt})$	-0.12*	-0.15**	-0.49***	-0.52***
	(0.063)	(0.073)	(0.18)	(0.20)
Log FVA-Ratio: $\ln(FVA^i_{xt}/IM^i_{xjt})$	-0.054		0.11	
	(0.074)		(0.21)	
Log Inv. IP-Ratio: $\ln(FG^i_{xt}/IM^i_{xjt})$	0.28***		0.62**	
	(0.10)		(0.27)	
Log IP-Ratio + Log FVA-Ratio $(\gamma^{IP} + \gamma^{FVA})$		0.26***		0.79***
		(0.078)		(0.23)
Observations	8,045	8,045	5,910	4,358
R-Squared	0.476	0.507		

Column Fixed Effects (both panels)				
Importer-Year	Y	N	Y	N
Industry-Year	Y	N	Y	N
Importer-Industry	Y	N	Y	N
Importer-Industry-Year	N	Y	N	Y
Exporter-Industry-Year	Y	Y	Y	Y

Note: See Table 6 notes. Standard errors (in parentheses) are clustered by importer-exporter pair. Significance levels: * $p < .1$, ** $p < .05$, *** $p < .01$.

Table 8: Temporary Trade Barriers and Value Added Content

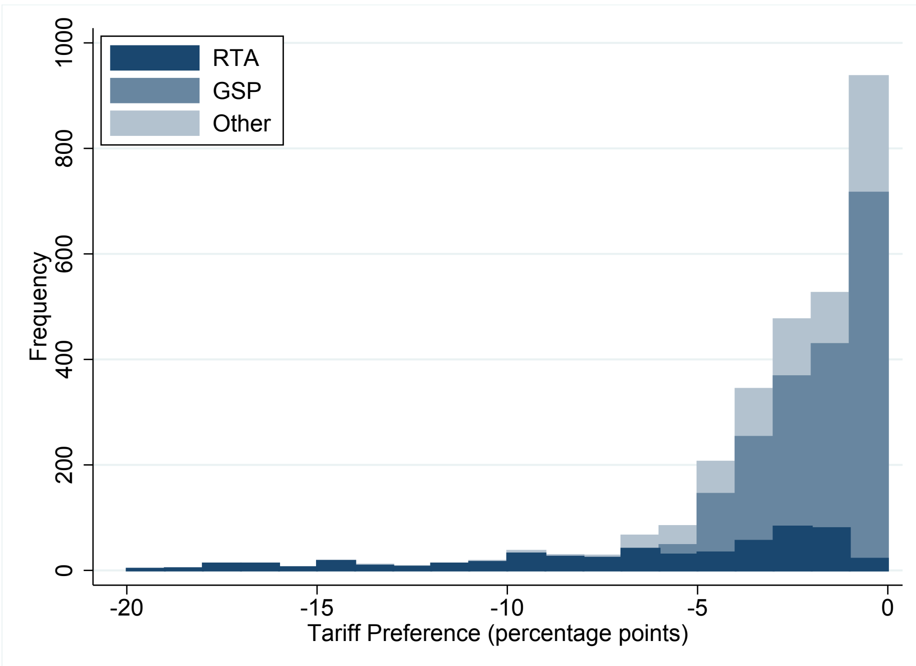
Panel A: Homogeneous Coefficients		
	(1)	(2)
Log DVA-Ratio: $\ln(DVA^{j}_{xi,t-5}/IM^{i}_{xj,t-5})$	-0.40***	-0.19***
	(0.079)	(0.065)
Log FVA-Ratio: $\ln(FVA^{i}_{x,t-5}/IM^{i}_{xj,t-5})$	-5.96***	
	(1.29)	
Log Inv. IP-Ratio: $\ln(FG^{i}_{x,t-5}/IM^{i}_{xj,t-5})$	6.29***	
	(1.31)	
Log IP-Ratio + Log FVA-Ratio $(\gamma^{IP} + \gamma^{FVA})$		0.17***
		(0.063)
Reciprocal Trade Agreement: RTA_{ijt}	0.12	-0.056
	(0.13)	(0.080)
Observations	5,912	5,912
R-Squared	0.371	0.761

Panel B: Heterogeneous Coefficients for China as an Exporter		
	(3)	(4)
$\ln(DVA^{j}_{xi,t-5}/IM^{i}_{xj,t-5}) \times$ exporter = China	-1.27***	-0.62*
	(0.41)	(0.33)
$\ln(DVA^{j}_{xi,t-5}/IM^{i}_{xj,t-5}) \times$ exporter $\neq$ China	-0.27***	-0.16**
	(0.073)	(0.062)
$\ln(FVA^{i}_{x,t-5}/IM^{i}_{xj,t-5}) \times$ exporter = China	-5.16***	
	(1.37)	
$\ln(FVA^{i}_{x,t-5}/IM^{i}_{xj,t-5}) \times$ exporter $\neq$ China	-6.03***	
	(1.30)	
Log Inv. IP-Ratio: $\ln(FG^{i}_{x,t-5}/IM^{i}_{xj,t-5})$	6.24***	
	(1.31)	
Log IP-Ratio + Log FVA-Ratio $(\gamma^{IP} + \gamma^{FVA})$		0.14**
		(0.057)
Reciprocal Trade Agreement: RTA_{ijt}	0.070	-0.053
	(0.14)	(0.079)
Observations	5,912	5,912
R-Squared	0.376	0.762

Column Fixed Effects (both panels)		
Importer-Year	Y	N
Industry-Year	Y	N
Importer-Industry	Y	N
Importer-Industry-Year	N	Y
Exporter-Industry-Year	Y	Y

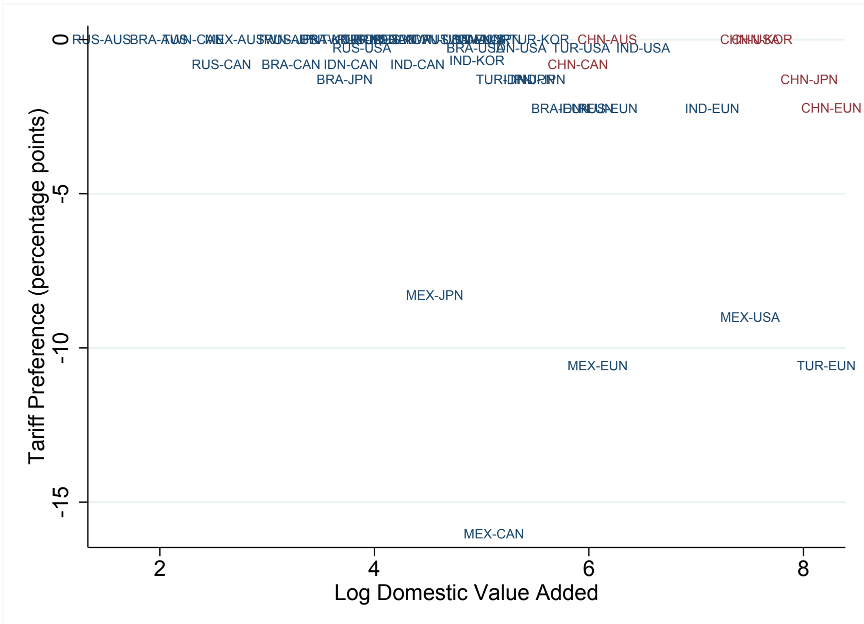
Note: Dependent variable in all columns is the temporary trade barrier coverage ratio for importer i against partner j for final goods imports in industry x: TTB^{i}_{xjt}. Log DVA-Ratio, FVA-Ratio, and Inv. IP-Ratios are lagged, one period back (five years), to reflect information available when TTBs were adopted. In Panel B, DVA and FVA are interacted with indicators for whether China is the exporting country. Standard errors (in parentheses) are clustered by importer-exporter-industry. Significance levels: * $p < .1$, ** $p < .05$, *** $p < .01$.

Figure 1: The Distribution of Tariff Preferences



Note: Tariff preference equals the applied bilateral tariff for importer i against exporter j in industry x minus the MFN applied tariff for importer i in industry x. The histogram includes only observations for which applied bilateral tariffs are lower than MFN, and excludes 36 observations with preferences < -20 for legibility. The legend indicates the institutional source of preferences. RTA stands for bilateral or "Regional Trade Agreement" and GSP stands for "Generalized System of Preferences." Other includes partial scope agreements and miscellaneous preference schemes. Bin width is set to 1 percentage point.

Figure 2: Tariff Preferences and Domestic Value Added in Foreign Final Goods



(a) Textiles and Apparel

(b) All Manufacturing Industries

Note: Figure includes high-income importers and emerging economies exports in 2005. High-income countries include Australia, Canada, the European Union, South Korea, and the United States. Emerging economies include the other 9 countries listed in Table 1. Textiles and Apparel is WIOD sector 4, and All Manufacturing is WIOD sectors 4-16. Labels indicate exporter-importer pair.

A Theory Appendix

This appendix provides details about extensions of the model discussed in Section 1.2.

A.1 Regional Trade Agreements

Suppose that two countries, i and j, engage in cooperative bilateral tariff negotiations, and that these negotiations mitigate the influence of bilateral terms-of-trade motives in the resulting RTA [Bagwell and Staiger (1999)]. In the limit as the terms of trade motive goes to zero, the government will behave as if $\frac{dp_x^j}{d\tau_{xj}^i} \to 0$. The first order condition of the government's government's optimal tariff problem becomes:[60]

$$\lim_{\frac{dp_x^j}{d\tau_{xj}^i} \to 0} G_{\tau_{xj}^i} = \frac{\partial M_{xj}^i}{\partial p_x^i} \frac{dp_x^i}{d\tau_{xj}^i} t_{xj}^i p_x^j + \delta_x^i q_x^i \frac{dp_x^i}{d\tau_{xj}^i} - (1 - \delta_{x*}^i) \frac{dFVA_x^i}{d\tau_{xj}^i} = 0. \tag{A1}$$

Thus, as cooperation reduces the terms of trade motive completely, the politically optimal tariff depends only on domestic political economy and FVA effects:

$$t_{xj}^i \to \frac{1}{\tilde{\epsilon}_{xj}^i} \left(\frac{\delta_x^i q_x^i}{\tilde{\lambda}_{xj}^i M_{xj}^i} - \frac{(1 - \delta_{x*}^i)}{\tilde{\lambda}_{xj}} \varepsilon_{x*}^{ri} \frac{FVA_x^i}{p_x^i M_{xj}^i} \right), \tag{A2}$$

where we define $\tilde{\lambda}_{xj} \equiv \frac{p_x^j}{p_x^i} > 0$, and $\tilde{\epsilon}_{xj}^i$ is the elasticity of import demand.[61] Thus, since the influence of domestic value-added on optimal tariffs operates through *foreign* final goods prices, eliminating terms-of-trade manipulation will also eliminate the role for DVA in shaping tariff policy.

In contrast, foreign value embodied in domestic production (FVA) will still shape the structure of tariff preferences even within reciprocal agreements unless behind the border externalities (via local price changes) are also eliminated under cooperative agreements. To the best of our knowledge, there is no empirical evidence addressing the question of whether cooperative trade agreements rule out non-terms of trade price externalities between signatories.

A.2 General Equilibrium with Endogenous Value Chains

This appendix derives the optimal bilateral tariff when the quantities of value added used in each sector and destination are endogenous.

There are two key differences relative to the baseline version of the model. First, there is a second mechanism by which a tariff change affects the return to value added: in addition to altering the *prices* of value added, $\vec{r}$, changes in final goods prices can shift the equilibrium pattern of value added *quantities* used in production, $\vec{\nu}$. Second, with endogenous value

[60] Note that $\frac{dM_{xj}^i}{d\tau_{xj}} = \frac{\partial M_{xj}^i}{\partial p_x^i} \frac{dp_x^i}{d\tau_{xj}^i} + \frac{\partial M_{xj}^i}{\partial p_x^j} \frac{dp_x^j}{d\tau_{xj}^i}$ and $\frac{dDVA_{xi}}{d\tau_{xj}^i} = \varepsilon_{xi}^{rj} \frac{DVA_{xi}^j}{p_x^j} \frac{dp_x^j}{d\tau_{xj}^i}$; absent TOT effects, $\Omega_{xj}^{Ri} \to 0$.

[61] $\tilde{\epsilon}_{xj}^i \equiv \left| \frac{\partial M_{xj}^i}{\partial p_x^i} \frac{p_x^i}{M_{xj}^i} \right| \geq 0$. (As $\frac{dp_x^j}{d\tau_{xj}^i} \to 0$, $\frac{dM_{xj}^i}{d\tau_{xj}} \to \frac{\partial M_{xj}^i}{\partial p_x^i} \frac{dp_x^i}{d\tau_{xj}^i}$).

added quantities, all elements of domestic local production, FVA, and DVA now depend on the *complete* vector of world prices via $\vec{\nu}(\vec{p})$. Commensurately, a change in any given bilateral tariff (on a particular good from a particular country) may (potentially) disrupt the entire world vector of prices in all sectors, in every country.[62] These broader price transmission relationships allow more potential indirect effects to operate through the endogenous reallocation of value added across 'outside' sectors (i.e. $s \neq x \in \mathcal{S}$) and 'third' countries ($c \neq i, j \in \mathcal{C}$). These more complicated price mappings complicate exposition, but do not change the basic mechanisms at work.

As before, national income is given by:

$$I^i = 1 + \vec{p^i} \cdot \vec{q^i}(\vec{p}) + R(\vec{p}, I^i) + \underbrace{\sum_{s\in\mathcal{S}} \sum_{c\neq i\in\mathcal{C}} r^c_{si}\nu^c_{si}}_{\equiv DVA_i(\vec{p})} - \underbrace{\sum_{s\in\mathcal{S}} \sum_{c\neq i\in\mathcal{C}} r^i_{sc}\nu^i_{sc}}_{\equiv FVA^i(\vec{p})} . \tag{A3}$$

Likewise, with the same government objective function, the optimal tariff imposed by country i on a given final good $x \in \mathcal{S}$ imposed against country $j \neq i \in \mathcal{C}$ is given by:

$$\begin{aligned} \tau^i_{xj} = \arg\max \quad & I^i + \zeta(\vec{p^i}) + \sum_s [\delta^i_s \pi^i_s(\vec{p}) - \delta^i_{s*} FVA^i_s(\vec{p}) + \delta^*_{si} DVA_{si}(\vec{p})]. \\ \text{s.t.} \quad & p^i_x = \tau^i_{xj} p^j_x \quad \text{and} \quad \tau^i_{xj} \leq \tau^{i,MFN}_x. \end{aligned} \tag{A4}$$

The first order condition of country $i's$ maximization problem is:

$$G_{\tau^i_{xj}} = \nabla I \cdot D_{\tau^i_{xj}}\vec{p} + \nabla\zeta \cdot D_{\tau^i_{xj}}\vec{p^i} + \sum_s [\delta^i_s \frac{d\pi^i_s}{d\tau^i_{xj}} - \delta^i_{s*} \frac{dFVA^i_s}{d\tau^i_{xj}} + \delta^*_{si} \frac{dDVA_{si}}{d\tau^i_{xj}}] = 0. \tag{A5}$$

The first term captures the total derivative of country i's income with respect to the tariff in question ($\frac{dI}{d\tau^i_{xj}} = \nabla I \cdot D_{\tau^i_{xj}}\vec{p}$, where$\nabla I$ is the gradient of income with respect to the $(1 \times SC)$ world-price vector, and $D_{\tau^i_{xj}}\vec{p}$ is the $(SC \times 1)$ derivative of the world price vector with respect to the bilateral tariff), and the second term is the total derivative of consumer surplus (where$\nabla\zeta\cdot$ is the $(1 \times S)$ gradient vector of indirect utility with respect to each of the S elements of the local price vector, $\vec{p^i}$, and $D_{\tau^i_{xj}}\vec{p^i}$ is the $(S \times 1)$ derivative of the local price vector with respect to the bilateral tariff). The last three terms capture the political economy influence attached to domestic production, DVA, and FVA for each sector.

Using Roy's identity, collecting terms, and expanding the political economy and value

[62]For intuition, consider a unilateral increase in τ^i_{xj}. In the baseline model in the text, this would cause r^j_{xi} to fall, but ν^j_{xi} would remain fixed by assumption. With endogenous value added, the reduction in r^j_{xi} would cause value added to exit sector x in now-less-attractive country j, disrupting the worldwide pattern of value added content quantities, $\vec{\nu}$, and thus the equilibrium pattern of worldwide final goods production and prices.

added terms yields:

$$G_{\tau^i_{xj}} = \sum_s \sum_{c \neq i} \left[-M^i_{sc} \frac{dp^c_s}{d\tau^i_{xj}} + t^i_{sc} p^c_s \nabla M^i_{sc} \cdot D_{\tau^i_{xj}} \vec{p} \right] +$$

$$+ \sum_s [\delta^i_s q^i_s \frac{dp^i_s}{d\tau^i_{xj}} + (1+\delta^*_{si}) \underbrace{\nabla DVA_{si} \cdot D_{\tau^i_{xj}} \vec{p}}_{\equiv \frac{dDVA_{si}}{d\tau^i_{xj}}} - (1 - \vec{\delta}^{\,i}_{s*}) \underbrace{\nabla FVA^i_s \cdot D_{\tau^i_{xj}} \vec{p}]}_{\equiv \frac{dFVA^i_s}{d\tau_{xj}}} = 0. \quad \text{(A6)}$$

Above we use ∇M^i_{sc} to represent the gradient of bilateral imports of each good s from trading partner c to country i with respect to the complete world price vector, and ∇DVA_{si} and ∇FVA^i_s to represent respectively the gradients of country i's domestic value added embodied in foreign production, and foreign value added returns used in country i's production of good good s with respect to the (complete) world price vector.

Paralleling our earlier approach, we introduce the term Ω^{Ri}_{xj} to capture the (potential) revenue effects of trade diversion.[63] Dividing through by the bilateral trade volume and $\frac{dp^j_x}{d\tau^i_{xj}}$ yields the optimal tariff expression:

$$t^i_{xj} \tilde{\epsilon}^i_{xj} = 1 + \sum_s \left[-\frac{\delta^i_s q^i_s}{\lambda^i_{sj} M^i_{xj}} - \frac{(1+\delta^*_{si}) \nabla DVA_{si} \cdot \vec{\Lambda}_{ixj}}{M^i_{xj}} + \frac{(1-\delta^i_{s*}) \nabla FVA^i_s \cdot \vec{\Lambda}_{ixj}}{M^i_{xj}} \right] - \tilde{\Omega}^{Ri}_{xj}, \quad \text{(A7)}$$

where $\tilde{\epsilon}^i_{xj}$ is the general equilibrium analog to the bilateral export supply elasticity in the baseline version of the model, $\lambda^i_{sj} \equiv \frac{dp^j_s}{d\tau^i_{xj}} / \frac{dp^i_s}{d\tau^i_{xj}}$ $\forall s \in \mathcal{S}$, and $\vec{\Lambda}_{ixj} \equiv \frac{D_\tau \vec{p}}{dp^j_x / d\tau^i_{xj}}$ is the $(SC \times 1)$ vector of the induced changes in the world price vector following a change in τ^i_{xj}, *relative* to the price change in the directly-affected sector x in country j.[64] Similarly, $\vec{\Lambda}^i_{ixj} \equiv \frac{D_\tau \vec{p}^{\,i}}{dp^j_x / d\tau^i_{xj}}$ is the $(S \times 1)$ vector of induced changes in the local (country i) prices *relative* to the change in p^j_x. Finally, let $\tilde{\Omega}^{Ri}_{xj} \equiv \Omega^{Ri}_{xj} / (\frac{dp^j_x}{d\tau^i_{xj}} M^i_{xj})$.

Decomposing the two value added terms into elasticities and empirically-measurable quantities of DVA and FVA, we can separate out the direct effect of the bilateral tariff change on the price of the target-good x in trading partners i and j apart from other

[63] $\Omega^{Ri}_{xj} \equiv \sum_s \sum_{c \neq i,j} \left[-E^i_{sc} \frac{dp^c_s}{d\tau^i_{xj}} + t^i_{sc} p^c_s \nabla_{\vec{p}} E^i_{sc} \cdot D_{\tau^i_{xj}} \vec{p} \right] + \sum_{s \neq x} \left[-E^i_{sj} \frac{dp^j_s}{d\tau^i_{xj}} + t^i_{sj} p^j_s \nabla_{\vec{p}} E^i_{sj} \cdot D_{\tau^i_{xj}} \vec{p} \right]$.

[64] Formally, we define $\tilde{\epsilon}^i_{xj} \equiv \frac{p^j_x}{E^i_{xi}} \frac{1}{\nabla_{\vec{p}} E^j_{xi} \cdot \vec{\Lambda}_{ixj}}$ to be the bilateral export supply elasticity allowing the tariff change to work through the *complete* vector of final good prices. Note that the elements of the $\vec{\Lambda}$ vector, which take the form of $\frac{dp^c_s}{d\tau} / \frac{dp^j_x}{d\tau}$, are the inverse of the $\lambda (\equiv \frac{dp^j}{d\tau} / \frac{dp^c_s}{d\tau})$ terms used in the main text (and in Bagwell and Staiger (1999)). We make this notational change because many standard modeling assumptions would render some elements of the numerator of our $\vec{\Lambda}$ vector zero (consistent with the absence of general equilibrium effects).

indirect general equilibrium effects.

$$
\begin{aligned}
\sum_s \left[\frac{(1+\vec{\delta}^*_s)\nabla DVA_s \cdot \vec{\Lambda}_{ixj}}{M^i_{xj}}\right] &= \frac{1}{M^i_{xj}} \sum_s (1+\delta^*_{si}) \sum_{c\neq i} (\nu^c_{si} \nabla r^c_{si} + r^c_{si} \nabla \nu^c_{si}) \cdot \vec{\Lambda}_{ixj} \\
&= \sum_s (1+\delta^*_{si}) \sum_{c \neq i} \left(\frac{r^c_{si}\nu^c_{si}}{p^c_s M^i_{xj}}\right) \left(\underbrace{\frac{p^j_x}{r^c_{si}} \nabla r^c_{si} \cdot \Lambda_{ixj}}_{\equiv \tilde{\varepsilon}^{rc}_{si(ijx)}} + \underbrace{\frac{p^j_x}{\nu^c_{si}} \nabla \nu^c_{si} \cdot \Lambda_{ixj}}_{\equiv \tilde{\varepsilon}^{\nu c}_{si(ijx)}} \right) \\
&= \underbrace{(1+\delta^*_{xi}) \frac{r^j_{xi}\nu^j_{xi}}{p^j_x M^i_{xj}} (\tilde{\varepsilon}^{rj}_{xi} + \tilde{\varepsilon}^{\nu j}_{xi})}_{\text{direct effect}} + \underbrace{\sum_{c\neq i} \sum_{s \neq x} (1+\delta^*_{si}) \frac{r^c_{si}\nu^c_{si}}{p^j_x M^i_{xj}} (\tilde{\varepsilon}^{rc}_{si} + \tilde{\varepsilon}^{\nu c}_{si}) + \sum_{c \neq i,j} (1+\delta^*_{xi}) \frac{r^c_{xi}\nu^c_{xi}}{p^j_x M^i_{xj}} (\tilde{\varepsilon}^{rc}_{xi} + \tilde{\varepsilon}^{\nu c}_{xi})}_{\text{indirect (GE) effects } \equiv \tilde{\Omega}^{DVAi}_{xj}} \\
&= (1+\delta^*_{xi})(\tilde{\varepsilon}^{rj}_{xi} + \tilde{\varepsilon}^{\nu j}_{xi}) \frac{DVA^j_{xi}}{p^j_x M^i_{xj}} + \tilde{\Omega}^{DVAi}_{xj}
\end{aligned}
\tag{A8}
$$

Following the same procedure for the FVA term:

$$
\begin{aligned}
\sum_s \left[\frac{(1-\delta^i_{s*})\nabla FVA^i_s \cdot \vec{\Lambda}_{ixj}}{M^i_{xj}}\right] &= \sum_s (1-\delta^i_{s*}) \sum_{c \neq i} \left(\frac{r^i_{sc}\nu^i_{sc}}{p^j_x M^i_{xj}}\right) \left(\underbrace{\frac{p^j_x}{r^i_{sc}} \nabla r^i_{sc} \cdot \Lambda_{ixj}}_{\equiv -\tilde{\varepsilon}^{ri}_{sc(ijx)}} + \underbrace{\frac{p^j_x}{\nu^i_{sc}} \nabla \nu^i_{sc} \cdot \Lambda_{ixj}}_{\equiv -\tilde{\varepsilon}^{\nu i}_{sc(ijx)}} \right) \\
&= \underbrace{-\sum_{c \neq i} (1-\delta^i_{x*}) \frac{r^i_{xc}\nu^i_{xc}}{p^j_x M^i_{xj}} (\tilde{\varepsilon}^{ri}_{xc} + \tilde{\varepsilon}^{\nu i}_{xc})}_{\text{direct effect}} - \underbrace{\sum_{c\neq i} \sum_{s \neq x} (1-\delta^i_{s*}) \frac{r^i_{sc}\nu^i_{sc}}{p^j_x M^i_{xj}} (\tilde{\varepsilon}^{ri}_{sc} + \tilde{\varepsilon}^{\nu i}_{sc})}_{\text{indirect effects } \equiv \tilde{\Omega}^{FVAi}_{xj}} \\
&= -(1-\delta^i_{x*})(\tilde{\varepsilon}^{ri}_{x*} + \tilde{\varepsilon}^{\nu i}_{x*}) \frac{FVA^i_x}{p^i_x M^i_{xj}} - \tilde{\Omega}^{FVAi}_{xj}.
\end{aligned}
\tag{A9}
$$

For economy of notation, we have rewritten the value added expressions using augmented elasticity terms (the $\tilde{\varepsilon}$s), which include both the mapping from final goods prices to value added (the εs in the main text) and *also* the mapping from tariffs to final goods prices via $\vec{\Lambda}_{ixj}$ (the λs in the main text).[65]

Finally, we also separate the political economy term into direct (sector x) and indirect (sectors $s \neq x \in \mathcal{S}$) components:

$$
\sum_s \frac{\delta^i_s q^i_s}{\lambda^i_{sj} M^i_{xj}} = \underbrace{-\frac{\delta^i_x q^i_x}{|\lambda^i_{xj}| M^i_{xj}}}_{\text{direct effect}} + \underbrace{\sum_{s \neq x} \frac{\delta^i_s q^i_s}{\lambda^i_{sj} M^i_{xj}}}_{\text{indirect effect } \equiv \tilde{\Omega}^{PEi}_{xj}} , \tag{A10}
$$

where we have used that λ^i_{xj} is unambiguously negative (as in the main text), while the sign of λ^i_{sj} is ambiguous $\forall s \neq x \in \mathcal{S}$.

Substituting the decompositions in (A8)-(A10) into the optimal tariff expression, we can

[65]The augmented elasticity terms for FVA are defined to maintain the sign conventions in the main text, using the fact that $\frac{dp^j_x}{d\tau^i_{xj}}$.

rewrite the optimal bilateral tariff expression:

$$t^i_{xj} = \frac{1}{\tilde{\epsilon}^i_{xj}} \left(1 + \underbrace{\frac{\delta^i_x q^i_x}{|\lambda^i_{xj}| M^i_{xj}}}_{(+)} \underbrace{- (1+\delta^*_{xi})(\tilde{\varepsilon}^{rj}_{xi} + \tilde{\varepsilon}^{\nu j}_{xi}) \frac{DVA^j_{xi}}{p^j_x M^i_{xj}}}_{(-)} \underbrace{- (1-\delta^i_{x*})(\tilde{\varepsilon}^{ri}_{x*} + \tilde{\varepsilon}^{\nu i}_{x*}) \frac{FVA^i_x}{p^i_x M^i_{xj}}}_{(-) \text{iff } \delta^i_{x*} < 1} - \tilde{\Omega}^i_{xj} \right), \quad \text{(A11)}$$

where $\tilde{\Omega}^i_{xj} \equiv \tilde{\Omega}^{Ri}_{xj} - \tilde{\Omega}^{FVAi}_{xj} + \tilde{\Omega}^{DVAi}_{xj} + \tilde{\Omega}^{PEi}_{xj}$captures all of the indirect effects of the tariff change on via country i's tariff revenue, domestic political economy and FVA in sectors other than x, as well as the DVA influences other sectors and in the returns to DVA in trading partners other than j. Note that most of these general equilibrium effects would arise in a broad class of GE frameworks, and are not about value-added components of trade, per se. Many assumptions standard in the literature (like specific factors) are employed to force these general equilibrium components to zero.

A.3 Input Tariffs in the Benchmark Model

This appendix introduces (exogenous) input tariffs to the benchmark model defined in Section 1.1. Suppose that country i levies an ad-valorem tax on all foreign sourced inputs – FVA – of $\hat{t}^i_s \in [0,1]$ in each sector $s \in \mathcal{S}$. (To simplify notation, let the input tariff be uniform across trading partners.) Country i's total revenue from input tariffs is then $\hat{R}(\vec{p}^1; \vec{\nu}) \equiv \sum_{s \in \mathcal{S}} \sum_{c \neq i \in \mathcal{C}} \hat{t}^i_s r^i_{sc} \nu^i_{sc} = \sum_{s \in \mathcal{S}} \hat{t}^i_s FVA^i_s$.

National income is (still) given by:

$$I^i = R(\vec{p}, I^i; \vec{\nu}) + 1 + \vec{p^i} \cdot \vec{q^i}(\vec{p^i}, \vec{\nu}^i) - \underbrace{\sum_{s \in \mathcal{S}} \sum_{c \neq i \in \mathcal{C}} r^i_{sc} \nu^i_{sc}}_{\equiv FVA^i(\vec{p}^i)} + \underbrace{\sum_{s \in \mathcal{S}} \sum_{c \neq i \in \mathcal{C}} r^c_{si} \nu^c_{si}}_{\equiv DVA_i(\vec{p}^*)}, \quad \text{(A12)}$$

where trade tax revenue now includes revenue from imports of both final goods and intermediate inputs:

$$R(\vec{p}, I^i; \vec{\nu}) \equiv \sum_{s \in \mathcal{S}} \sum_{c \neq i \in \mathcal{C}} (p^i_s - p^c_s) M^i_{sc}(\vec{p}, I^i; \vec{\nu}) + \sum_{s \in \mathcal{S}} \hat{t}^i_s FVA^i_s. \quad \text{(A13)}$$

The optimal final goods tariff is given implicitly by the augmented first order condition:

$$\begin{aligned} G^i_{\tau^i_{xj}} = \frac{dM^i_x}{d\tau^i_{xj}} t^i_{xj} p^j_x - M^i_{xj} \frac{dp^j_x}{d\tau^i_{xj}} + \delta^i_x q^i_x \frac{dp^i_x}{d\tau^i_{xj}} + \Omega^{Ri}_{xj} \\ - (1 - \hat{t}^i_x)(1 - \delta^i_{x*}) \frac{dFVA^i_x}{d\tau^i_{xj}} + (1 + \delta^*_{xi}) \frac{dDVA_{xi}}{d\tau^i_{xj}} = 0, \quad \text{(A14)} \end{aligned}$$

where Ω^{Ri}_{xj} now captures the revenue consequences of trade diversion in both final and intermediate goods.

Solving yields the optimal bilateral tariff expression for final good x:

$$t_{xj}^{i} = \frac{1}{\epsilon_{xj}^{i}} \left(1 + \frac{\delta_x^i q_x^i}{|\lambda_{xj}| M_{xj}^i} - (1 + \delta_{xi}^{*}) \varepsilon_{xi}^{rj} \frac{DVA_{xi}^j}{p_x^j M_{xj}^i} - \frac{(1 - \delta_{x*}^i)(1 - \hat{t}_x^i) \varepsilon_{x*}^{ri}}{|\lambda_{xj}|} \frac{FVA_x^i}{p_x^i M_{xj}^i} + \tilde{\Omega}_{xj}^i \right). \quad \text{(A15)}$$

The input tariff enters two ways. First the input tariff enters directly through the FVA coefficient: $\frac{(1-\delta_{x*}^i)(1-\hat{t}_x^i)\varepsilon_{x*}^{ri}}{|\lambda_{xj}|}$. All else equal, a higher input tariff, $\hat{t}_x^i$ would induce a higher final goods tariff because the input tariff allows the government to capture some of the benefit of final goods protection for foreign value added suppliers. Input tariffs thus operate mechanically in the same way as the political weight on FVA (δ_{x*}^i).

Additionally, input tariffs may enter the optimal tariff indirectly if they change the underlying mapping from final goods prices to input prices (and thus the ε_{x*}^{ri} terms). This would be the case, for instance, if government policy disrupts bargaining outcomes between upstream sellers and downstream buyers as in Antràs and Staiger (2012). Crucially, both of these potential effects of input tariffs on optimal final goods tariffs will be captured in our coefficient estimates, and do not change the directional predictions of the model.

Summarizing, exogenous input tariffs influence final goods tariffs only via tariff revenue and in a straightforward way. Moreover, while the direct effect of input tariffs is to dampen the trade liberalizing effect of FVA by inducing the government to internalize some of the benefits of higher protection for foreign suppliers, it cannot reverse the sign of the empirical prediction on FVA (because it is necessarily bound above by 1). And most importantly, while input tariffs influence the *quantitative* impact of trade in value added on final goods tariffs, they do not change the way we should approach the empirical exercise.

B Empirical Appendix

This appendix presents additonal details regarding the data we use and collects supplemental empirical results.

B.1 Data Details

In this section, we discuss how we compute value-added contents and details regarding the tariff data.

B.1.1 Computing Value Added Content

As noted in the text, our measures of domestic content in foreign production and foreign content in domestic production can be motivated as an application of the 'global value chain' decomposition of final goods developed in Los, Timmer and de Vries (2015).[66] We briefly describe the computation here.

As in the main text, let $i, j \in \{1, 2, \ldots, C\}$ denote countries and $s \in \{1, 2, \ldots, S\}$ denote industries. The World Input-Output Database includes an input shipments matrix, II_t, with $(S \times S)$ dimensional block elements $II_{ijt}(s, s')$ that record input shipments from sector s in country i to sector s' in country j. These matrices can easily be re-written in share form. Let A_{ijt} be a $(S \times S)$ dimensional matrix with elements $A_{ijt}(s, s') = II_{ijt}(s, s')/Y_j(s')$, which record the share of inputs from sector s in country i used by sector s' in country j as a share of gross output in sector s' in country j. Then assemble blocks A_{ijt} into the global input-output matrix A_t. The Leontief inverse of the global input-output matrix, $[I - A_t]^{-1}$, times any $(SC \times 1)$ vector of final goods output equals yields the $(SC \times 1)$ vector of gross output (from all countries and industries) required to produce those final goods.

Let f_{it} be the $(S \times 1)$ vector of final goods produced in country i, which are directly reported in the World Input-Output Database. Stack these into a $(SC \times 1)$ vector f_t, and compute $Y_t \equiv [I - A_t]^{-1} diag(f_t)$. Breaking this down, Y_t contains block elements Y_{ijt} which are $S \times S$ matrices describing output from country i used (directly or indirectly) to produce final goods in country j. Each sub-component $Y_{ijt}(s, s')$ is the amount of output from industry s in country i used in producing final output in industry s' in country j.

These output requirements can be translated into value-added content requirements if we know the value added to output ratios in each sector s and source country i: $R_{it}(s)$. The total amount of value added from country i embodied in country j's production in a particular industry $x \in \mathcal{S}$ is: $VA^j_{xit} \equiv \sum_s R_{it}(s) Y_{ijt}(s, x)$. We use these value added elements to construct proxies for country i's domestic value added embodied in foreign production of each sector $s \in \mathcal{S}$ in trading partner $j \neq i \in \mathcal{C}$ (DVA^j_{sit}) and foreign value added embodied in country i's domestic production of s (FVA^i_{st}). Specifically, for a given good x, $DVA^j_{xit} \equiv VA^j_{xit}$ and $FVA^i_{xt} \equiv \sum_{c \neq i \in \mathcal{C}} VA^i_{xct}$.

[66] The global value chain traces backward through the production chain from final goods to identify the sources of value added in those goods. This is different than the value-added export decomposition developed by Johnson and Noguera (2012), which traces value added forward through the production chain to determine where value added from each country is ultimately consumed. It is also different than the decomposition of gross exports advanced by Koopman, Wang and Wei (2014).

We compute value added content using the disaggregated 40 country version of the WIOD data set. We then aggregate value-added content across EU countries to form the EU composite, because EU countries have common external tariffs and trade policy.

B.1.2 Tariffs

As noted in Section 3.2, we draw our data from UNCTAD (TRAINS) and the WTO via the WITS website. We faced a number of challenges in transforming these raw data sources into a consistent set of tariff measures. Below we describe our procedure to clean and aggregate the tariff data.

First, there are a handful of instances in which a country's entire bilateral tariff schedule is missing in one of our four benchmark years. In most of these cases, when we can be confident that there were no major trade policy changes in that year, we take the tariff schedule from the closest available year for that country. In a few instances, we instead exclude the importer in that particular year. The following importing countries and years are excluded on these grounds: China (1995, 2000), South Korea (1995, 2000), Taiwan (1995, 2000), and Russia (2000). These countries are included as *exporters* in all years.

Second, there are cases where tariffs are misreported, or entirely missing, for a subset of products or partners in a given year. In some instances, we are able to resolve these idiosyncratic problems through inspection. For example, a country's data may omit a particular tariff preference program in a given year, even though that program exists in the country's data in the years immediately before and after the missing year. While it is possible that these programs were temporarily suspended, our investigative efforts to validate such possible temporary suspensions typically uncovered no corroborating evidence consistent with a genuine change in policy. Therefore, we use information on preferences from surrounding years. In a handful of other cases in which we cannot resolve these problems, we instead record tariffs as missing.

Third, tariff lines (products) are not defined consistently across countries at the most disaggregated (HS-8+) level. Therefore, we take the unweighted mean across (HS-8+) tariff lines within each HS 6-digit Harmonized System category, which are standardized across countries. We then classify these HS 6-digit categories into final versus intermediate use using BEC classifications as described in the text.

Fourth, some HS 6-digit tariff lines have multiple preferences recorded in the data. For example, Canada may report two tariffs for imports from Mexico: one under NAFTA and another under GSP. When one of the reported tariffs derives from an Article XXIV free trade agreement or customs union, we treat that tariff as the applicable tariff. When two or more non-FTA/CU tariffs are present, we adopt the lower of the two rates as the applicable tariff. In the end, we have information on the preference scheme under which every bilateral preferential tariff is offered in the data.[67]

Fifth, there are several technical issues that need to be addressed pertaining to exit/entry of HS 6-digit codes in the data (either over time or across countries at a given point in time) and non-ad valorem tariffs. We start with a data set that includes all available HS 6-digit

[67] One hurdle to identifying preference programs is that program identifiers in the raw UNCTAD/TRAINS data are often difficult to parse. When necessary, we cross-reference various secondary sources to identify the relevant preference schemes.

tariffs. We then refine the data in two dimensions. First, we discard all HS 6-digit sectors (by importer) in which tariffs are applied exclusively as specific duties.[68] Second, we retain only HS 6-digit categories for which we have a fully-balanced panel of tariffs — as in, for each importer, a given HS 6-digit tariff is observed for all partners in all years. This allows us to construct consistent tariff averages over time, as well as across partners at a given point in time.[69]

We aggregate these HS 6-digit tariffs to the WIOD industry level using simple averages, which yields measures for applied bilateral and MFN tariffs at the importer-exporter-industry-year level. We define a bilateral country pair to have a preferential tariff in a given industry and year if *any* bilateral applied HS 6-digit tariff for that importer-exporter-industry-year cell is below the MFN applied rate. Typically, the preference scheme in each cell is unique, and so we record the relevant program as the source of the tariff preferences at the industry level. For a small handful of cells, there are multiple preference schemes active within a given bilateral-industry-year cell (some HS 6-digit tariff lines within the industry receive preferences under one program, while others receive preferences under a different program). In these cases, we record the more important preference program, which typically accounts for the vast majority of preferences in the industry.

Sources of Tariff Preferences As noted in the text, there are preferential tariffs in about a third of the importer-exporter-industry-year cells. The GSP program accounts for the majority (69 percent) of these preferences. In our data, there are three primary sources of time-varying discretion in the GSP program. The first is that each GSP granting country chooses the set of countries to which to grant GSP access. The second is that each GSP granting country chooses the set of industries covered by GSP, where industry exemptions apply to all GSP-partners. The third is that the importing country chooses the level of the GSP tariff to apply to its GSP-partners.[70] Each of these decisions is updated over time, as countries introduce or renew their GSP programs.[71] One important point is that the way GSP is recorded in our data understates the actual degree of discretion with which the GSP

[68] To clarify, some importers may apply ad valorem tariffs in a given HS 6-digit sector, while others apply specific duties in that sector. We only discard the HS sector for importers that actually apply specific duties, and retain the sector for other importers. Specific duties account for less than 2 percent of the HS 6-digit tariff lines for final goods. Discarding them avoids the well-understood concerns involved in converting specific tariffs to ad valorem equivalents, which are particularly problematic for aggregation or comparability across industries and countries.

[69] The cost of discarding unbalanced observations is that we lose about 13 percent of the (non-specific duty) importer-exporter-HS6-year tariff observations. We have confirmed that average bilateral industry-level tariffs computed from this balanced data are comparable to unbalanced averages that use all of the data. Further, tariff preferences (applied minus MFN tariffs) are nearly identical in balanced and unbalanced HS 6-digit tariff panels. Therefore, while this balancing step is useful for internal consistency, it is not important for the results.

[70] Regarding the second and third items, GSP preferences are reported at the HS 6-digit level in our data. As we aggregate, we take the simple average of GSP and MFN tariffs within each WIOD industry. Consequently, composite industry-level tariffs reflect both the set of HS 6-digit categories that receive tariff preferences as well as the size of those tariff preferences. In our data, GSP tariffs do not vary across the set of partners included in each importer's GSP program (with a few minor exceptions). In some industries, no HS 6-digit category receives preferences, in which case the entire industry is excluded from the GSP program.

[71] GSP preferences are identified by the "year" of the importer's GSP program in the raw tariff data.

program is applied in practice.[72] As such, our results regarding discriminatory preferential tariffs in the GSP program are likely conservative, since our data understates the true extent of discretion under GSP.

Bilateral trade agreements and other miscellaneous preference programs make up the remainder of preferences in our data. The miscellaneous preferences are difficult to classify concisely. For example, one of the largest miscellaneous preference programs we observe is the so-called "Australia Tariff" in Canada's tariff schedule, under which Canada affords Australia preferential treatment for roughly 300 HS 6-digit categories.[73] Other idiosyncratic preference schemes are more limited, sometimes covering only a few miscellaneous HS 6-digit tariff lines.

Turning to bilateral trade agreements, we classify these preferences programs into two groups, consistent with our theoretical discussion in Section 1.2.1: *potentially* reciprocal trade agreements (RTAs) and non-reciprocal trade agreements.[74] Our baseline approach to classifying these agreements is as follows.

We define country i to have a potentially reciprocal trade agreement (RTA) with country j in year t if those countries have a trade agreement in force that was notified to the WTO under Article XXIV.[75] In the language of Article XXIV, these are commonly referred to as Customs Unions and Free Trade Areas. Article XXIV is a useful device to classify agreements because it requires countries to eliminate tariffs/duties on 'substantially all trade'. This requirement is evident in practice, as these agreements have much broader coverage on average than other trade agreements. Nonetheless, we repeat two points here that we emphasized in the main text. The first is that Article XXIV agreements still contain carve outs, which leave positive tariffs in many industries. The second is that some agreements in force have long, often highly asymmetric phase-in schedules.[76] These phase-in schedules are a source of discretion even inside reciprocal agreements. As a result of both of these sources of discretion, we treat these Article XXIV agreements as *potentially* reciprocal and test for the implications of reciprocity (i.e., that DVA should not influence tariffs inside RTAs).

We classify remaining trade agreements as non-reciprocal. These agreements are exclu-

[72] Specifically, importers deviate from the published GSP tariff schedule in our data for various (largely discretionary) reasons. For example, Blanchard and Hakobyan (2014) review the vagaries of country-product exclusions in the United States GSP program, including the discretionary application of "competitive needs limitations" and revocation of GSP privileges for violations of intellectual property and worker rights.

[73] Though a legacy of British colonial tariff preferences, this program was amended and re-authorized during our sample period, in 1998.

[74] A subtle note is that our language here differs a bit from the way the WTO describes these agreements. The WTO refers to all WTO-notified agreements as 'reciprocal' in that they involve the exchange of tariff preferences. We take 'reciprocal' to mean a sufficiently comprehensive and symmetric exchange of tariff preferences that nullifies bilateral terms-of-trade externalities within the agreement. There is not a strong presumption that terms-of-trade externalities are neutralized by partial agreements, covering a minority of trade. Whether agreements do achieve terms-of-trade neutralization is fundamentally an empirical question, which we address via our testing procedure.

[75] This definition identifies a set of reciprocal agreements among countries in our data that corresponds exactly to the set of FTAs and Customs Unions identified by Baier and Bergstrand (2007).

[76] A nice feature of our data is that we observe this phase-in process. For example, for the US-Australia free trade agreement, the United States implemented preferences immediately when the agreement entered into force, whereas Australia's implementation of preferences was more gradual. Similar issues arise for other agreements adopted within in our sample period (e.g., EU-Mexico, Japan-Mexico, etc.).

sively struck between developing countries, and most are notified to the WTO under the Enabling Clause.[77] Because they are notified under the Enabling Clause, these agreements are not bound by the 'substantially all trade' requirement of Article XXIV agreement. The data confirm that these agreements are much narrower in scope, having typical HS 6-digit coverage rates of less than 20 percent, compared to over 90 percent for RTAs. Reflecting this different standard, two of these agreements (the Asia-Pacific Trade Agreement and the Global System of Trade Preferences) are commonly referred to as "partial scope" agreements.

Table B1 lists the trade agreements in our data and our classification of them into reciprocal vs. non-reciprocal agreements. Because the division of agreements into reciprocal vs. non-reciprocal agreements is a subjective one, we also present an alternative broader classification in the table. Our broad RTA definition includes all Article XXIV agreements plus additional comprehensive agreements between developing countries. It is worth noting that these agreements are not necessarily free trade agreements, as commonly understood. For example, for the Brazil-Mexico agreement, the median tariff is 13 percent (the minimum is roughly 5.5 percent) at the industry level. While we focus on the definition of RTAs as WTO-notified Article XXIV agreements in our main results, we present supplemental results for the broad RTA classifications in Appendix B.

Another Look at MFN as a Constraint on Bilateral Applied Tariffs An additional salient feature of the data is that tariff preferences are constrained by the MFN rule. When the MFN tariff is low, so too is the potential scope for tariff preferences, since tariffs are then bound between zero and the MFN rate. Given this, we would expect that both the absolute value of the mean preference and the standard deviation of preferences would be low when average MFN rates are also low. In Panel (a) of Figure B1, we see that preferences are indeed near zero when MFN tariffs are low (note the y-axis records negative values, since we define preferences as bilateral applied tariffs minus MFN tariffs). In Panel (b), we see that variability in preferences is rising with mean MFN tariffs. Both these patterns are consistent with MFN-censoring constraining variation in the data.

B.2 Supplemental Empirical Results

This section explores two empirical results. The first is a robustness check concerning how we classify regional trade agreements. The second is instrumental variables estimation to accompany the empirical results in Section 4.2.

B.2.1 Robustness Check: Classifying RTAs

In this section, we demonstrate that our main results regarding the role of domestic value added are robust to how we define reciprocal trade agreements. To so so, we replicate results from Tables 2 and 3 using a broader definition of RTAs. This broader definition includes bilateral agreements adopted under Article XXIV plus comprehensive agreements not arising under Article XXIV.

[77]One important agreement — a preferential agreement between Mexico and Brazil — has not been notified to the WTO, according to the WTO's trade agreement database [http://rtais.wto.org/UI/PublicMaintainRTAHome.aspx].

In columns (1)-(3) of Table B2, we repeat the inside versus outside RTA analysis from Table 2. As before, the negative influence of DVA on tariffs manifests itself exclusively outside RTAs. Further, in columns (4) and (5), we show that the point estimate on DVA is negative in this alternative no-RTA sample, comparable in size to the main point estimates. We conclude that the exact definition of RTAs has little bearing on our analysis. Nonetheless, we retain non-Article XXIV agreements in our baseline no-RTA sample throughout the paper, because adoption of these is itself a manifestation of discretionary trade policy.

B.2.2 Identifying the Influence of Foreign Value Added via Instrumental Variables

In Table 6, we presented OLS estimates of Equation (18), with two alternative sets of fixed effects. We noted that while one might be concerned about the endogeneity of foreign value added with respect to tariffs, this should bias the coefficient upward (i.e., toward zero/positive values, given that the point estimate is negative). In this sense, the OLS estimate of the FVA effect may be conservative. Further, we noted there that IV estimates in that specification tend to support this interpretation. We present the details of that argument here.

To instrument Equation (18), we require instruments for DVA^j_{xit}, FVA^i_{xt}, FG^i_{xt}, and IM^i_{xjt}. Needless to say, finding four instruments is a formidable challenge.[78] For DVA^j_{xit}, we use the DVA-in-Services instrument presented previously in Section 4.1. We construct three additional instruments for FVA^i_{xt}, FG^i_{xt}, and IM^i_{xjt} as follows.

Instrument for FG The instrument for final goods production is based on predicting final goods production for industry x in country i by taking a weighted average of total final expenditure in destinations j to which i sold output in a base period. Let FG^i_{xjt} be the value of final goods shipments from country i to j in industry x at date t. Letting 0 denote a base period, then total final goods production at date t can be written as:

$$FG^i_{xt} = FG^i_{x0} \sum_j \left(\frac{FG^i_{xj0}}{FG^i_{x0}} \right) \left[\frac{FG^i_{xjt}}{FG^i_{xj0}} \frac{FG_{xj0}}{FG_{xjt}} \right] \left(\frac{FG_{xjt}}{FG_{xj0}} \right), \tag{B1}$$

where FG_{xjt} is total final expenditure on industry x in destination j. The first term records the shares of final goods production sold to each destination in the base period. The middle term in square brackets records changes in final goods expenditure shares. The third term records changes in final expenditure levels. For the purposes of constructing an instrument, suppose that final goods import shares are constant over time, so that $\frac{FG^i_{xjt}}{FG^i_{xj0}} \frac{FG_{xj0}}{FG_{xjt}} = 1$. And

[78] This particularly challenging in our context for two reasons. First, the fixed effects structure we adopt rules out many possible country, industry, or even country-industry instruments. Second, the potentially endogenous explanatory variables are correlated among themselves for structural reasons (e.g., FVA^i_{xt} depends on the level of FG^i_{xt}), and so many instruments for them are also correlated among themselves. As a result, many potential instruments suffer from weak instrument problems. We explicitly address weak instrument concerns below.

then re-write the expression in logs:

$$\ln\left(FG^i_{xt}\right) \approx \ln\left(FG^i_{x0}\right) + \ln\left(\sum_j \left(\frac{FG^i_{xj0}}{FG^i_{x0}}\right)\frac{FG_{xjt}}{FG_{xj0}}\right). \tag{B2}$$

Because we include importer-industry fixed effects in all specifications, final goods production in the base year ($\ln\left(FG^i_{x0}\right)$) is redundant. For identification, we rely solely on time variation in final goods production at the importer-industry level (with importer-specific and industry-specific effects differenced out), for which the second term is an instrument. Put differently, what we actually need is an instrument for growth in final goods production, and our instrument aggregates growth rates in destination expenditure using weights that depend on sales shares in the benchmark year. In constructing the instrument, we treat 1995 as the benchmark year.

Instrument for FVA The instrument for foreign value added in domestic production based on predicting how much foreign value added in used by industry x in country i using information on the foreign supply of value added in upstream industries. Intuitively, if foreign supply capacity grows quickly, then we expect the amount of foreign value added used in domestic production to rise. To capture this idea, we build an instrument as follows.

Let $FVA^i_{jt}(s,x)$ be the value added from country j and industry s used by industry x country i in production of final goods at date t. Again letting 0 denote a base period, FVA^i_{xt} can be written as:

$$FVA^i_{xt} = FVA^i_{x0}\sum_{j\neq i}\sum_s\left[\left(\frac{FVA^i_{jt}(s,x)}{FVA^i_{x0}}\right)\left(\frac{FVA^i_{jt}(s,x)}{FVA^i_{j0}(s,x)}\frac{VA^j_{s0}}{VA^j_{st}}\right)\left(\frac{VA^j_{st}}{VA^j_{s0}}\right)\right], \tag{B3}$$

where VA^j_{st} is total value added added in sector s of country j at date t. Similar to above, suppose that the value-added export shares are constant over time, so $\frac{FVA^i_{jt}(s,x)}{FVA^i_{j0}(s,x)}\frac{VA^j_{s0}}{VA^j_{st}} = 1$, and re-write the expression in logs:

$$\ln\left(FVA^i_{xt}\right) \approx \ln\left(FVA^i_{x0}\right) + \ln\left(\sum_{j\neq i}\sum_s\left(\frac{FVA^i_{jt}(s,x)}{FVA^i_{x0}}\right)\frac{VA^j_{st}}{VA^j_{s0}}\right). \tag{B4}$$

As above, the base year level of foreign value added ($\ln\left(FVA^i_{x0}\right)$) will be absorbed by our fixed effects. The second term is then an instrument for growth in foreign value added used in domestic production over time. We again treat 1995 as the benchmark year in constructing the instrument.

Instrument for Final Goods Imports To instrument for final goods imports, we measure bilateral final goods imports at the industry level in 1970, prior to the introduction of the tariff preferences observed in our data. We use bilateral trade data at the SITC 4-digit (Rev. 2) level from the NBER-United Nations Trade Data [Feenstra et al. (2005)]. We extract SITC categories corresponding to final goods using the BEC classification, and then concord SITC categories to our WIOD industries via ISIC industries.[79]

Estimation and Results Using these instruments, we re-estimate the linear specifications in Table 6 and present the results in Table B3, along with the baseline OLS estimates from Table 6 for reference. In Columns (1) and (3), we instrument for the three ratios on the right hand side of Equation 18 by constructing the ratio of the instruments for the numerator in each ratio to the instrument for final goods imports.[80] In columns (2) and (4), we do the same for DVA and instrument for final goods imports to identify $\gamma^{IP} + \gamma^{FVA}$.

In Panel A, IV estimates are negative for domestic value added, negative for foreign value added, and positive for final goods production. These are consistent with the OLS sign estimates. In terms of magnitudes, the IV point estimates tend to move away from zero relative to OLS. That said, the 2SLS point estimates are substantially less precise than OLS. Nonetheless, one can reject the null that the import penetration and FVA ratios are exogenous in a Durbin-Wu-Hausman endogeneity test.[81]

In Panel B, we replicate the IV estimates for the sample excluding RTAs. The IV estimates here also broadly confirm the OLS estimates, though the details are more nuanced. The point estimate on DVA doesn't move between the OLS and IV estimates, but becomes insignificantly different than zero in the IV estimation due to the loss of precision. We cannot reject that DVA is exogenous in a Durbin-Wu-Hausman endogeneity test. Given our prior results concerning the role of DVA – both in Panel A and in previous IV-specifications, we see no reason to change our views on the sign of the DVA effect based on these results. Turning to FVA, the coefficient on FVA becomes negative and significant when we instrument here. This brings the FVA results in this sub-sample more in line with the full sample, including RTAs. Further, we can easily reject exogeneity of the FVA-Ratio here.

Together with our previous IV results, these results corroborate our interpretation of the OLS estimates as indicative of causal relationships. In particular, the new concern in this specification concerns the role of FVA. Recalling that the principal endogeneity concern is that tariffs raise FVA and thus bias the the FVA coefficient upward (toward zero/positive values), we argued in the text that our OLS estimates likely understate FVA effects. The IV results are broadly consistent with this interpretation. That said, we are reluctant to take the magnitude of the FVA estimate too seriously here due to the wide confidence interval.

One final point to note is that we report two-stage least squares standard errors (clustered by importer-exporter pair) in the table. The appropriateness 2SLS standard errors is not obvious: the high correlations among endogenous variables and therefore the instruments we use for them could give rise to weak instrument problems. Therefore, in the table, we report various weak-IV statistics to gauge the reasonableness of the 2SLS standard errors. We report statistics that allow for clustering – including tests for under-identification and

[79]Because country definitions have changed over time, we concord historical countries to modern entities as best we can. For example, Germany today corresponds most closely to the former Federal Republic of Germany. Russia today corresponds to the former USSR. And so on. Further, more trade flows in the NBER-UN data are zero in 1970 than are zero today, likely due both to true changes from zeros to positive values over time and differences in reporting thresholds and/or missing data in the two data sources. In order to use the whole sample, we replace zeros in 1970 with the smallest values observed in the data.

[80]Including the instruments separately, without imposing this ratio restriction, yields similar results.

[81]Testing the exogeneity of the DVA-Ratio alone, one cannot reject exogeneity.

weak identification [Kleinbergen and Paap (2006)] and conditional first-stage F statistics [Sanderson and Windmeijer (2015)]. These statistics suggest that that 2SLS standard errors are acceptable.[82] Nonetheless, we also computed Anderson-Rubin style confidence intervals that are robust to weak identification. These are comparable to the 2SLS confidence intervals and do not alter inference in any important way.

[82]In interpreting these statistics, an unfortunate fact is that there is little guidance about what the values of these cluster-robust statistics need to be to be on safe ground. Values of 10 or above for the conditional F statistics are typically thought to be safe. The rK statistics compare reasonably favorably to critical values developed for homoskedastic models.

Table B1: Classifying Trade Agreements

	Years in Force	WTO Notification	RTA	Broad RTA
Bilateral Agreements				
Australia-United States	2005, 2009	Article XXIV	yes	yes
Brazil-Mexico	2005, 2009	None	no	yes
China-Indonesia (ASEAN)	2005, 2009	Enabling Clause	no	yes
European Union-Mexico	2000, 2005, 2009	Article XXIV	yes	yes
European Union-Turkey	2000, 2005, 2009	Article XXIV	yes	yes
Indonesia-South Korea	2009	Article XXIV	yes	yes
Japan-Indonesia	2009	Article XXIV	yes	yes
Japan-Mexico	2005, 2009	Article XXIV	yes	yes
Regional Agreements				
Asia-Pacific Trade Agreement	2005, 2009	Enabling Clause	no	no
Global System of Trade Preferences	1995, 2000, 2005, 2009	Enabling Clause	no	no
North American Free Trade Agreement	1995, 2000, 2005, 2009	Article XXIV	yes	yes

Note: Asia-Pacific Trade Agreement includes China, India, and South Korea (among others). Global System of Trade Preferences includes Brazil, India, Indonesia, Mexico, and South Korea (among others). The North American Free Trade Agreement (NAFTA) includes Canada, Mexico, and the United States.

Table B2: Bilateral Tariffs and Domestic Value Added in Foreign Production with Broad Definition of RTAs

	Full Sample			No RTA	No RTA Linear IV
	(1)	(2)	(3)	(4)	(5)
Log DVA: $\ln(DVA^j_{xit})$	-0.43**			-0.11*	-0.14***
	(0.17)			(0.062)	(0.049)
Log DVA Outside RTAs: $[1-RTA_{ijt}]\times\ln(DVA^j_{xit})$		-0.49**	-0.50*		
		(0.20)	(0.29)		
Log DVA Inside RTAs: $RTA_{ijt}\times\ln(DVA^j_{xit})$		0.030			
		(0.30)			
Reciprocal Trade Agreement: RTA_{ijt}	-3.73***	-6.26**	-6.17***		
	(0.65)	(2.47)	(1.76)		
Observations	8,853	8,853	8,853	8,076	8,076
R-Squared	0.991	0.991	0.991	0.998	0.998

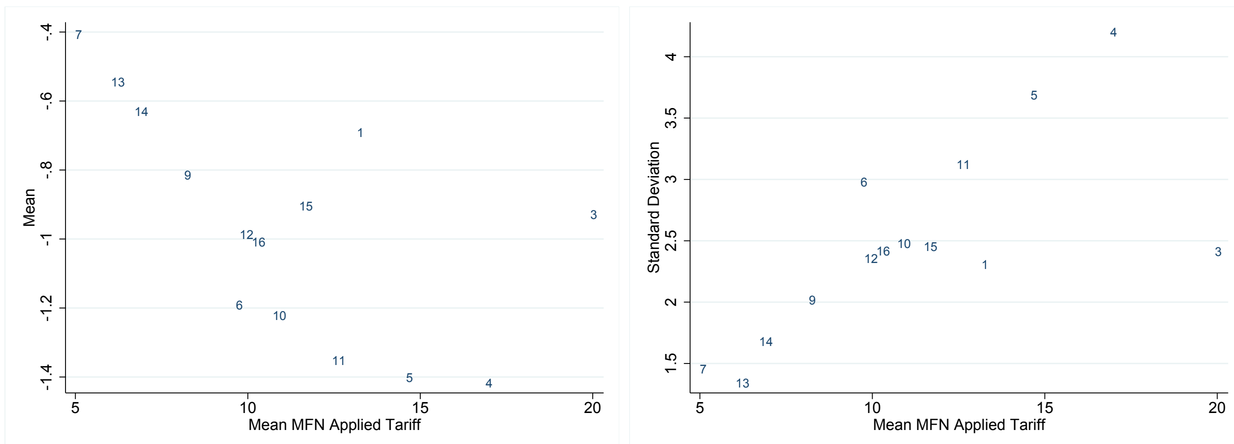
Note: Dependent variable in all columns is the applied bilateral tariff of country i in industry x against exporter j at time t: t^i_{xjt}. Log DVA ($\ln(DVA^j_{ijt})$) is domestic value added from the importing country(i) embodied in final production in industry x in the exporting country (j). Reciprocal Trade Agreement is an indicator that takes the value one if i and j have a reciprocal trade agreement in force, according to the broad definition in Table B1. Standard errors (in parentheses) are clustered by importer-exporter pair. Significance levels: * $p < .1$, ** $p < .05$, *** $p < .01$.

Table B3: Instrumental Variables Estimates for Bilateral Tariffs and Value-Added Content

Panel A: Full Sample				
	Baseline OLS		Linear IV	
	(1)	(2)	(3)	(4)
Log DVA-Ratio: $\ln(DVA^{j}_{xi,t}/IM^{i}_{xj,t})$	-0.48***	-0.55***	-0.97**	-0.96**
	(0.18)	(0.21)	(0.40)	(0.40)
Log FVA-Ratio: $\ln(FVA^{i}_{x,t}/IM^{i}_{xj,t})$	-0.31**		-18.5**	
	(0.15)		(7.45)	
Log Inv. IP-Ratio: $\ln(FG^{i}_{x,t}/IM^{i}_{xj,t})$	0.88***		19.2**	
	(0.30)		(7.67)	
Log IP-Ratio + Log FVA Ratio $(\gamma^{IP}+\gamma^{FVA})$		0.63***		0.68***
		(0.22)		(0.24)
Reciprocal Trade Agreement: RTA_{ijt}	-4.59***	-4.50***	-4.59***	-4.59***
	(0.89)	(0.90)	(0.85)	(0.85)
Observations	8,707	8,707	8,707	8,707
Under-Identification Test (rk LM statistic)			33.7	21.3
Weak-Identification Test (Wald rk F statistic)			13.3	12.0
Conditional F-Stat (Log DVA-Ratio)			25.65	24.26
Conditional F-Stat (Log FVA-Ratio)			53.53	
Conditional F-Stat (Log FG-Ratio)			53.52	
Panel B: No RTA Sample				
	Baseline OLS		Linear IV	
	(5)	(6)	(7)	(8)
Log DVA-Ratio: $\ln(DVA^{j}_{xi,t}/IM^{i}_{xj,t})$	-0.12*	-0.15**	-0.14	-0.13
	(0.063)	(0.073)	(0.25)	(0.25)
Log FVA-Ratio: $\ln(FVA^{i}_{x,t}/IM^{i}_{xj,t})$	-0.054		-6.36**	
	(0.074)		(3.21)	
Log Inv. IP-Ratio: $\ln(FG^{i}_{x,t}/IM^{i}_{xj,t})$	0.28***		6.65**	
	(0.10)		(3.26)	
Log IP-Ratio + Log FVA Ratio $(\gamma^{IP}+\gamma^{FVA})$		0.26***		0.29***
		(0.078)		(0.078)
Observations	8,045	8,045	8,045	8,045
Under-Identfication Test (rk LM statistic)			27.6	17.3
Weak-Identfication Test (Wald rk F statistic)			10.5	9.60
Conditional F-Stat (Log DVA-Ratio)			19.81	19.48
Conditional F-Stat (Log FVA-Ratio)			37.88	
Conditional F-Stat (Log FG-Ratio)			37.83	
Fixed Effects (both panels)				
Importer-Year	Y	N	Y	N
Industry-Year	Y	N	Y	N
Importer-Industry	Y	N	Y	N
Importer-Industry-Year	N	Y	N	Y
Exporter-Industry-Year	Y	Y	Y	Y

Note: See Table 6 notes. Under/Weak-Identification Tests are based on Kleinbergen and Paap (2006). Conditional F-Stats are based on Sanderson and Windmeijer (2015). Standard errors (in parentheses) are clustered by importer-exporter pair. Significance levels: * $p < .1$, ** $p < .05$, *** $p < .01$.

Figure B1: Mean and Standard Deviation of Tariff Preferences versus MFN Tariffs, by Sector



(a) Mean of Tariff Preferences

(b) Standard Deviation of Tariff Preferences

Note: Tariff preference equals the applied bilateral tariff for importer i against exporter j in industry x minus the MFN applied tariff for importer i in industry x. Both means and standard deviations are computed by sector, pooling all importer-exporter-year observations within sector, including those with zero preferences. The markers denote WIOD sector numbers, included in Table 1.