Global Value Chains and Trade Policy*

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March 29, 2021

Abstract

How do global value chain (GVC) 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 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 the foreign content of domestically-produced final goods. Using theory as a guide, we estimate the influence of GVC linkages on trade policy with data on bilateral applied tariffs, temporary trade barriers, and value-added contents for 14 major economies between 1995 and 2015. 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.

JEL Codes: F1, F13, F68

*We thank Adam Szeidl and three anonymous referees, whose insights and suggestions greatly improved the paper. We are also grateful to Thibault Fally, Nuno Limão, Ralph Ossa, Fernando Parro, Nina Pavcnik, Raymond Robertson, and Robert Staiger for detailed feedback on early drafts. Bown acknowledges financial support from the World Bank's Multi-Donor Trust Fund for Trade and Development. Carys Golesworthy provided outstanding research assistance.

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1 Introduction

The rise of global value chains (GVCs) has transformed the nature of production. In the modern global economy, most final goods are made by combining foreign and domestic inputs via supply networks that traverse 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. Value chain concerns have also been prominent in recent debates about the United Kingdom's exit from the European Union and the re-design of the North American Free Trade Agreement.[1] This policy emphasis derives from a tacit expectation that GVC linkages alter the conventional calculus of trade protection; 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 to GVCs by practitioners, they are largely absent in existing theoretical and empirical analyses of trade policy. One reason is that GVCs are a relatively new phenomenon, so 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] This factor trade severs the link between the location where goods are produced and the nationality of who earns the income generated from that production. Developing this insight, we show that government objectives over final goods tariffs can be characterized

[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 a high profile dispute between Nike and New Balance concerning United States import tariffs [Wall Street Journal (2013)] are testimony to the role of value chain concerns in shaping corporate positions on trade policy.

[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.

in terms of two basic GVC features: the pattern of trade in factor services, which defines how income generated by final goods production is apportioned across countries, and the system of pass-through elasticities that govern how income paid to agents engaged in the GVC depends on final goods prices. This approach reduces a complex trade policy problem to a tractable, intuitive one. Further, because GVC income is tied to the value-added content of final goods, we are able to capitalize on recent advances in measuring value-added contents to connect theory with trade policy empirics.

Embedding this production structure into a workhorse model of trade policy, we show that final goods tariffs will be decreasing in both the amount of domestic GVC income generated by production of foreign final goods and the amount of foreign GVC income generated by production of domestic final goods. We then assemble rich new data on bilateral applied tariffs, temporary trade barriers (TTBs), and value-added contents to estimate the influence of GVC linkages on trade policy outcomes for 14 major economies over the 1995-2015 period. Our empirical findings support the key mechanisms underlying the theory; 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 GVC linkages. To highlight the essential mechanics, we note that the use of GVC inputs 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. Further, it captures the most crucial aspects of GVCs, while remaining deliberately agnostic about non-essential micro-economic details.[3] This flexibility offers two important advantages: first, it implies that the 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.

We develop the theory in several steps. We first present the main argument in a benchmark two-good, two-country model with specific factors. We characterize the equilibrium relationship between GVC linkages and optimal tariffs on final goods, and we derive the com-

[3] While our value-added (factor exchange) approach distills the government's tariff problem for final goods, it is not appropriate for studying optimal input tariffs. We discuss this distinction in Section 2.5. 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)]. We therefore focus our theory of how GVCs influence discretionary policy on instruments (final goods tariffs) that governments use most often in practice.

parative statics that underlie our empirical approach. In a pair of extensions, we demonstrate that the key results are robust to allowing for endogenous reorganization of GVCs in response to tariffs, and we address the role of input tariffs, providing the theoretical basis for our focus on how GVCs modify protectionist motives over final goods.

The theory predicts that final goods tariffs deviate from the standard "inverse export supply elasticity rule" for two reasons. First, when foreign producers use inputs from the home country in production, the importing country's incentive to manipulate the terms of trade is diminished.[4] Put simply, an importer's tariff pushes down the price that foreign producers receive for their output, which hurts upstream domestic interests that supply inputs to that foreign industry. Thus, all else equal, a country will set lower tariffs against imports that embody more of its own domestic value-added content. Second, when domestic producers use foreign inputs in production, some of the protectionist rents from higher tariffs accrue to foreign input suppliers. This effect also dampens the government's motivation to apply import protection.[5]

Preparing to take these theoretical predictions to the data, we extend the stylized two-by-two model to allow for many countries and many goods. We also incorporate political economy motives for government policy, in the tradition of Grossman and Helpman (1994). In this extended model, we characterize unilaterally-optimal *bilateral* tariffs for final goods. In addition to providing bilateral, industry-specific predictions, this model sheds light on how political economy concerns interact with GVC linkages. If the government affords additional political weight to domestic suppliers of inputs used in foreign production, then the tariff liberalizing effect via the first channel will be stronger. Conversely, if the government affords political weight to foreign suppliers of inputs to domestic producers, then these political concerns may weaken (or even overturn) the second channel. In addition to these new results, the model also features the standard result that politically-optimal tariffs rise if the government favors domestic producers of final goods, which is an important empirical consideration [Goldberg and Maggi (1999); Gawande and Bandyopadhyay (2000)].

We then advance this analysis further, by describing 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. Specifically, the MFN rule constrains applied bilateral tariffs to

[4] While our model features a terms-of-trade motive for protection, the basic insights are portable to alternative environments, including models that feature extensive margin adjustments and de-location effects in addition to (or instead of) conventional terms-of-trade motives.

[5] Importantly, this second effect 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.

be set at or below a country's multilateral MFN tariff. At the same time, some bilateral tariffs are set via regional trade agreements, in which terms-of-trade concerns may be neutralized by cooperative negotiation [Grossman and Helpman (1995*b*); Bagwell and Staiger (1999)]. We account for both these institutions in our empirical strategy. The result is a framework for bilateral trade policy analysis in the presence of institutional constraints; this framework is an ancillary contribution that can be used for a variety of empirical applications.

Building on this foundation, we combine data on bilateral import protection and value-added content to estimate the influence of GVC linkages on tariff-setting in practice. Our analysis focuses on dimensions of policy over which governments have scope to implement discretionary levels of protection.[6] We first examine bilateral tariff preferences – downward deviations in applied bilateral tariffs from multilateral MFN levels. We then examine the use of temporary trade barriers (antidumping, safeguards, and countervailing duties) in a separate, complementary exercise. Throughout, we measure value-added contents using input-output methods and data from the World Input-Output Database.

Theory motivates the empirical specifications we adopt and our identification strategy. We control for confounding factors via observable control variables (e.g., the inverse import penetration ratio) and flexible fixed effects (which absorb variation in export supply elasticities). We attend to the institutional environment in which policy is set, first by accounting for censoring due to the MFN rule, and then exploring how the role of GVC linkages differs across trade policy regimes (e.g., inside versus outside RTAs). We also explore how economic forces shape coefficient heterogeneity in our sample, focusing the role of upstream and downstream product differentiation in shaping the pass-through elasticities from GVC income to optimal tariffs. We address threats to identification, which arise from potential simultaneity and omitted variables concerns, by using instrumental variables and controlling for observable proxies for potential confounding effects.

Our results support the theoretical predictions: higher domestic value-added content in foreign final goods, and higher foreign value-added content in domestic goods, are associated with systematically larger tariff preferences. Consistent with previous work on 'Protection for Sale' type political economy forces, we also find that tariff preferences are smaller – protection is greater – when the import penetration ratios is low. Further consistent with theory, the liberalizing effect of domestic content in foreign goods holds for tariffs set outside of RTAs, but not for those set within RTAs. The influence of domestic content is also strongest when it originates in upstream sectors that are differentiated, indicative of a strong pass-through

[6] 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.

from final goods prices to returns to upstream factors, and in downstream final goods sectors that are differentiated, which likely feature lower export supply elasticities. The estimated influence of GVC linkages on tariffs becomes stronger when we instrument for value-added content, and when we correct for censoring of applied bilateral tariffs induced by the MFN rule.

Finally, we show that temporary trade barriers (TTBs) respond to GVC linkages 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 content in foreign production to be strongest for TTB-use against China, where antidumping and other TTBs were most actively deployed during the 1995-2015 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 these approaches, we are agnostic about the nature of price determination within global value chains, and our results over optimal final goods tariffs obtain even if prices are determined by market clearing conditions, as in conventional models.

More recently, Antràs et al. (2021) and Caliendo et al. (2021) study optimal tariffs in quantitative models with roundabout production and imperfect competition. Beshkar and Lashkaripour (2020) conduct related analysis of optimal policy in a quantiative Ricardian framework with perfect competition.[7] While these very recent contributions advance the literature in a number of directions, the upshot is that optimal input tariffs depend critically on the precise modelling assumptions one adopts (see Antràs and Chor (2021) for a summary of this nascent literature). This constrasts with our theoretical findings for final goods tariffs, as we discuss at length in Section 2.5.

Our theory is also related to Blanchard (2007, 2010), which show 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 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

[7] Beshkar and Lashkaripour (2020) offer an elegant theoretical characterization of optimal trade taxes. A subtle but critically-important feature of their analysis is that it allows for export taxes, in addition to import tariffs. In contrast, we rule out export taxes, which are seldom used and even unconstitutional in the United States.

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 (2018); Nicita, Olarreaga and Silva (2018)]. 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, a couple of very recent papers leverage the value-added approach we develop in this paper and find results that echo our findings in different contexts. Ludema et al. (2019) explore the structure of protection and Chinese processing trade. Adapting the theory and bringing new data to bear, they find that input customization and political economy forces play an important role in shaping the relationship between GVCs and trade protection. Focusing instead on the discretionary removal of trade protections after the creation of the WTO, Bown, Erbahar and Zanardi (2020) find that bilateral DVA linkages predict the probability that duties will be removed, consistent with our findings.

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 2 presents the theory in a benchmark two-by-two model, derives comparative statics, and explores extensions with endogenous GVC formation and input tariffs. Section 3 bridges from theory to data, laying out our empirical strategy for investigating applied tariffs and describing the data. Section 4 presents the main empirical results for tariff preferences. Section 5 presents complementary empirical findings for Temporary Trade Barriers. Section 6 concludes.

2 Theory

In this section, we describe how global value chain linkages influence tariff setting in a two-country, two-good (2x2) environment, in the tradition of Johnson (1953-1954). To maintain focus, we restrict attention to a single trade policy instrument: an ad-valorem tariff applied to imports of a final good that is produced via a global value chain.

We lay out the baseline model in Section 2.1, in which we assume that the final good is produced by combining domestic and foreign specific factors (GVC inputs). In Section 2.2, we characterize the implicit function that links final goods tariffs to the (potentially observable) domestic value-added content of foreign goods and the foreign value-added content of domestic goods. We also provide a comparative statics proposition that traces exogenous changes in the endowment of GVC inputs through to optimal tariffs in Section 2.3. We then discuss two extensions of the baseline model. First, in Section 2.4, we relax the specific factors assumptions to allow for endogenous changes in GVC inputs in response to tariffs. Second, we describe how input tariffs can be incorporated into the theory in Section 2.5.

2.1 The 2x2 Benchmark Model

Section 2.1.1 describes the economic environment. Section 2.1.2 characterizes the economic equilibrium as a function of the tariff.

2.1.1 Economic Environment

Two countries, indexed by $c \in \{h, f\}$ and referred to as Home and Foreign, are populated with a continuum of identical agents who produce, trade, and consume two goods, indexed by $s \in \{x, y\}$. Let good y serve as the freely-traded numéraire, and let p^c denote the local price of good x measured in units of good y in country c. Together, the residents of each country hold claims on all of the country's endowments.

Preferences Agents in each country have identical Gorman form preferences, represented by the utility function: $U(d_x^c, d_y^c)$, where d_s^c denotes consumption of good s in country c.

Factor Endowments There are two types of factors. The first is a homogeneous factor (e.g., undifferentiated labor), which is perfectly mobile across sectors, but immobile across countries. The second is a set of specific factors, which we refer to as "GVC inputs." For now, assume that these GVC inputs are specific to the destination country and sector in which they are used to produce final goods. Let ν_h^c (ν_f^c) denote the quantity of the Home (Foreign) GVC input used in production of final good x in country c, and let $\vec{\nu}^c \equiv (\nu_h^c, \nu_f^c)$. (Regarding notation, superscripts will denote country location of final production, and subscripts identify the origin country of the GVC input.)

Technology Goods are produced under constant returns by atomistic firms in perfectly competitive markets. The numéraire good y is produced using homogeneous labor, while good x is produced by combining labor with GVC inputs. Production technologies are summarized by the following production functions:

$$q_x^c = f_x^c(l_x^c, \nu_h^c, \nu_f^c), \qquad \text{and} \qquad q_y^c = l_y^c, \tag{2.1}$$

where q_s^c is output of good s in country c, and l_s^c is the quantity of homogeneous labor used in production of good s.

This stylized depiction of the production process captures two essential features of global value chains. First, both domestic and foreign factors of production are used to produce output in a GVC. Second, GVCs 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, this lock-in is manifest as factor specificity.[8]

Consistent with perfect competition, GVC inputs capture all residual profit (quasi-rent) from local final good production. In this specific factors setting, this rent depends only on the local price of good x (p^c) and the quantities of GVC inputs available for use in production ($\vec{\nu}^c$). We are deliberately agnostic about the exact division of these quasi-rents between Home and Foreign input owners; We assume only that the mapping from final goods prices to the return to each GVC input is well-defined and positive.[9] Using r_h^c (r_f^c) to denote the per-unit return to ν_h^c (ν_f^c), we formalize this assumption as follows:

Assumption 2.1. *$r_j^c \equiv r_j^c(p^c; \vec{\nu}^c)$ where $\frac{\partial r_j^c(p^c;\vec{\nu}^c)}{\partial p^c} > 0$ for $c, j \in \{h, f\}$.*

This assumption rules out the possibility that a change in final goods revenue could lead to redistribution of rents between different input suppliers such that the return to one input (weakly) declines while the return to the other rises.[10]

[8] An important feature of this setup is that the production function is written in terms of primary factor inputs. This allows us to avoid specifying various microeconomic details about how intermediate inputs are transformed into final goods. A simple two-stage 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, in which inputs cross borders many times, are also compatible with our reduced-form representation of the production process.

[9] The division of rents is indeterminate with multiple specific factors. In a more general model, the division of rents would depend on supply-side primitives regarding frictions that govern matching between GVC input suppliers and final goods producers, bargaining power of different agents, etc.

[10] Outside a specific factors setting, the return to value-added inputs will depend on both the Home and Foreign price; we discuss this possibility further in Section 2.4.

Tariffs and Timing We assume that x is Home's natural import good and allow the Home government to impose an ad-valorem tariff on imports, applied to the Foreign selling price.[11] The government chooses its tariff to maximize aggregate indirect utility of Home residents, subject to balanced budget constraints and global market clearing conditions. Taking the tariff as given, firms maximize profits and consumers maximize welfare. The government has perfect foresight and there is no uncertainty in the model.

Both countries are assumed to be "large," in that government tariff choices may affect market-clearing prices. Following common practice [e.g. Bagwell and Staiger (1999)], we rule out the Metzer and Lerner paradoxes to ensure that an increase in the home country's tariff causes the price of the imported good to rise at Home and fall abroad. Using τ to represent one plus the tariff and $\tilde{p}^c$ to represent the equilibrium price of good x in country c, we assume that:

Assumption 2.2. $\frac{d\tilde{p}^f}{d\tau} \leq 0 \leq \frac{d\tilde{p}^h}{d\tau}$.

2.1.2 Model Solution

Production The technology for the numéraire good y normalizes the equilibrium wage to one in both countries. Profit maximization by atomistic firms and the local labor market clearing condition then determine the allocation of labor across sectors according to:

$$l_x^c(p^c; \vec{\nu}^c) = \arg\max_{l_x^c} \; p^c f_x^c(l_x^c, \nu_h^c, \nu_f^c) - l_x^c, \tag{2.2}$$

$$l_y^c(p^c; \vec{\nu}^c) = L^c - l_x^c(p^c; \vec{\nu}^c), \tag{2.3}$$

where L^c is the total local labor endowment in country c and $l_x^c + l_y^c \leq L^c$.[12] Substituting these labor allocation functions into the production functions yields the supply function for each good:

$$q_x^c(p^c; \vec{\nu}^c) = f_x^c(l_x^c(p^c; \vec{\nu}^c); \vec{\nu}^c) \tag{2.4}$$

$$q_y^c(p^c; \vec{\nu}^c) = l_y^c(p^c; \vec{\nu}^c). \tag{2.5}$$

[11] Export taxes are ruled out, since they are seldom used in practice, and even unconstitutional in the United States. From a theoretical perspective, allowing Foreign to charge an *exogenous* export tax would introduce an additional parameter to the model, but would not otherwise affect the predictions of the theory.

[12] To streamline notation, we suppress L^c as an argument going forward.

With perfect competition, GVC inputs capture residual profits from final good production, denoted π_x^c, which depend on the local price and factor use:

$$\pi_x^c(p^c;\vec{\nu}^c) \equiv r_h^c(p^c;\vec{\nu}^c)\nu_h^c + r_f^c(p^c;\vec{\nu}^c)\nu_f^c = p^c q_x^c(p^c;\vec{\nu}^c) - l_x^c(p^c;\vec{\nu}^c). \tag{2.6}$$

Consumption With Gorman form preferences, aggregate demand and indirect utility depend only on local prices and aggregate national income:

$$d_x^c(p^c, I^c) = \arg\max_{d_x^c} \quad U(d_x^c, d_y^c) \quad s.t. \quad d_y^c + p^c d_x^c \leq I^c, \tag{2.7}$$

$$d_y^c(p^c, I^c) = I^c - p^c d_x^c(p^c, I^c), \tag{2.8}$$

$$V(p^c, I^c) = U(d_x^c(p^c, I^c), d_y^c(p^c, I^c)), \tag{2.9}$$

where $V(\cdot)$ is indirect utility and I^c is national income.

National Income In turn, national income is the sum of factor payments plus tariff revenue, R^c:

$$I^c = L^c + r_c^h(p^h;\vec{\nu}^h)\nu_c^h + r_c^f(p^f;\vec{\nu}^f)\nu_c^f + R^c. \tag{2.10}$$

Home tariff revenue is $R^h = (p^h - p^f)M_x(\vec{p}, I^h;\vec{\nu}^h)$, where $M_x(\cdot) \equiv d_x^h(p^h, I^h) - q_x^h(p^h;\vec{\nu}^h)$ is Home's imports of good x; since Foreign practices free trade, $R^f = 0$. Because income depends on tariff revenue, and tariff revenue depends on income, Equation (2.10) implicitly defines income as a function of prices and GVC input use: $I^c \equiv I^c(\vec{p};\vec{\nu})$.

Equivalently, national income can be written (implicitly) as the sum of the value of domestic final good production at local prices and tariff revenue, less payments to foreign GVC inputs used in domestic production (FVA), plus income earned by domestic GVC inputs used in foreign production (DVA):

$$I^c = p^c q_x^c(p^c;\vec{\nu}^c) + q_y^c(p^c;\vec{\nu}^c) + R^c - \underbrace{r_j^c(p^c;\vec{\nu}^c)\nu_j^c}_{\equiv FVA^c} + \underbrace{r_c^j(p^j;\vec{\nu}^j)\nu_c^j}_{\equiv DVA_c}, \tag{2.11}$$

where $j \neq c$. The first three components of this expression mirror standard models. The last two components reflect GVC linkages. Foreshadowing results to come, note that FVA^c and DVA_c depend on final goods prices via the endogenous return to GVC inputs. Because tariffs influence these final goods prices, trade policy affects income in a non-standard way in the presence of GVCs.

Market Clearing and Equilibrium Prices The relative price of x in Home is determined by its tariff and the foreign equilibrium price according to the no-arbitrage condition:

$$p^h(\tau, p^f) = \tau p^f. \tag{2.12}$$

The equilibrium Foreign price ($\tilde{p}^f$) is then determined by market clearing:

$$d_x^h(p^h(\tau,\tilde{p}^f),\tilde{p}^f;\vec{\nu}) + d_x^f(p^h(\tau,\tilde{p}^f),\tilde{p}^f;\vec{\nu}) = q_x^h(p^h(\tau,\tilde{p}^f);\vec{\nu}^h) + q_x^f(\tilde{p}^f;\vec{\nu}^f), \tag{2.13}$$

where supply and demand are given by Equations (2.4), (2.7), and (2.11).[13] The equilibrium foreign price is a thus a function of Home's tariff and $\vec{\nu}$: $\tilde{p}^f \equiv \tilde{p}^f(\tau;\vec{\nu})$.

2.2 The Optimal Tariff

The Home government chooses the tariff to maximize aggregate indirect utility, subject to optimal consumer and producer responses and market clearing conditions. Suppressing exogenous arguments, the optimal tariff (τ^o) is given by:

$$\begin{aligned} \tau^o = \arg\max_{\tau} \quad & V\big(p^h, I(p^h,p^f)\big) \\ \text{s.t.} \quad & p^h = \tau p^f = \tilde{p}^h(\tau) \quad \text{and} \quad p^f = \tilde{p}^f(\tau). \end{aligned} \tag{2.14}$$

The associated first order condition is:

$$V_\tau = V_p \frac{d\tilde{p}^h}{d\tau} + V_I \left\{ \frac{\partial I(p^h,p^f)}{\partial p^h}\frac{d\tilde{p}^h}{d\tau} + \frac{\partial I(p^h,p^f)}{\partial p^f}\frac{d\tilde{p}^f}{d\tau} \right\} = 0, \tag{2.15}$$

where $V_p \equiv \frac{\partial V(p^h,I^h)}{\partial p^h}$ and $V_I \equiv \frac{\partial V(p^h,I^h)}{\partial I^h}$.[14] Applying Roy's identity, using the derivatives of Equation (2.11) with respect to p^h and p^f, and collecting terms yields:

$$V_\tau = V_I\Bigg[\underbrace{(\tau^o-1)p^f\frac{dM_x}{d\tau} - M_x\frac{d\tilde{p}^f}{d\tau}}_{\text{terms-of-trade motive}} - \frac{dFVA^h}{d\tau} + \frac{dDVA_h}{d\tau}\Bigg] = 0. \tag{2.16}$$

The expression above the underbrace captures the standard terms-of-trade cost-shifting motive [Johnson (1951-1952)]. The remaining two terms in (2.16) reflect the influence of GVC linkages on the optimal tariff: tariffs change the income accruing to Foreign GVC inputs in Home production (FVA^h) and Home GVC inputs used in Foreign production (DVA_h).

[13] Combining (2.7) and (2.11) yields: $d^c(p^c, I^c(\vec{p};\vec{\nu})) = d^c(\vec{p};\vec{\nu}), c \in \{h,f\}$, as written in (2.13). By Walras' law, the market for y also clears according to the national balanced budget conditions embedded in (2.8).

[14] Assumption 2.2 ensures that the second order condition, $V_{\tau\tau} < 0$, is satisfied for sufficiently small tariffs.

With an eye toward empirical applications, we decompose $\frac{dFVA^h}{d\tau}$ and $\frac{dDVA_h}{d\tau}$ as follows:

$$\frac{dFVA^h}{d\tau} = \frac{dFVA^h}{dp^h}\frac{d\tilde{p}^h}{d\tau} = \underbrace{\left(\frac{dr_f^h}{dp^h}\frac{p^h}{r_f^h}\right)}_{\equiv\varepsilon_f^{rh}>0}\underset{+}{\frac{r_f^h\nu_f^h}{p^h}}\underset{+}{\frac{dp^h}{d\tau}} = \varepsilon_f^{rh}\frac{FVA^h}{p^h}\frac{d\tilde{p}^h}{d\tau} > 0, \tag{2.17}$$

$$\frac{dDVA_h}{d\tau} = \frac{dDVA_h}{dp^f}\frac{d\tilde{p}^f}{d\tau} = \underbrace{\left(\frac{dr_h^f}{dp^f}\frac{p^f}{r_h^f}\right)}_{\equiv\varepsilon_h^{rf}>0}\underset{+}{\frac{r_h^f\nu_h^f}{p^f}}\underset{-}{\frac{dp^f}{d\tau}} = \varepsilon_h^{rf}\frac{DVA_h}{p^f}\frac{d\tilde{p}^f}{d\tau} < 0. \tag{2.18}$$

Here ε_f^{rh} and ε_h^{rf} represent the elasticity of the return to GVC inputs with respect to changes in the local final goods price in Home and Foreign, respectively. These elasticities are positive under Assumption 2.1: an increase in the factory-gate price of a given final good implies higher returns to all of the value-added inputs used to make it.[15]

Substituting Equations (2.17) and (2.18) into the first order condition, applying the market-clearing condition, and isolating τ^o, we arrive at an implicit function that defines the optimal tariff:

$$\tau^o = 1 + \frac{1}{\epsilon_x^f}\left(1 - \varepsilon_h^{rf}\frac{DVA_h}{p^f E_x^f} - \varepsilon_f^{rh}\frac{FVA^h}{p^h E_x^f}\frac{1}{|\lambda|}\right), \tag{2.19}$$

where $\lambda \equiv \frac{d\tilde{p}^f}{d\tau}\Big/\frac{d\tilde{p}^h}{d\tau} < 0$ and $\epsilon_x^f > 0$ is foreign export supply elasticity.[16]

This expression echoes the canonical solution for the optimal tariff of a national-income maximizing government, as in Johnson (1951-1952), but it is modified to incorporate GVC linkages. Specifically, the inverse export supply elasticity captures the terms-of-trade motive for tariff setting by large countries;[17] GVC linkages alter that motive in two ways.

First, the use of Home GVC inputs in foreign production serves to dampen the terms-of-trade cost-shifting motive. The reason is that $\frac{dDVA_h}{d\tau} = \frac{dDVA_h}{dp^f}\frac{d\tilde{p}^f}{d\tau} < 0$: an increase in Home's tariff, which lowers the price of foreign-produced final goods, is passed back through the value chain (in the form of lower returns) to Home's suppliers of GVC inputs used in foreign production. In effect, GVC links lead the large importing country to internalize some of the terms-of-trade externality. As in Equation (2.18), the strength of this mechanism is increasing with the pass-through elasticity from foreign final goods prices to domestic GVC

[15] Note that Home's tariff affects GVC income only through local final goods prices. In a model with endogenous GVC inputs and sufficient input substitutability across borders and/or sectors, GVC income depends on the complete vector of final goods prices worldwide; see Appendix A.3.

[16] In the presence of GVCs, export supply elasticity includes potential Foreign income effects from changes in GVC income. Thus, we define: $\epsilon_x^f \equiv \epsilon_x^f(\tau, \vec{\nu}) = \frac{p^f}{E_x^f}\frac{dE_x^f(p^f, I^f)}{dp^f} + \frac{\partial E_x^f(p^f, I^f)}{\partial I^f}\frac{dFVA}{dp^h}\frac{p^f}{\lambda E_x^f}$, where the first term is the direct analog to the trade elasticity in conventional models without GVC income.

[17] When foreign export supply is less elastic, the Home government has greater market power to improve its terms of trade at the expense of foreign exporters and will therefore set a higher tariff.

inputs (ε_h^{rf}) and the magnitude of the GVC input trade (DVA_h).

Second, the use of Foreign GVC inputs in Home production gives rise to a second, distinct spillover channel. An increase in Home's tariff raises income earned by those foreign factors of production, $\frac{dFVA^h}{d\tau} = \frac{dFVA}{dp^h}\frac{d\tilde{p}^h}{d\tau} > 0$: Home's tariff raises the price received by domestic import-competing final goods producers, at the expense of domestic consumers. When Home production uses foreign-sourced GVC inputs, some of the protectionist rents generated by this price increase are passed back upstream to Foreign input suppliers. This FVA pass-through mechanism – from Home's tariff to its domestic price, and from the domestic price to the return to Foreign GVC inputs embedded in domestic production – constitutes a distinct domestic-price externality that also serves to drive down the optimal tariff, all else equal. The strength of the mechanism is again increasing with the pass-through elasticity ε_f^{rh} and the magnitude of GVC input trade (FVA^h).

In Equation (2.19), we further note that the trade volume (E_x^f) and the elasticity of trade (ϵ_x^f) scale the (direct) relationship between the GVC terms and the optimal tariff. This is because the trade volume influences the strength of GVC linkages as a counterweight to the terms-of-trade motive. All else equal, higher trade volumes magnify the terms-of-trade motive relative to the (direct) trade-liberalizing influence GVC linkages.

The optimal tariff expression in Equation (2.19) offers valuable insights into the equilibrium relationship between the tariff level and the elasticity of trade, trade values, pass-through elasticities, and GVC income. Further, by linking optimal tariffs to potentially-observable GVC income linkages, it will serve to structure our empirical investigation to follow. Before pushing forward in that direction, we pause to present comparative statics results that describe how optimal tariffs change in response to exogenous changes in GVCs.

2.3 Comparative Statics

In this section, we characterize the impact of exogenous changes in the endowment of GVC inputs on the optimal tariff. Specifically, consider an increase in either the quantity of Home GVC inputs used in Foreign production (ν_h^f), or the quantity of Foreign GVC inputs used in Home production (ν_f^h). These changes will lead Home's optimal tariff to decline, as long as their direct effects outweigh their indirect effects. The following proposition formalizes this statement.

Proposition 1. *The optimal tariff is decreasing with GVC inputs ν_h^f [ν_f^h] if and only if the (unambiguously negative) direct first-order influence of ν_h^f [ν_f^h] on the optimal tariff outweighs any indirect second-order influence of ν_h^f [ν_f^h] on the tariff via changes in trade volumes, trade elasticity, and pass-through rates; i.e. if and only if Condition 1 [2] is satisfied.*

Condition 1. *Necessary and sufficient condition for* $\frac{d\tau^o}{d\nu_h^f} < 0$*:*

$$\left[\underbrace{\frac{dr_h^f}{dp^f}}_{\text{direct effect(+)}} + \underbrace{\frac{d}{d\nu_h^f}\left(\frac{dr_h^f}{dp^f}\right)\nu_h^f + \frac{d}{d\nu_h^f}\left(\frac{dr_f^h}{dp^h}\frac{1}{|\lambda|}\right)\nu_f^h}_{\text{(indirect) changes in pass-through rates (+/-)}} + \underbrace{\frac{d}{d\nu_h^f}\left((\tau^o - 1)E_x^f(\epsilon_x^f - 1)\right)}_{\text{(indirect) change in terms of trade motive (+/-)}} \right]\Bigg|_{\tau^o} > 0.$$

Condition 2. *Necessary and sufficient condition for* $\frac{d\tau^o}{d\nu_f^h} < 0$*:*

$$\left[\underbrace{\frac{dr_f^h}{dp^h}\frac{1}{|\lambda|}}_{\text{direct effect(+)}} + \underbrace{\frac{d}{d\nu_f^h}\left(\frac{dr_h^f}{dp^f}\right)\nu_h^f + \frac{d}{d\nu_f^h}\left(\frac{dr_f^h}{dp^h}\frac{1}{|\lambda|}\right)\nu_f^h}_{\text{(indirect) changes in pass-through rates (+/-)}} + \underbrace{\frac{d}{d\nu_f^h}\left((\tau^o - 1)E_x^f(\epsilon_x^f - 1)\right)}_{\text{(indirect) change in terms of trade motive (+/-)}} \right]\Bigg|_{\tau^o} > 0.$$

[**Proof in Appendix A.1**] These conditions are satisfied, for example, in a setting with iso-elastic trade and constant pass-through from final goods prices to returns to GVC inputs. We provide a functional form example, with quadratic utility and Cobb-Douglas production, that serves to illustrate the proposition in Appendix A.2.

The following corollary, which follows directly from Equation (2.19), offers another useful benchmark.

Corollary 1.1. *Compare an equilibrium with GVC input trade, in which* $\hat{\nu}_h^f, \hat{\nu}_f^h > 0$*, against a no-GVC benchmark, in which* $\bar{\nu}_h^f, \bar{\nu}_f^h \equiv 0$*. If* $\epsilon_x^f(\tau; \hat{\nu}_h^f, \hat{\nu}_f^h) \geq \epsilon_x^f(\tau; \bar{\nu}_h^f, \bar{\nu}_f^h)\ \forall\ \tau$ *then* $\hat{\tau}^o < \bar{\tau}^o$*.*

In other words, a sufficient (but not necessary) condition for the introduction of trade in GVC inputs to reduce the optimal tariff is that introducing GVC input trade does not increase the importing country's leverage to depress foreign prices by reducing the elasticity of export supply.

2.4 The Optimal Tariff with Endogenous GVCs

Thus far, we have analyzed optimal tariffs under the assumption that GVC inputs are specific factors. We now relax that assumption, allowing producers to re-optimize their use of GVC inputs in response to price changes. To distinguish effects that operate through prices versus quantities, we allow for frictions that limit the substitutability of GVC inputs across destinations, so that the equilibrium returns to those inputs may differ across countries. Beyond this, we are agnostic about the underlying determinants of GVC structure; we assume only that an increase in the local price of the (non-numéraire) final good weakly increases the return to, and the use of, the GVC inputs used in its production. This assumption (formalized in Appendix A.3) is a natural extension of Assumption 2.1. To streamline analysis, we also adopt quasi-linear preferences.

As before, Home's national income is given by Equation (2.11), and the government maximizes aggregate indirect utility subject to the arbitrage and market clearing conditions described in Equation (2.14). The optimal tariff takes the form:

$$\tau^o = 1 + \frac{1}{\epsilon_x^f}\left(1 - (\tilde{\varepsilon}_h^{rf} + \tilde{\varepsilon}_h^{\nu f})\frac{DVA_h}{p^f E_x^f} - (\tilde{\varepsilon}_f^{rh} + \tilde{\varepsilon}_f^{\nu h})\frac{FVA^h}{p^h E_x^f} + \eta\right), \tag{2.20}$$

where ϵ_x^f is the foreign export supply elasticity for final goods (holding $\vec{\nu}$ fixed), η captures the impact of changes in final goods trade as a result of the endogenous change in input use, and the $\tilde{\varepsilon}$s are analogs to the pass-through elasticity terms in the baseline specific factors model. See Appendix A.3 for details of the derivation and precise definition of these terms.

The first substantive difference between this expression and the corresponding optimal tariff in the specific factors model (Equation (2.19)) is that the pass-through terms attached to DVA and FVA now allow for potential changes in both the *prices* (via $\tilde{\varepsilon}^r$) and *quantities* (via $\tilde{\varepsilon}^\nu$) of GVC inputs used in response to tariff changes. In the specific factors setting, the $\tilde{\varepsilon}_j^{rc}$ terms were unambiguously positive, and the $\tilde{\varepsilon}_j^{\nu c}$ terms were identically zero. In this more general model, the signs of $\tilde{\varepsilon}_h^{rf} + \tilde{\varepsilon}_h^{\nu f}$ and $\tilde{\varepsilon}_f^{rh} + \tilde{\varepsilon}_f^{\nu h}$ depend on the relative responsiveness of GVC income to changes in local prices versus changes in prices abroad. Concretely, $\tilde{\varepsilon}_h^{rf} + \tilde{\varepsilon}_h^{\nu f} > 0$ as long as the decrease in the foreign final goods price due to Home's tariff causes DVA to fall more than the potential increase in DVA associated with higher final goods prices at home. Likewise, $\tilde{\varepsilon}_f^{rh} + \tilde{\varepsilon}_f^{\nu h} > 0$ as long as the increase in FVA induced by the increased price of the final good at Home outweighs any potential decline in FVA due to the decline in the foreign price of the final good. Sufficient international segmentation in input markets will ensure that these conditions hold.[18]

The second difference is that there is a new term, η, in the optimal tariff, which captures the impact of changes in GVC input use on final goods production patterns. Notably, some or all of η may cancel with the endogenous input reallocation components of the DVA and FVA terms (the $\tilde{\varepsilon}^\nu$s); how much depends on assumptions regarding the underlying market structure governing input use. For example, if GVC inputs are paid the value of their marginal product, then as frictions in input markets fall to zero, η will cancel the $\tilde{\varepsilon}^\nu$ terms, leaving just the price-pass through mechanisms (the $\tilde{\varepsilon}^r$s). (See Lemma 2 in Appendix A.3.)

[18] Ludema et al. (2019) find that when inputs are highly substitutable across end-uses and countries, and inelastically demanded by downstream producers, it is possible under certain parameter restrictions that an increase in a home country's tariff could cause DVA to fall. For this to happen, an increase in Home's tariff would need to drive up Home's demand for the (tradeable) GVC input in Home so much that it outweighs the negative impact of the concomitantly lower demand for the input overseas. These conditions are special, but not impossible.

In summary, although 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. And although the behavior of the pass-through elasticity terms depends on particular model assumptions, the *sign* of these pass-through terms will be positive as long as the income associated with a given GVC input is more responsive to the local price where the input is used than it is to prices elsewhere. Thus, the basic predictions for how GVCs influence tariff setting are robust to relaxation of the specific-factors assumption, as long as Home's GVC income is decreasing in its tariffs. Accordingly, our predictions would obtain in many models of global value chains.

2.5 Input Tariffs

In analyzing tariffs for final goods, we have abstracted from the simultaneous analysis of input tariffs. We pause here to explain why it is both reasonable and prudent to so.

We begin by introducing input tariffs into the benchmark model. We show that an exogenous tax on Home's foreign-sourced GVC inputs attenuates the impact of FVA on the optimal final goods tariff, but does not change the key directional predictions of the model. We then consider endogenous input tariffs. In the benchmark specific factors model, we note that endogenous input tariffs are both uninteresting and unrealistic: the optimal tariff is set to extract all rents accruing to foreign GVC inputs. Then, we briefly discuss input tariffs in models with endogenous GVC input use. We argue that general predictions for how input tariffs depend on GVC linkages are elusive, in contrast to our results for final goods tariffs.

2.5.1 Input Tariffs in the Benchmark Model

Returning to the specific factors model in Section 2.1, suppose that Home levies an exogenous, ad-valorem tax $g \in [0,1]$ on the foreign-sourced GVC inputs used in domestic production, ν_f^h, applied to the local price of these inputs, r_f^h. All other assumptions and model structure are the same.

As before, national income is given by (2.11), but tariff revenue is now:

$$R^h = (p^h - p^f)M_x^h + g r_f^h \nu_f^h. \tag{2.21}$$

Maximizing aggregate indirect utility subject to market clearing conditions, the first order condition of Home's optimal tariff problem is given by:

$$V_\tau = V_I\left[(\tau^o - 1)p^f\frac{dM_x}{d\tau} - M_x\frac{d\tilde{p}^f}{d\tau} - (1-g)\frac{dFVA^h}{d\tau} + \frac{dDVA_h}{d\tau}\right] = 0. \tag{2.22}$$

Applying the market-clearing condition, using the same tariff decompositions in Equations (2.17) and (2.18), and isolating τ^o, yields the augmented optimal tariff expression:

$$\tau^o = 1 + \frac{1}{\epsilon_x^f}\left(1 - \varepsilon_h^{rf}\frac{DVA_h}{p^f E_x^f} - (1-g)\varepsilon_f^{rh}\frac{FVA^h}{p^h E_x^f}\frac{1}{|\lambda|}\right). \tag{2.23}$$

The input tariff enters this optimal (final good) tariff expression in two ways. First, the input tariff directly weakens the link between FVA and the optimal tariff: all else equal, higher input tariffs allow the Home government to capture more of the protectionist rents associated with final goods tariffs, dampening the tariff-liberalizing influence of FVA on trade protection. Additionally, input tariffs may enter the optimal final goods tariff indirectly, by changing the underlying mapping from final goods prices to input prices (and thus the ε_f^{rh} term).[19] Crucially, neither of these potential effects of input tariffs on final goods tariffs changes the directional predictions of the model. The upshot: introducing arbitrary input tariffs does not change the basic structure of the optimal final goods tariff, or our central finding that GVCs erode mercantilist motives for trade protection in final goods.[20]

2.5.2 Endogenous Input Tariffs

We now take up the question of the optimal tariff on inputs: what is the Home country's optimal tax (g^o) applied to foreign-sourced GVC inputs used in Home production? Although the structure of this problem is similar to the optimal tariff problem for final goods, the nature of the solution is qualitatively different. The directional relationship between input tariffs and GVCs is fundamentally model-dependent, in a way that the relationship between final goods tariffs and GVCs is not.

To begin, notice that allowing for an endogenous input tariff in the context of our benchmark specific-factors setting is trivial. If GVC inputs are fixed, the Home government would use input tariffs to extract all rents associated with foreign-supplied inputs. The optimal input tariff is thus a corner solution at $g^o = 1$. The associated final goods tariff would still be given by Equation (2.23), but with $g = 1$, the optimal tariff would not depend on FVA. Moreover, if the foreign government also used an optimal import tariff to extract all of Home's GVC income (DVA), then Home's optimal final good tariff would collapse to the familiar inverse elasticity rule. This makes sense: if input tariffs allow governments to

[19] This might be the case, for instance, if government policy disrupts bargaining outcomes between upstream sellers and downstream buyers as in Antràs and Staiger (2012).

[20] Adding an exogenous input tax to the model with endogenous GVC input use, described in Section 2.4, yields the general equilibrium analog to Equation (2.23). See Appendix A.4. The qualitative conclusions are the same.

completely expropriate the rents associated with GVC trade, governments will behave as if all factors of production used in local production are their own. This result, however, is as counterfactual as it is obvious; in practice, tariffs on intermediate inputs are systematically lower than final goods tariffs, and they are also very low in absolute terms.

Meaningful analysis of endogenous input tariffs thus requires a general equilibrium setting in which GVC inputs respond endogenously to prices. Drawing on the framework from Section 2.4, we analyze the optimal input tariff in Appendix A.4. For a given final good tariff τ, the first order condition for the optimal input tariff is given by:

$$V_g = V_I \left[(\tau - 1) p^f \frac{dM_x}{dg} - M_x \frac{d\tilde{p}^f}{dg} + p^h \nabla_{\vec{\nu}} q_x^h \cdot D_g \vec{\nu} + \frac{dDVA_h}{dg} - (1 - g^o) \frac{dFVA^h}{dg} + FVA \right] = 0 \quad (2.24)$$

On examination, it is clear that optimal input tariffs, like final goods tariffs, will be characterized by an (own) inverse elasticity rule: the greater the elasticity of foreign-sourced GVC inputs, the lower the optimal input tax on those inputs, all else equal. As is the case for final goods tariffs, this inverse elasticity rule will be moderated by GVC linkages, reflected in a series of cross-elasticities: how the input tariff affects the pattern of input use and thus final goods production, prices, trade and the associated tax revenue, and DVA.

The relationship between GVCs and optimal input tariffs depends on the structure of these cross-elasticities. Unfortunately, there is no obvious disciplining device for placing bounds on them, which implies that one cannot easily sign the directional relationship between input tariffs and GVC linkages. Even in our simple setting, specific assumptions – whether GVC inputs are complements or substitutes in production, or whether there are differences in productivity across countries (so that a reallocation of inputs across countries would change the global supply of the final good) – would be needed to pin down definitive results.[21]

A signature strength of our theoretical approach to evaluating final goods tariffs is that it side-steps hard-to-quantify production details, yet yields predictions that are amenable to direct econometric investigation. Extending the analysis to input tariffs defeats this valuable advantage. Thus, we set aside input tariffs for the remainder of the paper to focus on the relationship between GVC linkages and trade protection for final goods only.

[21] Recent work highlights the complexity of the issue. Antràs and Chor (2021) investigate the optimal tariff structure in a stylized two-country partial equilibrium structure with a single final good, Leontief technology, and one undifferentiated input. Even with sufficient structure to sign the cross effects of input tariffs on final goods prices and vice versa, they find a taxonomy of outcomes and conclude that "the manner in which vertical linkages affect optimal tariffs depends on subtle aspects of the environment."

3 Theory to Data

In this section, we modify the benchmark model introduced in Section 2 to suit empirical application, and we describe our empirical strategy and data. Section 3.1 extends the 2x2 model to allow for many sectors and countries, and introduces political economy motives for tariff setting. In Section 3.2, we then discuss how two important institutional features of the world trading system – the most favored nation (MFN) rule and regional trade agreements – can be incorporated into the analysis. Section 3.3 translates the theory into an empirical estimation framework, and Section 3.4 surveys threats to identification. We conclude by presenting the data in Sections 3.5 and 3.6.

3.1 Many-Country, Many-Good Model with Political Economy

Building on Section 2.1, suppose the 'home' country (indexed by h) now produces, consumes, and trades S final goods (in set $\mathcal{S}$) plus one freely-traded homogeneous numéraire good (indexed by 0) with C trading partners (in set $\mathcal{C}$). Beyond the increase in the number of goods and countries, there are two substantive changes in the model. We discuss them briefly here, and refer the reader to Appendix A.5 for a complete exposition.

First, we adopt quasi-linear preferences for additional tractability, as is standard in the literature [Grossman and Helpman (1994)]. Preferences are now given by:

$$U^c(d_0^h, \vec{d_s}^h) = d_0^h + \sum_{s \in \mathcal{S}} u_s(d_s^h) \qquad \forall h \in \mathcal{C}, \tag{3.1}$$

where $\vec{d_s}^h$ is the vector of country h's consumption of each non-numéraire good and sub-utility over each non-numéraire good, $u_s(\cdot)$, is increasing, continuously differentiable, and strictly concave. We assume that every individual has sufficient income to consume a strictly positive quantity of the numéraire, so that demand for non-numéraire goods is independent of income.

Second, we introduce political economy motivations for policy. Following Helpman (1997) and Ludema and Mayda (2013), we assume that the Home government maximizes the sum of aggregate indirect utility and a set of "special interest factors" associated with the quasi-rents from production in different final goods sectors:

$$G^h = V^h + \sum_{s \in \mathcal{S}} [\delta_s^{DPE} \pi_s^h + \delta_s^{DVA} DVA_{sh} + \delta_s^{FVA} FVA_s^h], \tag{3.2}$$

where V^h is Home's (endogenous) aggregate indirect utility, π_s^h is the total residual profit from Home's local production of s, $DVA_{sh} = \sum_{j \neq h} DVA_{sh}^j$ where $DVA_{sh}^j = r_{sh}^j(p_s^j; \vec{\nu}_s^j)\nu_{sh}^j$ is the total return to Home's value-added inputs used in (all) foreign production of good s, and $FVA_s^h = \sum_{j \neq h} r_{sj}^h(p_s^h; \vec{\nu}_s^h)\nu_{sj}^h$ is the total return to (all) foreign value-added inputs used in Home's production of good s.

The parameters $\delta_s^{DPE}, \delta_s^{FVA}$, and δ_s^{DVA} are exogenous political economy weights associated with each final goods sector $s \in \mathcal{S}$. These weights accommodate a variety of political economy motivations. The parameter δ_s^{DPE} captures any additional consideration that the Home government affords to rents earned in domestic final goods production of good s at Home (π_s^h). Similarly, δ_s^{DVA} reflects any extra political value that the Home government places on the returns to Home's domestic value-added inputs used in foreign final goods production (DVA_{sh}).[22] Finally, δ_s^{FVA} represents the political weight (if any) given to *foreign* income associated with the use of foreign value-added inputs used in Home's production (FVA_s^h). We do not impose *a priori* restrictions on these weights, but standard arguments would imply positive values for politically active constituencies.[23]

Endowments, technology, and remaining model structure – including multi-country, multi-sector analogs to Assumptions 2.1 and 2.2 – are the same as in the 2x2 benchmark model. We allow arbitrary exogenous tariffs or other trade barriers between Home's trading partners, but require that prices obey a set of SC no-arbitrage conditions: $p_s^h \leq \tau_{sc}^h p_s^c, \forall c \neq h \in \mathcal{C}, s \in \mathcal{S}$, which hold with equality when there is trade.[24] Equilibrium prices are then pinned down by a set of S market clearing conditions that ensure global demand equals global supply for each non-numéraire good: $\sum_{c \in \mathcal{C}} d_s^c(\tilde{p}_s^c) = \sum_{c \in \mathcal{C}} q_s^c(\tilde{p}_s^c; \vec{\nu}_s^c)$ for all $s \in \mathcal{S}$. Balanced budget conditions for each country clear the market for the numéraire.

Politically-Motivated Bilateral Tariffs The Home government chooses its politically-optimal bilateral tariffs ($\{\tau_{xj}^h\}_{j \neq h}$) to maximize Equation (3.2), subject to balanced budget,

[22]Since both $\sum_s \pi_s^h$ and $\sum_s DVA_{sh}$ are included in Home's national income, they are already included in V^h with a weight of 1; thus, δ_s^{DPE} and δ_s^{DVA} capture any *additional* weight afforded to these rents by the Home government, above and beyond their direct contribution to aggregate welfare.

[23]Standard 'Protection-for-Sale' lobbying [Grossman and Helpman (1994)] would imply $\delta_x^{DPE} > 0$ for any politically active industry. The parameter δ_s^{DVA} would be positive if domestic value-added input suppliers advocate for better market access on behalf of their downstream buyers who are located abroad. Further, $\delta_s^{FVA} > 0$ if the government responds to lobbying by foreign suppliers [Gawande, Krishna and Robbins (2006)]. Alternatively, foreign suppliers of GVC inputs could be represented in domestic politics by downstream buyers, similar to the phenomenon of 'tariff jumping' foreign investors that earn "political goodwill" and *quid pro quo* tariff cuts described by Bhagwati et al. (1987). Note the restriction $\delta_s^{DPE} = \delta_s^{FVA} = \delta_s^{DVA} = 0$ yields a national welfare maximizing government.

[24]Alternatively, one could adopt a competing exporters framework [Bagwell and Staiger (1997)], an Armington trade structure, or assume internationally segmented markets. Such assumptions impose additional constraints on price movements in response to tariff changes (and thus our λ terms) and third-country effects, but do not change the key mechanisms of the model, as long as bilateral price movements are consistent with Assumption 2.2.

market clearing, and no arbitrage constraints, taking other countries' policies as given. Referring to Appendix A.5 for the derivation, we present the implicit solution for Home's optimal tariffs (analogous to Equation (2.19)) here:

$$\tau^h_{xj} = 1 + \frac{1}{\epsilon^j_{xh}} \left(1 + \frac{\delta^{DPE}_x}{|\lambda^h_{xj}|} \frac{p^h_x q^h_x}{p^h_x E^j_{xh}} - (1+\delta^{DVA}_x) \varepsilon^{rj}_{xh} \frac{DVA^j_{xh}}{p^j_x E^j_{xh}} - \frac{(1-\delta^{FVA}_{x*}) \varepsilon^{rh}_{x*}}{|\lambda^h_{xj}|} \frac{FVA^h_x}{p^h_x E^j_{xh}} - \tilde{\Omega}_{xj} \right). \quad (3.3)$$

Outside the parentheses, $\epsilon^j_{xh} \equiv \frac{dE^j_{xh}}{dp^j_x} \frac{p^j_x}{E^j_{xh}} > 0$ is the export supply elasticity for x imported by h from j. Inside the parentheses, q^h_x is the quantity of good x produced in h, and E^j_{xh} is the quantity of country j's exports of x to h. DVA^j_{sh} is the return to value-added inputs from h used by j in industry s, and FVA^h_s is the return to foreign inputs used by Home industry s; both are defined above. ε^{rj}_{xh} is the elasticity of the return to h's GVC inputs used by industry x in country j with respect to p^j_x, and ε^{rh}_{x*} is the elasticity of the return to (all) foreign GVC inputs used by industry x in home with respect to p^h_x. Finally, $\lambda^h_{xj} \equiv \frac{d\tilde{p}^j_x}{d\tau^h_{xj}} / \frac{d\tilde{p}^h_x}{d\tau^h_{xj}} < 0$, and $\tilde{\Omega}_{xj}$ captures potential third-country effects of trade diversion (see the appendix for the full characterization of this term).

Discussion While the optimal bilateral tariff in Equation (3.3) reflects the same mechanisms underlying Equation (2.19) in the 2x2 model, there are several new features that inform our empirical strategy.

First, there is a new term that captures the potential influence of domestic political economy forces in tariff setting, which depends on the product of the inverse import penetration ratio ($p^h_x q^h_x / p^h_x E^j_{xh}$) with the parameter δ^{DPE}_s. This term reflects how a politically-motivated government trades off the interests of import-competing domestic producers of good x against social welfare: all else equal, the government will offer more generous tariff protection when import penetration (and thus the social cost of trade protection) is low. Such 'Protection-for-Sale' influences have been established as empirically important determinants of tariff policy in practice [Goldberg and Maggi (1999); Gawande and Bandyopadhyay (2000)].

Second, political economy motivations may also reinforce or attenuate the influence of GVCs. If the government affords additional political consideration to the interests of the its "upstream" suppliers of GVC inputs used in foreign production, ($\delta^{DVA}_x > 0$), the trade-liberalizing potential of DVA will be even stronger, all else equal. Conversely, if the government responds to the interests of the foreign suppliers of GVC inputs used in local production ($\delta^{FVA}_x > 0$), the trade-liberalizing influence of FVA will be attenuated. Nonetheless, as long as domestic consumer concerns dominate the interests of foreign suppliers of GVC inputs

($\delta_x^{FVA} < 1$), bilateral tariffs would decrease in FVA.[25]

Third, notice that τ_{xj}^h depends on the *bilateral* value of Home's GVC income from foreign production (DVA_{xh}^j) and the *multilateral* value of foreign GVC income from home production (FVA_x^h). The intuition for the multilateral role of FVA is that any increase in the local price of x (p_x^h) is necessarily passed on to *all* foreign suppliers of GVC inputs, not just those from country j.[26] In contrast, τ_{xj}^h depends only on the bilateral value of domestic content in foreign production (DVA_{xh}^j), because the terms-of-trade externality is fundamentally bilateral. As the home country uses its tariff to depress the foreign output price, it cares about the repercussions only for its own input suppliers, not for third country input suppliers.

3.2 Trade Policy Institutions

We now introduce two institutional features of the trade policy regime under which tariff preferences are set: the most-favored-nation rule and regional trade agreements. These institutions modify the government's optimal policy problem in ways that impact our empirical strategy when exploring applied bilateral tariffs.

3.2.1 The MFN Rule

The most-favored-nation (MFN) rule dictates that WTO members may not discriminate in their applied tariffs across their WTO-member trading partners, but for defined exceptions to this rule specified in the 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 effectively serve as an upper bound on applied bilateral tariffs.[27]

To incorporate this constraint into the model, we define the government's *applied* tariff problem, as distinct from its optimal tariff problem. The government sets applied tariffs $\{\tau_{xj}^{h,\text{applied}}\}$ to maximize is objective function in Equation (3.2) subject to to the additional constraint that $\tau_{xj}^{h,\text{applied}} \leq \tau_x^{h,\text{MFN}}$, where $\tau_x^{h,\text{MFN}}$ denotes (one plus) its MFN tariff, along with

[25] This baseline assumption is supported by existing evidence which suggests that governments value aggregate social welfare far more than even *domestic* political interests [Goldberg and Maggi (1999)]. However, since we estimate the relationship between tariffs and FVA without *a priori* sign restrictions, we do not rule out the possibility that $\delta_x^{FVA} > 1$ *ex ante*.

[26] In deriving Equation 3.3, we impose a common pass-through elasticity across foreign input suppliers (ε_{x*}^{rh}), reflecting this multilateral argument. Relaxing this assumption, one would replace FVA_x^h with an elasticity-weighted average of bilateral foreign GVC income.

[27] 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.

balanced budget, market clearing, and no-arbitrage conditions. Adding this MFN constraint, the applied bilateral tariff then will then satisfy:

$$\tau_{xj}^{h,\text{applied}} = \min\{\tau_{xj}^{h}, \tau_{x}^{h,MFN}\}, \tag{3.4}$$

where τ_{xj}^{h} is the unconstrained optimal tariff given by Equation (3.3). Following Grossman and Helpman (1995*a*), we take MFN tariffs as given when analyzing politically-optimal applied bilateral tariffs.[28]

3.2.2 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 via negotiation in setting tariffs. Theoretically, these negotiations 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 RTAs. We review the key arguments here, with a more formal treatment in Appendix A.6.

Specifically, our theory suggests that domestic content in foreign goods (DVA_{xh}^{j}) matters because it counteracts the conventional terms-of-trade motive for positive tariffs. If bilateral cooperation via negotiation itself negates the bilateral terms-of-trade externality, then we would not expect to see the imprint of DVA on tariff preferences set under RTAs. Whether RTAs actually serve to nullify bilateral terms-of-trade externalities in reality is an open question, on which there is little existing evidence. In contrast to this terms-of-trade mechanism, the role for foreign value added (FVA_{x}^{h}) in shaping optimal tariffs depends on the *domestic* (local) price externality. Thus, whether cooperation alters the role of FVA in tariff setting is even less clear; neither the theoretical nor empirical trade literature provides a clear answer as to whether cooperative agreements neutralize behind-the-border externalities.[29] Ultimately, we treat the impact of RTAs on applied tariffs as an open question to be answered by our data, when we explore heterogeneity by trade policy regime below.

[28] 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 [Bagwell and Staiger (1997); McLaren (2002); Saggi (2009); Limão (2006); Estevadeordal, Freund and Ornelas (2008)]. Lastly, MFN tariffs for many countries were set under the Uruguay Round, which concluded before the start of our sample period.

[29] If RTAs eliminate *all* cross-border externalities between countries, then FVA effects would disappear under cooperative agreements. However, note that the FVA effect reflects a *multilateral* externality. It is not clear to us whether a bilateral agreement could fully mitigate this multilateral externality.

3.3 Empirical Strategy

The GVC-augmented tariff theory summarized by Equation (3.3) guides our empirical strategy. To move from this implicit expression for the optimal tariff to a concrete estimation framework, it is helpful to invoke an approximation argument. We take a linear approximation around a baseline equilibrium in which there are no GVC linkages ($\vec{\nu} = 0$, such that $DVA^j_{xh} = 0$ and $FVA^h_x = 0 \; \forall x \in \mathcal{S}, j \in \mathcal{C}$).[30] The result is:

$$t^h_{xj} = \frac{1}{\bar{\epsilon}^j_{xh}} + \gamma^{IP}_{xhj} \left(\frac{FG^h_{xt}}{\bar{p}^h_x \bar{E}^j_{xh}} \right) + \gamma^{DVA}_{xhj} \left(\frac{DVA^j_{xh}}{\bar{p}^j_x \bar{E}^j_{xh}} \right) + \gamma^{FVA}_{xh} \left(\frac{FVA^h_x}{\bar{p}^h_x \bar{E}^j_{xh}} \right) + \omega_{xhj}, \tag{3.5}$$

where $t^h_{xj} \equiv \tau^h_{xj} - 1$, bars denote equilibrium objects evaluated at the point of approximation, $FG^h_{xt} \equiv p^h_x q^h_x$, $\gamma^{IP}_{xhj} \equiv \frac{\delta^{PE}_x}{\bar{\epsilon}^j_{xh} |\bar{\lambda}^h_{xj}|}$, $\gamma^{DVA}_{xhj} \equiv -\frac{(1+\delta^{DVA}_x)\bar{\varepsilon}^{rj}_{xh}}{\bar{\epsilon}^j_{xh}}$, $\gamma^{FVA}_{xhj} \equiv -\frac{(1-\delta^{FVA}_x)\bar{\varepsilon}^{rh}_{x*}}{\bar{\epsilon}^j_{xh} |\bar{\lambda}^h_{xj}|}$, and ω_{xhj} includes approximation errors and potential trade diversion effects.[31]

This expression is a mix of observable variables and parameters that cannot be measured directly. The three key observables are the levels of final goods production (FG^h_{xt}), foreign GVC income generated by home production (FVA^h_{xt}), and domestic GVC income from foreign production (DVA^j_{xht}). Each of these is measurable in our data, using the value-added content of final goods as a proxy for GVC income. In Equation (3.5), each of these observables is written as a ratio to bilateral imports in the no-GVC equilibrium, which we do not observe. In forming our estimating equation below, we will use realized bilateral imports as a proxy for these unobserved values to compute the ratios.[32] In terms of language, we refer to the ratio of domestic final goods production to bilateral imports as the inverse import penetration ratio, or IP ratio for short. We refer to the ratios of foreign value added and domestic value added to bilateral final goods imports as the FVA ratio and DVA ratio.

In using these ratios in a regression context, we face two standard, related empirical challenges. The first is that data for each ratio is positively skewed, with a long right tail. This right tail variation is difficult to reconcile with (more moderate) observed variation in

[30]This type of linearization is common in the literature [e.g., Ludema and Mayda (2013)], and Ludema et al. (2019) adopt a similar point of linearization in a closely related model with GVCs.

[31]$\omega_{xhj} \equiv u_{xhf} - \tilde{\Omega}_{xj}$, where u_{xhf} is the approximation error and $\tilde{\Omega}_{xj}$ captures potential trade diversion effects. Third-country effects are generally ambiguous in sign, and plausibly small, especially for smaller trade partners that may generate little or no trade diversion; they can be eliminated from the theory by invoking additional modelling assumptions (e.g., Armington preferences or international market segmentation). In practice, our fixed effects also remove importer-industry and exporter-industry characteristics, which likely absorbs some of this residual variation.

[32]Using realized imports here introduces a potential simultaneity problem, where actual imports depend on tariffs, which we will resolve using instrumental variables below. A subtle point is that import quantities are evaluated at exporter prices in the first and third ratios and at importer prices in the second. We suppress this distinction in the empirical work, because we are not able to measure imports at different prices in the same data set that we use to construct the numerators.

tariffs, without resorting to extreme (unobserved) coefficient heterogeneity that neutralizes these effects. Compounding this issue, the second challenge is that each ratio includes a variable in the denominator that is potentially measured with error. Specifically, most observations in the right tail of the ratio distribution have low values for imports. If imports are measured with error, then variation among right tail observations will be largely driven by the measurement error itself. We address these issues by taking logs of these ratios in our empirical estimating equation.

Beyond the ratios, the remaining parameters, including the inverse export supply elasticity ($1/\epsilon^h_{xj}$) and parameters underlying the γ-terms in Equation (3.5), are not directly observed. In prior empirical applications of optimal tariff theory, the inverse export supply elasticity has been constrained to be importer and industry specific.[33] Thus, following this prior work would suggest an importer-industry fixed effect is sufficient to absorb the inverse elasticity term. Relaxing this assumption, we also allow for importer-year or importer-industry-year fixed effects, depending on the specification, as well as exporter-industry-year fixed effects. Together, these fixed effects absorb plausible variation in the inverse elasticity.

Reflecting the flexibility we allowed in the underlying theory, the coefficients attached to the ratios in Equation (3.5) are potentially heterogeneous, since they depend on political economy weights, pass-through elasticities, and the export supply elasticity. These three objects are not directly observable, estimates of them are not generally available, and they cannot be computed in the absence of a fully specified quantitative model. Thus, we treat them as parameters to be estimated. We start by assuming that each coefficient is homogeneous in our benchmark estimation, as in $\gamma^{IP} = \gamma^{IP}_{xhj}$, $\gamma^{FVA} = \gamma^{FVA}_{xhj}$, and $\gamma^{DVA} = \gamma^{DVA}_{xhj}$. From this baseline, we then explore the potential for coefficient heterogeneity across country pairs and sectors, where the composite effects may differ in economically meaningful dimensions. In exploring data on applied tariff levels, we focus in particular on how the impacts of DVA across partners differ depending whether preferences are conferred via regional trade agreements, based on the discussion in Section 3.2.2. Shifting attention to price mechanisms, we explore whether DVA effects differ systematically across sectors and partners based on upstream and downstream production differentiation, which are proxies for pass-through elasticities and export supply elasticities.

Drawing on Section 3.2.1, we recall that applied tariffs are constrained by the MFN rule. Taking this constraint into account, along with the discussion above, we arrive at the

[33] Among others, see Broda, Limão and Weinstein (2008), Ludema and Mayda (2013), and Nicita, Olarreaga and Silva (2018). Extending this literature, Soderbery (2018) provides estimates of bilateral trade elasticities. While these are difficult to employ directly in our empirical work, due to large measurement error in the estimates and aggregation issues, Soderbery reports that almost three-quarters of the variation in his bilateral elasticity estimates is explained by importer-product fixed effects. Our combination of fixed effects would push this explained variation higher.

following empirical framework for examining applied bilateral tariffs:

$$t_{xjt}^{h,applied} - t_{xt}^{h,MFN} = \min\{t_{xjt}^{h} - t_{xt}^{h,MFN}, 0\}, \text{ with} \tag{3.6}$$

$$t_{xjt}^{h} - t_{xt}^{h,MFN} = \Phi_{xhjt} + \gamma^{FG} \ln\left(\frac{FG_{xt}^{h}}{IM_{xjt}^{h}}\right) + \gamma^{DVA} \ln\left(\frac{DVA_{xht}^{j}}{IM_{xjt}^{h}}\right) + \gamma^{FVA} \ln\left(\frac{FVA_{xt}^{h}}{IM_{xjt}^{h}}\right) + e_{xhjt}, \tag{3.7}$$

where t denotes the time period, IM_{xjt}^{h} is the value of bilateral imports by h of goods from sector x in country j, Φ_{xhjt} denotes the set of fixed effects, and e_{xhjt} is a regression residual. Noting the sign convention (more generous preferences are associated with *more negative* tariffs relative to MFN), theory predicts that $\gamma^{FG} > 0$ and $\gamma^{DVA} < 0$. With the prior that $\delta_{x}^{FVA} < 1$, then we expect $\gamma^{FVA} < 0$ as well.

We present results for two alternative sets of fixed effects. The first specification includes importer-industry, importer-year, and exporter-industry-year fixed effects, as in $\Phi_{xhjt} = \phi_{xh} + \phi_{ht} + \phi_{xjt}$. Under this specification, we are able to separately estimate all three γ-coefficients attached to the ratios. In this specification, γ^{FVA} is primarily identified based on multilateral variation in average tariff preferences and foreign value added by importer and industry over time.[34] In contrast, γ^{DVA} is identified both by variation across trade partners for a given importer and industry in the cross section, as well as variation over time.

The second specification includes importer-industry-year and exporter-industry-year fixed effects: $\Phi_{xhjt} = \phi_{xht} + \phi_{xjt}$. In this specification, we can identify γ^{DVA}, along with a composite coefficient $\gamma^{FG} + \gamma^{FVA}$, which is identified by variation in bilateral imports across partners within a given importer-industry-year cell. Note further that the importer-industry-year fixed effect differences out multilateral changes in the DVA ratio within each importer and industry, sharpening the focus on bilateral variation for identification of γ^{DVA}. This bilateral variation is predominantly cross-sectional in nature, as we discuss further below.

A second point worth noting in Equation (3.6) is that we have rewritten the dependent variable to be the tariff preference, defined as $t_{xjt}^{h,applied} - t_{xt}^{h,MFN}$, with corresponding redefinition of the optimal tariff preference ($t_{xjt}^{h} - t_{xt}^{h,MFN}$). This means that a uniform reduction in all tariffs leaves the dependent variable unchanged. Further, if only MFN tariffs change, then tariff preference margins would be compressed. This can be interpreted as a tightening of the the censoring bound in our empirical setup, and it ensures that changes in MFN tariffs are not driving our empirical results.[35]

[34] More precisely, due to the importer-year fixed effects, identification is based on differential changes across industries within a given importer. Variation in imports across trading partners within a given importer and industry provides a secondary source of identification, through their impact on the FVA ratio.

[35] In OLS specifications that do not adjust for censoring, reductions in MFN tariffs (holding $t_{xjt}^{h,applied}$ constant) bias γ^{DVA} and γ^{FVA} toward zero, which works against rejecting the null. Note that this redefinition is redundant with importer-industry-year fixed effects, which absorb all multilateral tariff variation.

3.4 Threats to Identification

Assessing threats to identification requires taking a stand on the nature of the regression residual (e_{xhjt}) in Equation (3.7). Because the regression includes proxies or controls for the key determinants of optimal tariffs suggested by theory, the most straightforward interpretation of it is that it represents a pure structural error (e.g., measurement error in tariffs) that is orthogonal to the regressors. In this event, we are estimating an equilibrium relationship from the model, and we can directly interpret OLS parameter estimates as describing the optimal policy rule.[36]

We acknowledge, however, that this structural assumption is strong. So, we seek to address threats to identification that originate inside the model, as well as potential concerns that originate outside the model.

Within the model, the key concern is that the residual represents true tariff variation not explained by the model. In this case, there is a potential simultaneity problem, wherein the realized values of the ratios on the right-hand side are correlated with the residual. For example, DVA^j_{xht} depends on the price of foreign output (p^j_{xt}), and this price is a function of country h's tariff on imports of x from j (t^h_{xjt}). This mechanism would induce a negative correlation between $\ln(DVA^j_{xht})$ and e_{hjxt}, which could bias the coefficient estimates. Related arguments hold for final production, foreign value added, and bilateral imports. In this multivariate context, with more than one potentially endogenous variable, it is not obvious *a priori* which direction the bias would run for individual coefficients, but the overarching concern is that the coefficients could be biased in directions that would lead us to erroneously find support for our theoretical predictions.[37] To address these simultaneity concerns, we use an instrumental variables strategy.

Remaining threats to identification lie outside the model. First, there are measurement error concerns regarding right-hand side variables – e.g., value-added contents are undoubtedly measured with error. Second, one might reasonably be concerned about omitted variables that influence both tariffs and value-added content. Because we include the main determinants of tariffs suggested by the theory in our empirical specification, as well as a rich set of fixed effects, we do not have strong priors about which omitted variables might present

[36]Note that simultaneity concerns – that true tariffs may influence value-added content, final goods production, and imports – are not an impediment to estimation of the equilibrium policy rule in this case.

[37]Taking each partial correlation in isolation, the possible negative correlation between $\ln(DVA^j_{xit})$ and e_{ijxt} would bias the coefficient on $\ln(DVA^j_{xit})$ towards being negative, thus tending to confirm the theory. On the other hand, the possible positive correlation between $\ln(FVA^j_{xit})$ and e_{ijxt} would tend to bias this coefficient in the positive direction. This second case of positive bias is less of a concern than the first, because the bias would work against confirming the theory. Notwithstanding this intuition, we re-emphasize that intuition regarding directions of simultaneity bias in the single endogenous regressor case is not necessarily applicable in this multivariate context.

a threat to identification. Nonetheless, we explore how our results change in response to adding standard proxies for bilateral relationships.

Having flagged these issues, we defer implementation details to Section 4.3.

3.5 Data

This section briefly describes sources and methods for compiling our data on bilateral tariffs and value-added content, with full details in Appendix B.1.

Bilateral Tariffs We construct bilateral, industry-level tariffs on final goods for five benchmark years: 1995, 2000, 2005, and 2010, and 2015. We start with product-level tariff schedules collected by UNCTAD (TRAINS) and the WTO, which we obtain via the World Bank's WITS website. Combining these sources and aggregating product lines yields a data set of bilateral tariffs at the Harmonized System (HS) 6-digit level. We then identify final goods (consumption and capital goods) in the data and link HS categories to WIOD industries using a correspondence developed by the OECD. We take simple averages across HS categories within each industry to measure industry-level applied bilateral and MFN tariffs.

Value-Added Content of Final Goods Production We use data from the World Input-Output Database (WIOD) to compute the national origin of value added contained in the final goods that each country produces, which allow us to construct the empirical counterparts to the domestic and foreign value added terms in the theory. The exact procedure, which is based on Los, Timmer and de Vries (2015), is described in the appendix. Combining data from two versions of the WIOD dataset, we are able to construct value-added contents for 14 "countries" (13 countries, plus the composite EU region) and 14 industries, which are listed in Table 1, that cover the 1995-2014 period. We use value-added contents from 2014 in our analysis of tariffs in 2015.

3.6 First Look at the Data

Before moving to formal analysis, we pause to discuss sources of variation in the bilateral tariff data. We then relate observed tariff variation to value-added content in an illustrative case to fix ideas.

Tariff Preferences Our empirical strategy focuses on differences between bilateral applied tariffs and applied MFN rates. We start here with a brief summary description of the four main policy regimes under which countries offer lower-than-MFN tariffs to selected trading partners, with additional discussion in Appendix B.1.

The first regime is the Generalized System of Preferences (GSP), which is an explicitly unilateral preference regime through which developing countries receive preferential treatment from high-income importers. 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. One point worth emphasizing here is that free trade agreements do not typically entail completely free trade: carve-outs in Article XXIV agreements are pervasive, and almost half of tariffs imposed on RTA partners are greater than zero in our data.[38] The third source of preferences derives from trade agreements struck between developing countries under the auspices of the WTO's Enabling Clause, including so-called "Partial Scope Agreements." Lastly, a handful of idiosyncratic programs and one-off preferences constitute a fourth source of preferences in our data.

In Figure 1, we track the overall prevalence of tariff preferences, broken down into three broad categories: RTAs, GSP, and Other (partial scope and miscellaneous). Because our country panel is imbalanced, we report this break-down of tariff preferences for both the 10 importing countries with data available in all years, alongside the analogous information for the set of all countries from 2005 onward.

The first point to note is that tariff preferences are widespread: depending on the year, between 30-40% of all importer-exporter-industry cells have preferential tariffs. The second point to note is that the prevalence of tariff preferences has been increasing over time, rising by about ten percentage points from 1995 to 2015. At the same time, because many preferences remain in place throughout our sample period, the cross-section of preferences (across sectors and trading partners) is an important source of identifying variation. The third important feature of the data is that the composition of preferences changes over time. In general, RTAs and partial scope agreements have become more important sources of preferences over time, and they seem to progressively displace GSP preferences. Since the magnitude of tariff preferences is generally larger under RTAs and partial scope agreements than under the GSP, this policy substitution represents a deepening of preferences over time.

Case Study: Textiles, Leather, and Footwear Before moving to the full empirical estimation, we briefly introduce data for the Textiles, Leather, and Footwear sectors, where

[38]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).

value chain linkages are salient to policymakers, and the scope for and use of tariff discretion is high. We examine two simple manipulations of the data, both to fix ideas and to highlight the sources of identifying variation we exploit in the empirical analysis.

We start by examining the relationship between FVA and average tariff preferences, focusing on long-differences within importer-industry cells. Define the (multilateral) mean tariff preference by importer and industry as $\bar{t}^i_{xt} = \frac{1}{C-1}\sum_{j\neq i}\left(t^i_{xjt} - t^{i,MFN}_{xt}\right)$, with corresponding change over time $\Delta_t \bar{t}^i_{xt}$.[39] Figure 2 plots $\Delta_t \bar{t}^i_{xt}$ against changes in the (log) FVA ratio – defined as $\Delta_t \ln\left(\frac{FVA^i_{xt}}{IM^i_{xt}}\right)$ – by importer and industry, from 1995 to 2015. As is evident in the figure, there is a negative correlation in the data, consistent with theory: countries that saw comparatively more growth in FVA relative to gross imports also offered the greatest expansion of preferential market access to their trading partners.[40] This type of time series variation by importer and industry will be used to identify FVA effects, which are fundamentally multilateral in nature, as discussed in section 3.1.

Next we examine the relationship between DVA and bilateral tariff preferences, focusing on the cross-sectional dimension of the data. Honing in on a set of high-income importers buying goods from a set of emerging-market exporters, Figure 2 plots bilateral tariff preferences $(t^i_{xj} - t^{i,MFN}_x)$ against the (log) DVA ratio $[\ln\left(\frac{DVA^i_{xjt}}{IM^i_{xt}}\right)]$ by country-pair in 2015.[41] We note three key points in the figure. First there is a negative correlation between applied tariffs and the DVA ratio, consistent with theory: high-income importers offered more generous tariff preferences for imports of Textiles, Leather, and Footwear to emerging-market trading partners that use more of their own value-added inputs in production of those goods. Second, there is sizable variation in tariff preferences (on the y-axis) and the (log) DVA ratio across partners (on the x-axis). This type of cross-sectional variation is the main source of identification for the role of DVA in our empirical estimation. Lastly, there is an obvious censoring problem in the figure, as indicated by the mass of country pairs with zero preference. This censoring may bias the simple correlation toward zero, so we adjust for it in the empirical work that follows.

[39] Changes in mean tariff preferences are driven both by expansion in the number of countries receiving preferences over time, and changes in the average depth of preferences.

[40] One particular feature of the Textiles, Leather, and Footwear sectors is that most importers experience declines in their FVA ratios over time, due to imports rising faster than FVA (which is also rising in absolute terms for most countries). Our estimation exploits *differences* in these changes across sectors and countries, rather than the absolute level of these changes.

[41] We construct comparable sets of importers and exporters to mimic the role of importer-industry and exporter-industry fixed effects in the analysis.

4 Results I: Tariffs and GVCs

We present results for tariffs in three steps. First, we present a baseline specification in Section 4.1, in which we use OLS and Tobit regressions to describe how applied and optimal tariffs are related to value-added content under the assumption that effects are homogeneous across country pairs and sectors. We then pivot in Section 4.2 to examine heterogeneity in responses, depending on the trade policy regime under which tariff preferences are conferred and the sectors in which they occur. We then address threats to identification in Section 4.3, by appealing to instrumental variables and incorporating additional control variables into the empirical specification.

4.1 Baseline Specification

We present estimates of Equations (3.6)-(3.7) in Table 2. In all columns, the dependent variable is the observed tariff preference: $t_{xjt}^{h,applied} - t_{xt}^{h,MFN}$. In columns (1)-(2), we present OLS results, ignoring censoring induced by the MFN rule. In columns (3)-(4), we present Tobit estimates that adjust for censoring. In columns (1) and (3), we include importer-year and importer-industry fixed effects, which allows us to identify the coefficient attached to the ratio of FVA to bilateral imports (γ^{FVA}) separately from the coefficient on the import penetration ratio (γ^{IP}). In columns (2) and (4), we include importer-industry-year fixed effects, where we can only identify the joint coefficient $\gamma^{FVA} + \gamma^{IP}$, identified from bilateral variation in imports. Note that theory does not restrict the sign of this joint coefficient, so we do not seek to interpret its estimated sign or statistical significance.[42] Exporter-industry-year fixed effects are included in all specifications, and all columns feature standard errors that are clustered by importer-exporter pair.

In column (1), we see that the OLS coefficients on the DVA ratio is negative: applied bilateral tariffs are lower (tariff preferences are larger) when the bilateral DVA ratio is high, consistent with the theoretical prediction. The coefficient is little changed in column (2), where we add an importer-industry-year fixed effect to hone in on variation across bilateral partners. To interpret the magnitudes, it is typical for the DVA ratio to vary by 5 log points across exporters within a given importer and industry.[43] The point estimate in column (1) is about -1, so moving from low to high DVA partners corresponds to roughly a 5 percentage point reduction in observed applied tariffs. Since the median tariff is around 8 percent in our data, this represents a substantial expansion of market access.

[42]Although the joint coefficient need not be exactly equal to the sum of the γ^{FVA} and γ^{IP} from the specification with importer-industry and importer-year fixed effects, we find it is typically quite close.

[43]This is the median difference between maximum and minimum values across the 13 trading partners in each importer-industry-year cell.

In column (1), applied bilateral tariffs are also lower when the multilateral FVA ratio is larger, consistent with political economy forces being relatively weak ($\delta_x^{FVA} < 1$). Focusing on time variation, some sectors see increases in the FVA ratio over time, with typical values on the order of 1 log point, while others see declines, with typical values of -1 log points. These differential changes lead to declines of about 2 percentage points in mean tariff preferences in sectors with growing FVA ratios relative to those with falling FVA ratios.

As a final point to note in column (1), the coefficient on the IP ratio is positive: a higher ratio of domestic final goods production to imports (or a lower import penetration ratio) is associated with higher tariffs, consistent with the government having stronger political economy incentives to protect domestic producers in this case. While this coefficient is of secondary interest to us as a control variable, we note that these estimates are consistent with empirical findings in the existing literature [Goldberg and Maggi (1999); Gawande and Bandyopadhyay (2000)].

Turning to Tobit estimates of the same specification in column (3), we see that adjusting for censoring pushes both the coefficients on the DVA ratio and FVA ratio away from zero, roughly doubling the size of the estimated coefficients. This is consistent with our interpretation that MFN tariffs represent a constraint on countries' use of bilateral discretion in tariff setting. Put differently, optimal tariffs appear to be more sensitive to value-added content than are actual applied tariffs.

4.2 Exploring Heterogeneity

With a baseline established, we now turn to alternative cuts of the data that explore heterogeneity in our results based on the nature of preferences and underlying economic forces that could shape how GVC linkages influence tariff setting. We explore heterogeneity across trade policy regimes in Section 4.2.1 and by degrees of upstream and downstream product differentiation in Section 4.2.2.

4.2.1 Trade Policy Regimes

As discussed in Section 3.6, preferences are granted under different policy regimes in our data, including RTAs, the GSP, and other miscellenous preference programs. Further, building on Section 3.2.2, preferences granted through RTAs may reflect cooperation, potentially displacing DVA effects within those agreements. Thus, we turn to parsing out the role of trade policy institutions.

To begin, we replicate our baseline estimation including an additional indicator variable RTA_{hjt} that takes the value one when countries h and j have a regional trade agreement in place at date t. The coefficient on RTA_{hjt} is the (conditional) mean difference in tariffs between pairs with and without an RTA in place, thus it removes some of the variation in bilateral tariffs available for estimation of DVA and FVA effects. Nonetheless, in Panel A of Table 3, we continue to find negative and significant coefficients on both the DVA and FVA terms under both OLS in columns (1)-(2) and Tobit in columns (3)-(4).

Reflecting the fact that there is diminished residual variation after controlling for RTAs, the estimated coefficients are smaller (in absolute value) in Panel A than in the baseline (Table 2). This is expected. First, the RTA indicator removes considerable cross-sectional variation, which is the main source of identifying variation for the DVA effect; in essence, the RTA indicator supplants the role for DVA in predicting which bilateral pairs form RTAs, thus conferring each other the largest preferences. It also has important implications for the FVA coefficient. FVA effects are primarily identified by changes in mean tariffs by importer and industry over time. Since the RTA indicator removes the average reduction in applied tariffs due to RTA adoption, it absorbs the impact of progressive RTA expansion over our sample period (depicted in Figure 2) on mean importer-industry preferences. Thus, by including the RTA indicator we discard important time series variation for identification of FVA effects.

Turning to Panel B in Table 3, we interact each right-hand side variable with the RTA indicator, which allows us to estimate heterogeneous coefficients by type of preference. The motivation for this specification follows the discussion in Section 3.2.2: if RTAs completely neutralize the bilateral terms-of-trade externality, then DVA should not influence tariffs set under RTAs, meaning that the coefficient on the interaction term $RTA_{hjt} \times \ln(DVA^{j}_{xht}/IM^{h}_{xjt})$ should be zero. At a minimum, we expect diminished sensitivity of tariffs to DVA if RTAs at least partially neutralize the bilateral terms-of-trade externality. Assuming that $\delta^{FVA} < 1$, we expect to find that the coefficient on the FVA ratio is negative for tariffs set both within and outside regional agreements, since its impact reflects a local price externality that is multilateral in scope (see Section 3.2.2).

Comparing the results in the first and second rows of Panel B, we find that the coefficient on the DVA ratio within RTAs is not statistically different from zero in any specification, and it is meaningfully smaller than the estimated coefficient outside RTAs across the board. Further, the coefficient on the FVA ratio is negative and significant both within and outside RTAs, consistent with theory. It is striking that FVA effects are so strong inside RTAs, despite null results concerning DVA effects inside the same set of RTAs.

In Table 4, we focus attention entirely on non-RTA preferences, dropping all observations with $RTA_{hjt} = 1$ from the estimation. In Panel A, we repeat the baseline estimation in this sub-sample; we find negative coefficients attached to the DVA and FVA ratios, although they are attenuated in magnitude in this sample where preferences are less generous on average.

To explore preference setting under the GSP program versus partial scope agreements and other miscellaneous programs, 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.[44] 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. We then define an indicator 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 this non-RTA subsample of the data, in large part because advanced countries have limited scope under WTO rules to confer preferences outside of RTAs.[45] For country pairs with $GSP_{ij} = 0$, non-GSP preference schemes are the source of observed tariff preferences.

In Panel B of Table 4, we split coefficients based on whether a given country pair could potentially have a GSP program in place. We find that higher DVA ratios are associated with lower bilateral tariffs both inside and outside the GSP scheme. For GSP-eligible pairs, this pattern is apparent only when we adjust for censoring, which is quite sensible given that the advanced countries that grant GSP preferences generally also have very low MFN tariff bindings; thus there is strong censoring in this subset of the data. We also see that higher FVA ratios are associated with lower tariffs among non-GSP country pairs, where partial scope agreements are the most important source of preferences. We do not find significant effects of FVA within GSP-eligible pairs. Recalling that FVA effects are identified in large part based on time variation at the importer-industry level, this is not surprising. The relatively static nature of the GSP program implies there is limited time series variation among this group; further, GSP arrangements are replaced by other agreements over time (see Figure 1), so attrition may also work against finding sharp results here.

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

[45] Many pairs with $GSP_{ij} = 1$ have no recorded bilateral preferences (i.e., j receives MFN treatment from i), because some potentially GSP eligible exporters are excluded by GSP-granting countries. 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. GSP-granting countries are also able to exclude entire sectors from their GSP programs. Further, GSP schedules change over time for some importers, though there is strong persistence over time for most country pairs.

4.2.2 Upstream and Downstream Differentiation

In this section, we examine heterogeneous effects that are mediated by pass-through and trade elasticities in the model. We focus on documenting heterogeneous responses of tariffs to DVA, where we can use bilateral variation for identification. Referring back to Equation (3.5), the coefficient attached to the DVA ratio is $\gamma_{xhj}^{DVA} \equiv -\frac{(1+\delta_x^{DVA})\varepsilon_{xh}^{rj}}{\epsilon_{xh}^{j}}$. In the numerator, ε_{xh}^{rj} is the elasticity of pass-through from downstream price changes to upstream returns to value-added inputs. In the denominator, the export supply elasticity (ϵ_{xh}^{j}) may also be heterogeneous.[46] We appeal to first principles to organize this heterogeneity based on differences in product differentiation across across upstream and downstream sectors.[47] We discuss each in turn.

Upstream Differentiation The theory highlights the important role of pass-through elasticities, embodied in ε_{xh}^{rj}, in mediating the relationship between GVC linkages and tariffs. All else equal, sectors in which final goods prices are more closely linked to the returns to GVC inputs should see a more pronounced (inverse) relationship between GVC income and tariffs. We now invoke a simple argument about product differentiation in upstream sectors to think about sources of variation in ε_{xh}^{rj}. We sketch the argument here, and discuss implementation further in Appendix B.2.

Pass-through elasticities may differ across country pairs because upstream sectors differ in the responsiveness of input prices to downstream output prices, and the *composition* of sectors that supply GVC inputs to downstream producers may differ across bilateral partners. For example, suppose that country h supplies a commodity (e.g., oil) and a differentiated manufactured input (e.g., electronic components) to downstream industry x in countries j and k. All else equal, we would expect returns to the commodity input to be relatively insensitive to changes in output prices for individual downstream producers that use it, while the returns to specialized inputs are likely to be sensitive to downstream product prices. Thus, if country h supplies predominantly commodity inputs to industry x in country j, but supplies predominantly differentiated inputs to industry x in country k, we would expect the pass-through from p_x^j to h's GVC income to be relatively low compared to the pass-through from p_x^k; i.e. $\varepsilon_{xh}^{rj} < \varepsilon_{xh}^{rk}$.

Based on this argument, we decompose domestic value-added in foreign production

[46] We omit discussion of political economy weights because we lack clear proxies for them. See Ludema et al. (2019) for evidence on political economy motives in the GVC context.

[47] While it would be ideal to use direct empirical estimates of these elasticities to discipline the analysis, this is not feasible in practice. Estimating these heterogeneous elasticities is outside the scope of our analysis, while off-the-shelf estimates of pass-through elasticities do not exist, and existing estimates of export supply elasticities are both noisy and ill-suited to the aggregated industry dimension of our data.

(DVA^j_{xh}) based on whether it originates in upstream industries that are plausibly differentiated or nondifferentiated. We do this two ways. First, we simply treat value added originating in the manufacturing sector as differentiated, and value added originating in the nonmanufacturing sector as non-differentiated. This is crude, but transparent. Second, we use the classification developed by Rauch (1999) to compute the share of value added from each upstream industry that is differentiated versus nondifferentiated. In both cases, adding up over upstream industries yields bilateral measures for DVA originating in differentiated upstream sectors ($DVA^{j,Diff}_{xh}$) versus undifferentiated sectors ($DVA^{j,NonDiff}_{xh}$). We then form DVA ratios with each of these components and repeat our baseline estimation.

We report results for this exercise in Panel A of Table 5, where all columns include importer-industry-year fixed effects. Columns (1)-(2) report coefficients for the manufacturing versus non-manufacturing split of upstream value added, whereas columns (3)-(4) report results using the Rauch classification. In all columns, we see that tariffs respond strongly to DVA originating from differentiated upstream industries, but are weakly related to DVA originating in non-differentiated industries, as expected.

Downstream Differentiation Turning our attention to downstream industries, export supply elasticities (ϵ^j_{xh}) tend to be correlated with measures of product differentiation [Broda, Limão and Weinstein (2008)]. To the extent that more differentiated (downstream) industries are characterized by lower trade elasticities, the theory predicts that tariffs in these sectors should be more responsive to GVC linkages. Thus, we can also examine heterogeneity in γ^{DVA}_{xhj} across downstream industries (x) based on their degree of production differentiation.

We again consider two alternative classifications. We first allow for heterogeneous coefficients on the DVA ratio for manufacturing versus nonmanufacturing industries. With the prior that manufacturing is differentiated while nonmanufacturing is not, we expect tariffs to respond more strongly to DVA in manufacturing. We then classify final goods sectors based on the Rauch classification, where we define a downstream industry to be differentiated if more than 50% of the underlying SITC categories in it are differentiated.

In Panel B of Table 5, we re-estimate the baseline model with importer-industry-year fixed effects, splitting coefficients across sectors based on whether they are differentiated or undifferentiated. In all cases, the coefficient on the DVA ratio is negative, suggesting that tariffs respond to value-added content in both sector groups. However, the coefficient for differentiated downstream industries tends to be larger (in absolute terms) in differentiated industries. This is most strongly true for the Rauch-based split, where we can reject equality of the coefficients at the 1% level. This evidence is broadly consistent with the basic economic forces in our model.

4.3 Instruments and Additional Controls

This section addresses the threats to identification that we identified in Section 3.4. We address simultaneity and omitted variable bias concerns in tandem, using a combination of instruments and additional controls.

At the outset, we emphasize that the nature of the empirical strategy and data present formidable challenges for instrumental variables analysis. First, our baseline OLS estimation, based on Equation (3.7), includes multiple potentially endogenous variables, which are correlated among themselves for legitimate economic reasons.[48] Second, because we include fixed effects in all specifications, there is less residual variation available for us to use in identification.[49] Our task is thus to find instruments that isolate sufficient independent variation in potentially endogenous variables, conditional on an already-rich set of fixed effects. Third, because some right-hand side variables are correlated among themselves, we anticipate that instruments for them might also be correlated among themselves, which presents another challenge to finding multiple strong, plausibly exogenous IVs.

Given these challenges, it is useful to partition the instrumental variables analysis into two components, based on the two alternative fixed effects specifications we have used thus far. First, conditional on including an importer-industry-year fixed effect, we seek instruments for DVA^j_{xht} and IM^h_{xjt}. Second, when we replace the importer-industry-year fixed effect with importer-industry and importer-year fixed effects in order to use time series variation within importers and industries to identify the FVA effect, we need to add instruments for FVA^h_{xt} and FG^h_{xt} as well. We discuss instruments and present results in this order.

DVA and Imports The instrument selection problems for domestic value added and imports are related, in that both are bilateral variables and they are correlated with each other. We need two valid instruments (conditional on controls) that induce sufficient independent variation in DVA and imports to identify the coefficients.

The first instrument is targeted at breaking the potential simultaneity problem between DVA^j_{xht} and any residual variation in tariff preferences contained in e_{xhjt}. One potential instrument is to use DVA in an outside sector $z \neq x$, which is not directly a function

[48] At the bilateral level, non-tariff bilateral trade costs may influence both bilateral DVA content and final goods imports. At the industry level, the level of foreign value added is mechanically related to the level of final goods production.

[49] Note that we do not include bilateral (importer-exporter) fixed effects in any specification, because many bilateral preferences schemes are present throughout our data (see Figure 1). Removing the bulk of variation attributable to these schemes via bilateral fixed effects leaves us with scarce residual variation to use in identifying DVA effects. In effect, we risk throwing out the baby with the bathwater; it is not clear to us that this within transformation would improve identification, particularly when we can control for observable proxies for omitted variables directly in the empirical specification. Further, the theory does not directly support the inclusion additional fixed effects.

of t^h_{xjt} and thus plausibly uncorrelated with e_{xhjt}. In what follows, we adopt the services sector as this outside sector (itself not subject to tariffs), and we refer to this instrument as DVA-in-Services. As a concrete example, the identification assumption is then that the amount of US value-added content used in India's service sector is not determined by the US import tariff on textiles from India, controlling for remaining observables and fixed effects. This instrument is likely to be relevant, due to common supply-side factors that make h an attractive input supplier for j across many sectors, including services.

The main threat to the exclusion restriction derives from potential spillovers across sectors, whereby a reduction in tariffs in sector x could change demand for output in sector z, which could feed back into DVA^j_{zht}. While possible, we think this is unlikely to be a substantial concern for three reasons. First, services sector output is largely non-traded, and thus dependent on domestic demand in country j; as such, any spillover channel that operates through the impact of tariffs on bilateral imports by h from j is likely to be weak. Second, the direction of this potential spillover is unclear *ex ante*, and may differ across sectors, so it seems reasonable to expect such spillovers to be small on average. Third, any potential for spillover effects to contaminate the estimation is mitigated by the inclusion of an exporter-industry-year fixed effect in all specifications. This fixed effect purges the instrument of all exporter-year variation and therefore implicitly controls for the level of services output in the destination, which would be the main channel through which spillovers would operate.

To instrument for bilateral imports, we exploit heterogeneity in the distance elasticity of trade across sectors. Specifically, we construct the instrument by interacting the (log) bilateral distance across trading partners with an indicator that takes the value 1 if industry x has a high distance elasticity of trade.[50] We then control directly for log bilateral distance in the second stage, ensuring that we use only heterogeneity in distance effects for identification. This instrument is well-suited to identify bilateral variation in imports that is independent from DVA, because the distance elasticity of imports varies across sectors, while the distance elasticity of bilateral DVA content largely does not. The instrument is valid under the assumption that the direct influence of distance on tariffs (if any) is homogeneous across sectors, conditional on the remaining observables.[51]

[50] We partition industries into high/low groups based on distance elasticities obtained from gravity regressions with importer-industry-year and exporter-industry-year fixed effects. These distance elasticities range from -1.5 to -1, and we assign industries with distance elasticities less than -1.25 to the high elasticity group; for this group, we cannot reject equality between each industry's distance elasticity and the highest distance elasticity sector. These industries are all plausibly heavy, low value-to-weight goods that may be costly to ship long distances: Agriculture and Natural Resources (1), Pulp and Paper Goods (7), Rubber and Plastics (10), Basic and Fabricated Metals (12), and Transport Equipment (15).

[51] While we believe this assumption to be credible, we discuss an alternative strategy to instrument for imports in Appendix B.2, which yields similar results.

FVA and FG In our specifications with importer-year fixed effects, we design shift-share instruments for FVA^h_{xt} and FG^h_{xt}, which combine observed cross-sectional variation at the beginning of our sample with plausibly-exogenous growth patterns. This approach allows us to exploit just the plausibly-exogenous component of inter-temporal variation in FG and FVA across sectors.

Specifically, we use a "pull" instrument for FG^h_{xt}, which for each importer h interacts the share of final output in industry x sold to each destination j in the base year (1995) with subsequent growth in *destination-specific* expenditure on industry x. Correspondingly, we construct a "push" instrument for FVA^h_{xt}. Let FVA^h_{zxj0} be value added from upstream sector z in country j used by industry x in country h in the base year, with $FVA^h_{x0} = \sum_{j\neq h}\sum_z FVA^h_{zxj0}$. Then we interact these bilateral FVA sourcing shares with *foreign* value-added growth in upstream sectors to form the instrument. The instruments take the form:

$$\ln \widehat{FG}^h_{xt} = \ln\left(\sum_j \left(\frac{FG^h_{xj0}}{FG^h_{x0}}\right)\frac{FG_{xjt}}{FG_{xj0}}\right) \tag{4.1}$$

$$\ln \widehat{FVA}^h_{xt} = \ln\left(\sum_{j\neq h}\sum_s \left(\frac{FVA^h_{j0}(s,x)}{FVA^h_{x0}}\right)\frac{VA^j_{st}}{VA^j_{s0}}\right) \tag{4.2}$$

Controls In addition to the instruments described above, we also add additional control variables to address concerns about potential omitted variables bias. While theory does not present us with guidance about which controls might be necessary to add to the regression, we consider conventional bilateral controls used in the empirical trade literature. As noted above, all specifications will include (log) bilateral distance as a control variable. We also include colonial history, common language, and a common border (contiguity).[52] These controls have been shown to predict the adoption of bilateral trade agreements (RTAs) in previous work by Baier and Bergstrand (2004) and Egger et al. (2011), so are reasonable controls for determinants of bilateral preferences more generally.

Results We present results with these instrumental variables and additional controls in Table 6. Panel A reports results from specifications that include importer-industry-year fixed effects, in which only the instruments for DVA^h_{xjt} and IM^h_{xjt} are used. In column (1), we report OLS estimates that control for bilateral distance.[53] In columns (2)-(4), we

[52] We obtain these variables from the CEPII GeoDistance Database: http://www.cepii.fr/CEPII/fr/bdd_modele/presentation.asp?id=6. Bilateral characteristics for the EU are defined using GDP-weighted averages of bilateral characteristics for each individual EU country; thus, colonial linkages, common language, and contiguity are not strict indicator variables when the EU is a trading partner.

[53] The direct effect of distance is positive, while γ^{DVA} and $\gamma^{IP} + \gamma^{FVA}$ are somewhat diminished relative to the comparable estimates in column (2) of Table 2. Interpreting this result requires care, because we

report instrumental variables results. The first take-away is that the coefficient attached to the DVA ratio is negative in all specifications, and larger in absolute value than the OLS baseline. The second result is that this DVA coefficient is relatively stable with introduction of auxiliary bilateral control variables. Note that the estimate of $\gamma^{IP} + \gamma^{FVA}$ is driven toward zero in these specifications; we have little to say about this, since theory does not make a prediction for the value of this sum.

In Panel B of Table 6, we report results for specifications with importer-industry and importer-year fixed effects, in which we can estimate γ^{IP} and γ^{FVA} separately, as well as γ^{DVA}. The headline result is that the coefficient on the FVA ratio is negative in the IV estimation while the coefficient on the inverse import penetration ratio is positive, and the instrumental variables estimates are generally larger in absolute value than the commensurate OLS estimates. The coefficients on the FVA and IP ratios are significant at conventional levels in columns (6) and (7), but weaker in column (8) when we control for regional trade agreements (as discussed earlier, removing variation attributable to RTAs significantly reduces the inter-temporal variation available for identification of these coefficients).[54]

These instruments perform relatively well despite the challenges identified above.[55] In Panel A, the instruments pass rule-of-thumb thresholds (test statistics greater than 10), so conventional standard errors are likely appropriate. In Panel B, the case is less clear-cut based on the Wald rk F-statistic test for weak identification, though the conditional F-Statistics exceed rule-of-thumb thresholds. Thus, while we present conventional standard errors in parentheses in Panel B, we also provide weak-IV robust confidence intervals in brackets for the key coefficients.[56]

Supplemental IV Results In Appendix B, we "stress test" the IV strategy described above in several ways. First, we consider an alternative instrument for imports, based on

have introduced a control variable that is naturally correlated with the remaining right-hand side variables; the coefficient on bilateral distance may be positive either because it directly matters for tariff setting, or because it is correlated with the DVA ratio and IM^h_{xjt}. Put differently, γ^{DVA} and $\gamma^{IP} + \gamma^{FVA}$ now estimate the influence of *only* the variation in the DVA ratio and imports that is not explained by bilateral distance on preferential tariffs. Some of the variation that is "partialed out" by bilateral distance may in fact be "good variation" that is informative about the theory.

[54] The RTA indicator removes the impact of the spread of RTAs on mean preferences at the importer and industry level, which reduces the time series variation available to estimate γ^{FVA} and γ^{DPE}. From a theoretical perspective, FVA and domestic political economy should influence preferences both inside and outside RTAs, so there is not a strong *ex ante* argument to control for RTAs in this specification. Thus, while discarding this variation pushes γ^{FVA} and γ^{DPE} toward zero, this is not the preferred estimate.

[55] There is little guidance in the literature about appropriate critical values to use in screening for weak instruments with multiple instruments and clustered standard errors [Andrews, Stock and Sun (2019)].

[56] These confidence intervals are based on the projection method, applied to the conditional likelihood ratio (CLR) test statistic with nominal size of 10%. They are also conservative, in that these intervals cover the true value with probability that is strictly higher than the size of the test.

values of bilateral imports that are predetermined with respect to tariffs observed in our data, which replaces the heterogeneous distance effects instrument used above. Second, we separately consider an alternative instrument for DVA^h_{xjt}, again based on predetermined values of bilateral DVA in 1970. While this alternative DVA instrument contains useful variation and delivers consistent qualitative results, it is weak in some specifications, and so requires separate discussion. Nonetheless, we show in the appendix that the core IV results are robust to these permutations.

5 Results II: Temporary Trade Barriers and GVCs

In addition to bilateral applied tariffs, governments use non-tariff barriers to restrict imports. In this section we examine whether GVC linkages influence these polities as well. We focus on a specific class of these barriers, known collectively as temporary trade barriers (TTBs), which include antidumping, safeguards, and countervailing duties. These policies are both directly observable and politically salient trade policy instruments in the modern economy.

Temporary trade barriers are a natural testing ground for the GVC 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. 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 TTBs specifically, appear to respond to optimal tariff considerations, which suggests TTBs may offer fertile territory for exploring the effects of DVA in particular.[57]

Data and Empirical Strategy We obtain data on temporary trade barriers (TTBs) – antidumping, safeguards, and countervailing duties – from the World Bank's Temporary Trade Barriers Database [Bown (2016)]. 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. Following Trefler (1993) and Goldberg and Maggi (1999), among others, we construct import coverage ratios, which measure the stock of accumulated bilateral TTBs imposed by each importer against individual exporters in each

[57] 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)].

industry and year. See Appendix B.1.3 for further data details.

In examining TTB use, our empirical specifications follow the approach for applied tariffs with two modifications. First, instead of measuring the downward deviation of applied bilateral tariffs from MFN tariffs, our dependent variable now measures the *coverage ratio*: the share country h's imports from trading partner j that face a positive TTB in a given year and sector. These coverage ratios follow the same sign conventions we used for bilateral tariffs: lower coverage ratios are associated with lower trade protection. Second, 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. 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 currently in effect were actually adopted.

Results Table 7 presents ordinary least squares estimates for TTB coverage ratios.[58] Consistent with 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.[59]

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 non-zero 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

[58] Although TTB coverage ratios have a mass point at zero, several arguments lead us to opt for OLS to analyze them, rather than limited dependent variable methods. First, positive values are relatively rare in the data, occurring in only 6 percent of our importer-exporter-industry-year cells. Binary outcome models (e.g., Probit and Logit) are potentially 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 seems untenable in our context. Second, as a practical matter, standard censoring arguments suggest that OLS coefficients of interest would be biased toward zero. Thus, OLS is a robust and likely conservative approach to characterizing our data.

[59] In the table, we cluster on importer-exporter-industry, because TTB policy decisions are independent across industries. The inferences we draw are robust to clustering by importer-exporter pair instead.

[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 bilateral value-added content influences TTB use depending on whether China is the exporting country. To this end, we interact the DVA measure with an indicator for whether China is the exporter, and then re-estimate the specifications from Panel A. (Since both FVA and FG are multilateral (not bilateral), we have no *a priori* expectation that they should impact TTB use against China differently from TTB use writ large.)

The results are reported in Panel B of Table 7. The main finding is that TTB coverage ratios are substantially more sensitive to DVA content when China is the exporter. There is some evidence for similar targeting for non-Chinese exporters in column (3), but it is substantially weaker. Thus we conclude that importers seem to target TTB use against China in a manner that shields their own upstream suppliers from harm.

6 Conclusion

This paper introduces a new value-added approach for exploring 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 where goods are made, 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. These results demonstrate the empirical importance of specific channels through which global value chains shape governments' trade policy choices.

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 empirical investigation of optimal input tariffs. We readily acknowledge a role for future work in studying the determination of input tariffs themselves. As we discussed in Section 2.5, input tariffs are contingent on a host of issues that are largely irrelevant in the study of final goods tariffs, including the division of quasi-rents between downstream final goods producers and their input suppliers, possible hold-up problems, and complementarities across inputs in production. These issues present fertile territory for quantitative analysis, and very recent work by Antràs et al. (2021) and Caliendo et al. (2021) make early advances in this direction.

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. At the same time, we look forward to future work on the role of GVC linkages in shaping multilateral tariffs, with potential implications for the theory of trade agreements.

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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 (Release 2013) 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 Value-Added Content

	OLS		Tobit	
	(1)	(2)	(3)	(4)
DVA ratio: $\ln(DVA^{j}_{xht}/IM^{h}_{xjt})$	-0.98***	-1.09***	-2.37***	-2.58***
	(0.27)	(0.30)	(0.50)	(0.54)
FVA ratio: $\ln(FVA^{h}_{xt}/IM^{h}_{xjt})$	-0.97***		-1.71***	
	(0.23)		(0.44)	
IP ratio: $\ln(FG^{h}_{xt}/IM^{h}_{xjt})$	2.13***		4.65***	
	(0.48)		(0.92)	
IP ratio + FVA ratio ($\gamma^{IP} + \gamma^{FVA}$)		1.29***		3.18***
		(0.33)		(0.60)
Observations	11,281	11,281	11,281	11,281
R-Squared	0.364	0.389		

Column Fixed Effects				
Importer-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: Standard errors (in parentheses) are clustered by importer-exporter pair. Significance levels: * $p < .1$, ** $p < .05$, *** $p < .01$.

Table 3: Heterogeneity by Trade Policy Regime: Regional Trade Agreements

Panel A: Controlling for RTAs				
	OLS		Tobit	
	(1)	(2)	(3)	(4)
DVA ratio: $\ln(DVA^{j}_{xht}/IM^{h}_{xjt})$	-0.34**	-0.38**	-0.97***	-1.07***
	(0.15)	(0.17)	(0.34)	(0.38)
FVA ratio: $\ln(FVA^{h}_{xt}/IM^{h}_{xjt})$	-0.66***		-1.19***	
	(0.18)		(0.34)	
IP ratio: $\ln(FG^{h}_{xt}/IM^{h}_{xjt})$	1.06***		2.37***	
	(0.31)		(0.63)	
IP ratio + FVA ratio ($\gamma^{IP}+\gamma^{FVA}$)		0.45**		1.29***
		(0.19)		(0.42)
Reciprocal Trade Agreement: RTA_{hjt}	-5.64***	-5.58***	-8.74***	-8.61***
	(0.81)	(0.83)	(1.19)	(1.17)
Observations	11,281	11,281	11,281	11,281
R-Squared	0.547	0.564		

Panel B: Heterogeneous Coefficients by RTA Status				
	OLS		Tobit	
	(5)	(6)	(7)	(8)
DVA ratio (outside): $[1-RTA_{hjt}]\times\ln(DVA^{j}_{xht}/IM^{h}_{xjt})$	-0.37**	-0.42**	-1.03***	-1.14***
	(0.15)	(0.17)	(0.34)	(0.38)
DVA ratio (inside): $RTA_{hjt}\times\ln(DVA^{j}_{xht}/IM^{h}_{xjt})$	-0.018	-0.055	-0.66	-0.74
	(0.40)	(0.41)	(0.51)	(0.53)
FVA ratio (outside): $[1-RTA_{hjt}]\times\ln(FVA^{h}_{xt}/IM^{h}_{xjt})$	-0.55***		-0.80**	
	(0.18)		(0.37)	
FVA ratio (inside): $RTA_{hjt}\times\ln(FVA^{h}_{xt}/IM^{h}_{xjt})$	-2.83***		-5.17***	
	(0.88)		(1.56)	
IP ratio (outside): $[1-RTA_{hjt}]\times\ln(FG^{h}_{xt}/IM^{h}_{xjt})$	0.98***		2.03***	
	(0.29)		(0.60)	
IP ratio (inside): $RTA_{hjt}\times\ln(FG^{h}_{xt}/IM^{h}_{xjt})$	3.04***		6.20***	
	(0.73)		(1.44)	
IP ratio + FVA ratio ($\gamma^{IP}+\gamma^{FVA}$)		0.25		1.11**
		(0.43)		(0.53)
FVA ratio outside − inside RTA		2.44***		4.44***
		(0.92)		(1.72)
IP ratio outside − inside RTA		-2.20***		-4.20***
		(0.70)		(1.48)
Reciprocal Trade Agreement: RTA_{hjt}	-8.48***	-8.60***	-15.3***	-15.1***
	(1.76)	(1.85)	(2.95)	(2.97)
Observations	11,281	11,281	11,281	11,281
R-Squared	0.554	0.572		
Column Fixed Effects				
Importer-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: $RTA_{hjt}=1$ if countries h and j have an Article XXIV trade agreement in force, and zero otherwise. Standard errors (in parentheses) are clustered by importer-exporter pair. Significance levels: * $p<.1$, ** $p<.05$, *** $p<.01$.

Table 4: Heterogeneity by Trade Policy Regime: Non-RTA Preferences

Panel A: No RTA Sample				
	OLS		Tobit	
	(1)	(2)	(3)	(4)
DVA ratio: $\ln(DVA^{j}_{xht}/IM^{h}_{xjt})$	-0.12*	-0.15**	-0.52**	-0.63***
	(0.060)	(0.070)	(0.21)	(0.24)
FVA ratio: $\ln(FVA^{h}_{xt}/IM^{h}_{xjt})$	-0.38***		-0.54*	
	(0.13)		(0.30)	
IP ratio: $\ln(FG^{h}_{xt}/IM^{h}_{xjt})$	0.60***		1.42***	
	(0.14)		(0.42)	
IP ratio + FVA ratio ($\gamma^{IP}+\gamma^{FVA}$)		0.26***		1.01***
		(0.074)		(0.29)
Observations	10,399	10,399	10,399	10,399
R-Squared	0.369	0.401		

Panel B: Heterogeneous Coefficients by GSP Eligibility				
	OLS		Tobit	
	(5)	(6)	(7)	(8)
DVA ratio (ineligible): $[1-GSP_{hj}]\times\ln(DVA^{j}_{xht}/IM^{h}_{xjt})$	-0.15**	-0.18**	-0.75**	-0.87**
	(0.064)	(0.074)	(0.32)	(0.35)
DVA ratio (eligible): $GSP_{hj}\times\ln(DVA^{j}_{xht}/IM^{h}_{xjt})$	-0.070	-0.10	-0.56***	-0.67***
	(0.071)	(0.080)	(0.21)	(0.24)
FVA ratio (ineligible): $[1-GSP_{hj}]\times\ln(FVA^{h}_{xt}/IM^{h}_{xjt})$	-0.58***		-2.86***	
	(0.16)		(0.93)	
FVA ratio (eligible): $GSP_{hj}\times\ln(FVA^{h}_{xt}/IM^{h}_{xjt})$	-0.093		0.060	
	(0.17)		(0.31)	
IP ratio (ineligible): $[1-GSP_{hj}]\times\ln(FG^{h}_{xt}/IM^{h}_{xjt})$	0.83***		4.24***	
	(0.20)		(1.01)	
IP ratio (eligible): $GSP_{hj}\times\ln(FG^{h}_{xt}/IM^{h}_{xjt})$	0.22		0.67*	
	(0.17)		(0.40)	
IP ratio + FVA ratio ($\gamma^{IP}+\gamma^{FVA}$)		0.17**		0.85***
		(0.086)		(0.27)
FVA ratio outside − inside GSP eligibility		-0.53**		-3.23***
		(0.20)		(1.08)
IP ratio outside − inside GSP eligibility		0.65***		3.93***
		(0.22)		(1.10)
GSP eligibility: GSP_{hj}	1.26*	1.33*	12.2***	13.1***
	(0.67)	(0.69)	(3.52)	(3.56)
Observations	10,399	10,399	10,399	10,399
R-Squared	0.380	0.411		
Column Fixed Effects				
Importer-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: $GSP_{hj}=1$ if country h could grant country j GSP preferences, and zero otherwise. Standard errors (in parentheses) are clustered by importer-exporter pair. Significance levels: * $p<.1$, ** $p<.05$, *** $p<.01$.

Table 5: Heterogeneity by Upstream and Downstream Differentiation

Panel A: Upstream Differentiation				
	Manuf. vs. Non-Manuf.		Rauch Classification	
	OLS	Tobit	OLS	Tobit
	(1)	(2)	(3)	(4)
DVA ratio (differentiated)	-1.22**	-2.37**	-2.43*	-4.82**
	(0.57)	(0.98)	(1.33)	(2.31)
DVA ratio (undifferentiated)	0.10	-0.21	1.39	2.45
	(0.44)	(0.93)	(1.21)	(2.30)
IP ratio + FVA ratio ($\gamma^{IP} + \gamma^{FVA}$)	1.27***	3.10***	1.21***	2.92***
	(0.31)	(0.57)	(0.28)	(0.53)
Observations	11,281	11,281	11,281	11,281
R-Squared	0.397		0.400	

Panel B: Downstream Differentiation				
	Manuf. vs. Non-Manuf.		Rauch Classification	
	OLS	Tobit	OLS	Tobit
	(5)	(6)	(7)	(8)
DVA ratio (differentiated)	-1.11***	-2.70***	-1.30***	-1.30***
	(0.30)	(0.55)	(0.32)	(0.30)
DVA ratio (undifferentiated)	-1.02***	-2.06***	-0.75**	-0.75***
	(0.38)	(0.58)	(0.29)	(0.26)
IP ratio + FVA ratio (differentiated)	1.29***	3.27***	1.52***	1.52***
	(0.31)	(0.60)	(0.34)	(0.32)
IP ratio + FVA ratio (undifferentiated)	1.25***	2.78***	0.91***	0.91***
	(0.42)	(0.64)	(0.31)	(0.28)
Observations	11,281	11,281	11,281	11,281
R-Squared	0.389		0.394	

Note: See Section 4.2.2 for definitions of differentiated and undifferentiated upstream and downstream sectors. All columns include importer-industry-year and exporter-industry-year fixed effects. Standard errors (in parentheses) are clustered by importer-exporter pair. Significance levels: * $p < .1$, ** $p < .05$, *** $p < .01$.

Table 6: Instruments and Additional Controls

Panel A: Importer-Industry-Year Fixed Effects				
	OLS	Instrumental Variables		
	(1)	(2)	(3)	(4)
DVA ratio: $\ln(DVA^{j}_{xht}/IM^{h}_{xjt})$	-0.68***	-1.77***	-1.54***	-1.32***
	(0.24)	(0.59)	(0.52)	(0.46)
IP ratio + FVA ratio ($\gamma^{IP}+\gamma^{FVA}$)	0.77***	0.28	0.07	-0.16
	(0.25)	(0.33)	(0.31)	(0.28)
Log Bilateral Distance	0.86***	1.91***	2.12***	1.35***
	(0.29)	(0.58)	(0.59)	(0.45)
Colony			2.74**	0.81
			(1.13)	(0.78)
Common Language			0.21	0.56
			(0.63)	(0.58)
Contiguity			-1.36	0.37
			(1.14)	(1.09)
Reciprocal Trade Agreement: RTA_{hjt}				-5.69***
				(0.89)
Observations	11,281	11,281	11,281	11,281
Under-Identfication Test (rk LM statistic)		21.11	21.27	21.28
Weak-Identfication Test (Wald rk F statistic)		11.99	12.09	12.10
Conditional F-Stat (DVA ratio)		23.98	24.15	24.16
Conditional F-Stat (IP ratio + FVA ratio)		25.98	25.66	25.56

Panel A: Importer-Industry + Importer-Year Fixed Effects				
	OLS	Instrumental Variables		
	(5)	(6)	(7)	(8)
DVA ratio: $\ln(DVA^{j}_{xht}/IM^{h}_{xjt})$	-0.56***	-1.79***	-1.56***	-1.32***
	(0.19)	(0.60)	(0.53)	(0.46)
		[-3.12,-0.73]	[-2.73,-0.62]	[-2.33,-0.71]
FVA ratio: $\ln(FVA^{h}_{xt}/IM^{h}_{xjt})$	-0.77***	-4.51**	-3.50*	-2.44
	(0.20)	(2.20)	(1.90)	(1.64)
		[-6.46,-0.60]	[-6.02,-0.14]	[-6.08,0.46]
IP ratio: $\ln(FG^{h}_{xt}/IM^{h}_{xjt})$	1.40***	4.73**	3.53*	2.29
	(0.37)	(2.35)	(2.00)	(1.71)
Log Bilateral Distance	0.98***	1.99***	2.17***	1.34***
	(0.29)	(0.57)	(0.58)	(0.43)
Colony			2.76**	0.81
			(1.11)	(0.76)
Common Language			0.20	0.56
			(0.62)	(0.56)
Contiguity			-1.36	0.37
			(1.11)	(1.06)
Reciprocal Trade Agreement: RTA_{hjt}				-5.69***
				(0.87)
Observations	11,281	11,281	11,281	11,281
Under-Identfication Test (rk LM-Stat)		21.02	21.29	21.33
Weak-Identfication Test (Wald rk F-Stat)		6.29	6.34	6.35
Conditional F-Stat (DVA ratio)		12.64	12.74	12.76
Conditional F-Stat (FVA ratio)		72.62	76.43	77.18
Conditional F-Stat (IP ratio)		87.01	91.71	92.67

Note: Instrumental variables results are obtained via two-stage least squares; see Section 4.3 for description of the instruments. All columns include exporter-industry-year fixed effects. Standard errors (in parentheses) are clustered by importer-exporter pair. Significance levels: * $p < .1$, ** $p < .05$, *** $p < .01$. Under/Weak-Identification Tests are based on Kleinbergen and Paap (2006); conditional F-statistics are based on Sanderson and Windmeijer (2016). In Panel B, weak-IV robust confidence intervals, based on the projection method applied to the conditional likelihood ratio (CLR) test static with 10% nominal size, are reported in brackets.

Table 7: Temporary Trade Barriers and Value Added Content

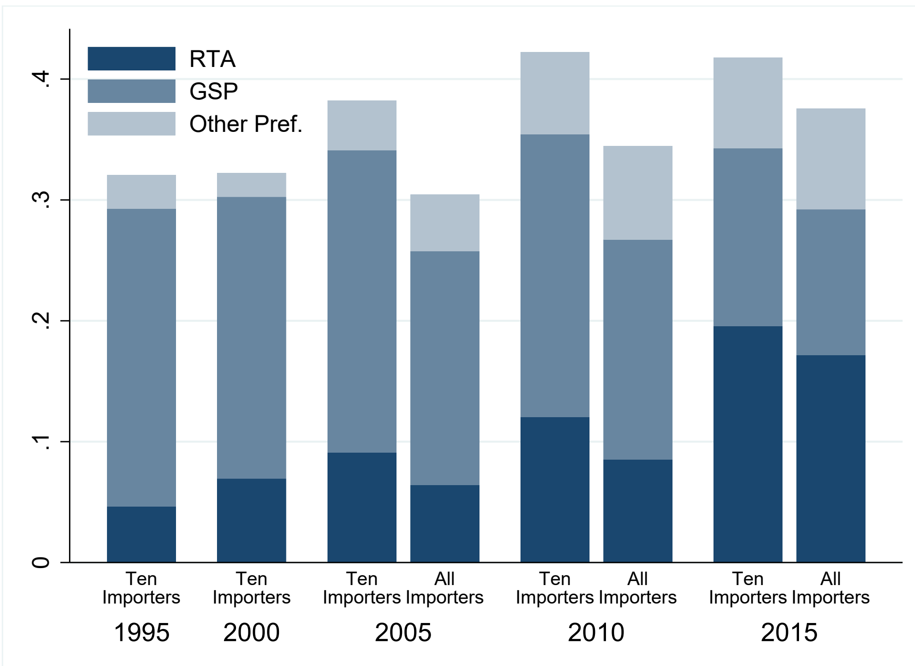
Panel A: Homogeneous Coefficients		
	(1)	(2)
DVA ratio: $\ln(DVA^{j}_{xht}/IM^{h}_{xjt})$	-0.22***	-0.17**
	(0.065)	(0.070)
FVA ratio: $\ln(FVA^{h}_{xt}/IM^{h}_{xjt})$	-1.56***	
	(0.52)	
IP ratio: $\ln(FG^{h}_{xt}/IM^{h}_{xjt})$	1.76***	
	(0.52)	
IP ratio + FVA ratio ($\gamma^{IP} + \gamma^{FVA}$)		0.16***
		(0.059)
Observations	8,515	8,515
R-Squared	0.249	0.486

Panel B: Heterogeneous Coefficients for China as an Exporter		
	(3)	(4)
DVA ratio (China): $\ln(DVA^{j}_{xh,t-5}/IM^{h}_{xj,t-5}) \times \mathbf{1}(j = \text{China})$	-0.65**	-0.54**
	(0.28)	(0.27)
DVA ratio (not China): $\ln(DVA^{j}_{xh,t-5}/IM^{h}_{xj,t-5}) \times [1 - \mathbf{1}(j = \text{China})]$	-0.19***	-0.13*
	(0.062)	(0.069)
FVA ratio: $\ln(FVA^{h}_{xt}/IM^{h}_{xjt})$	-1.58***	
	(0.52)	
IP ratio: $\ln(FG^{h}_{xt}/IM^{h}_{xjt})$	1.75***	
	(0.52)	
IP ratio + FVA ratio ($\gamma^{IP} + \gamma^{FVA}$)		0.14**
		(0.057)
Observations	8,515	8,515
R-Squared	0.251	0.488

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

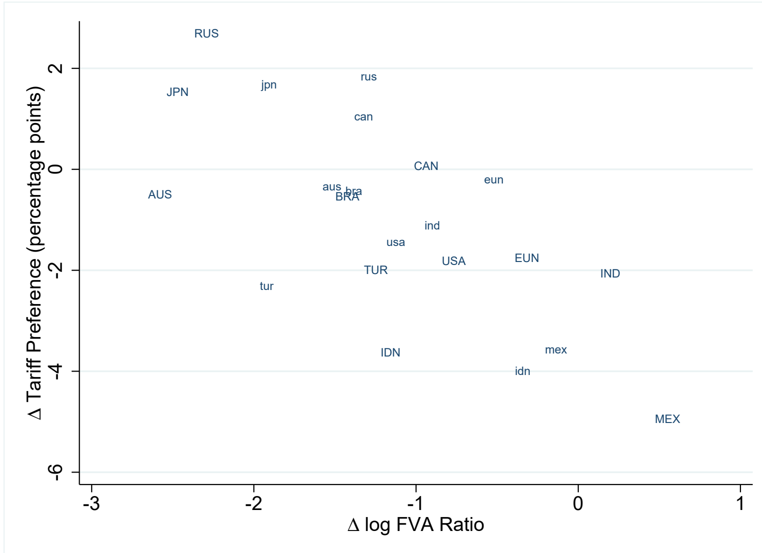
Note: Dependent variable in all columns is the temporary trade barrier coverage ratio for importer h against exporter j for final goods imports in industry x: TTB^{h}_{xjt}. The DVA ratio, FVA ratio, and IP ratios are lagged to reflect information available when TTBs were adopted. In Panel B, the DVA ratio is interacted with an indicator for whether China is the exporting country ($\mathbf{1}(j = \text{China})$). Standard errors (in parentheses) are clustered by importer-exporter-industry. Significance levels: * $p < .1$, ** $p < .05$, *** $p < .01$.

Figure 1: Tariff Preferences over Time

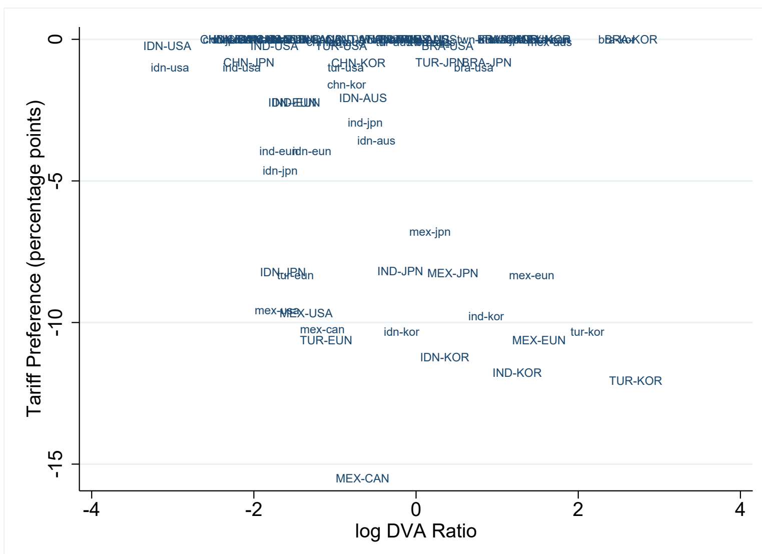


Note: the figure reports the share of importer-exporter-industry cells (with non-zero MFN tariffs) that have preferential tariffs in place by year: $\frac{\sum_{i\neq j}\mathbf{1}(t^{i}_{xjt}<t^{i,MFN}_{xt})}{\sum_{i\neq j}\mathbf{1}(t^{i,MFN}_{xt}>0)}$. Preferences are broken down by whether they are occur under a regional trade agreement, the GSP program, or other preferential agreements. The bars labelled "Ten Importers" report data for a balanced panel of 10 importing countries with data available in all years, and the bars labelled "All Importers" report data for all importing countries.

Figure 2: Textiles, Leather, and Footwear Case Study



(a) Change in Mean Tariff Preference vs. Change in log FVA Ratio within Importer and Industry from 1995 to 2015



(b) Tariff Preferences vs. log DVA Ratio in 2015: High Income Importers and Emerging Market Exporters

Note: Sub-figure (a) plots changes in mean preferential tariffs by importer and industry, given by $\Delta_t \bar{t}^h_{xt} = \frac{1}{C-1}\sum_{j\neq h}\Delta_t\left(t^h_{xjt} - t^{h,MFN}_{xt}\right)$, against changes in the (multilateral) log FVA ratio, given by $\Delta\ln\left(\frac{FVA^h_{xt}}{IM^h_{xt}}\right)$, between 1995 and 2015. Sub-figure (b) plots $t^h_{xjt} - t^{h,MFN}_{xt}$ against $\ln\left(DVA^h_{xjt}/IM^h_{xjt}\right)$ for high income importers and emerging economies exporters in 2015. 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, excluding Russia who faced economic sanctions in 2015. Labels indicate the importing country in Sub-figure (a) and the (ordered) exporter-importer pair in Sub-figure (b). In both figures, data for Textiles and Apparel (WIOD sector 4) is represented by capitalized labels, and data for Leather and Footwear (WIOD sector 5) is represented by lower case labels.

A Theory Appendix

A.1 Proof of Proposition 1

To prove Proposition 1 we need to derive the necessary and sufficient conditions under which: (i) $\frac{d\tau^o}{d\nu_h^f} < 0$ and (ii) $\frac{d\tau^o}{d\nu_f^h} < 0$. These derived expressions will be Conditions 1 and 2 in the text.

Recall that τ^o is given by the first order condition of Home's indirect utility function with respect to the tariff:

$$V_\tau(\tau^o) = 0, \tag{A1}$$

where $V_\tau \equiv \frac{dV^h}{d\tau} = \frac{\partial V(p^h,I^h)}{\partial p^h}\frac{dp^h}{d\tau} + \frac{\partial V(p^h,I^h)}{\partial I^h}\frac{dI^h}{d\tau}$, using $\frac{dI^h}{d\tau} = \frac{\partial I(p^h,p^f)}{\partial p^h}\frac{dp^h}{d\tau} + \frac{\partial I(p^h,p^f)}{\partial p^f}\frac{dp^f}{d\tau}$. Taking the total derivative of (A1) characterizes the relationship between the optimal tariff and GVC inputs in DVA (ν_h^f) and FVA (ν_f^h):

$$V_{\tau\tau}d\tau^o + V_{\tau\nu_h^f}d\nu_h^f + V_{\tau\nu_f^h}d\nu_f^h = 0, \tag{A2}$$

where we again use subscripts as shorthand for derivatives: $V_{\tau\tau} \equiv \frac{d^2V^h}{d\tau^2}, V_{\tau\nu_h^f} \equiv \frac{d^2V^h}{d\tau d\nu_h^f}$ and $V_{\tau\nu_f^h} \equiv \frac{d^2V^h}{d\tau d\nu_f^h}$.

Consider part (i) of Proposition 1 first, focusing on the DVA input, ν_h^f and holding ν_f^h fixed. Evaluating (A2) at the optimal tariff, we have:

$$\frac{d\tau^o}{d\nu_h^f} = -\frac{V_{\tau\nu_h^f}}{V_{\tau\tau}}\bigg|_{\tau^o}. \tag{A3}$$

By the second order condition of the optimal tariff problem, $V_{\tau\tau}\Big|_{\tau^o} < 0$. Thus, the necessary and sufficient condition for the optimal tariff to be declining in DVA-inputs reduces to:

$$\frac{d\tau^o}{d\nu_h^f} < 0 \iff V_{\tau\nu_h^f}\bigg|_{\tau^o} < 0. \tag{A4}$$

Using the first order condition in (2.16), together with expressions (2.17) and (2.18), collecting terms, using the market clearing condition, and applying the envelope condition at τ^o, we have:

$$V_{\tau\nu_h^f}\Big|_{\tau^o} = \frac{d}{d\nu_h^f}\left(\frac{dV}{d\tau}\right) \tag{A5}$$

$$= \frac{d}{d\nu_h^f}\left(V_I\left\{(\tau^o-1)p^f\frac{dM_x}{d\tau} - M_x\frac{d\tilde{p}^f}{d\tau} - \frac{dr_f^h}{dp^h}\nu_f^h\frac{dp^h}{d\tau} + \frac{dr_h^f}{dp^f}\nu_h^f\frac{d\tilde{p}^f}{d\tau}\right\}\right) \tag{A6}$$

$$= \frac{d}{d\nu_h^f}\left(V_I\frac{d\tilde{p}^f}{d\tau}\underbrace{\left\{(\tau^o-1)E_x^f(\epsilon_x^f-1) - \frac{dr_f^h}{dp^h}\nu_f^h\frac{1}{\lambda} + \frac{dr_h^f}{dp^f}\nu_h^f\right\}}_{=0@\tau^o}\right) \tag{A7}$$

$$= \underset{+}{V_I}\underset{-}{\frac{d\tilde{p}^f}{d\tau}}\frac{d}{d\nu_h^f}\left((\tau^o-1)E_x^f(\epsilon_x^f-1) - \frac{dr_f^h}{dp^h}\nu_f^h\frac{1}{\lambda} + \frac{dr_h^f}{dp^f}\nu_h^f\right)\Bigg|_{\tau=\tau^o}. \tag{A8}$$

From here, we can rewrite (A4) as:

$$\frac{d\tau^o}{d\nu_h^f} < 0 \iff \frac{d}{d\nu_h^f}\left((\tau^o-1)E_x^f(\epsilon_x^f-1) - \frac{dr_f^h}{dp^h}\nu_f^h\frac{1}{\lambda} + \frac{dr_h^f}{dp^f}\nu_h^f\right)\Bigg|_{\tau^o} > 0 \tag{A9}$$

Rewriting the second inequality delivers the necessary and sufficient condition for the optimal tariff to be decreasing in the quantity of Home's value added used in foreign production stated in Condition 1:[1]

$$\left[\frac{dr_h^f}{dp^f} + \frac{d}{d\nu_h^f}\left(\frac{dr_h^f}{dp^f}\right)\nu_h^f + \frac{d}{d\nu_h^f}\left(\frac{dr_f^h}{dp^h}\frac{1}{|\lambda|}\right)\nu_f^h + \frac{d}{d\nu_h^f}\left((\tau^o-1)E_x^f(\epsilon_x^f-1)\right)\right]\Bigg|_{\tau^o} > 0.$$

The indirect effects of a change in ν_h^f on Home's terms-of-trade motive and on pass-through rates (from tariffs to prices, embedded in λ, and from final goods prices to GVC income in the $\frac{dr_j^c}{dp^c}$ terms) are generally ambiguous in sign. As long as these indirect effects are not both negative and large, Condition 1 will be satisfied, and Home's optimal tariff will be decreasing in its domestic GVC inputs embodied in Foreign production.

The derivation of the necessary and sufficient condition for FVA closely parallels that above, so we do not repeat it here; the result is Condition 2 in the text.

A.2 A Functional Form Example

This appendix presents a simple functional-form version of the model with quadratic utility and Cobb-Douglass production for the non-numéraire good. This exercise fixes ideas and allows us to derive the explicit form of the optimal tariff in terms of model primitives.

[1] The derivative $\frac{d}{d\nu_h^f}$ includes the direct influence of ν_h^f as well as any potential changes in final good prices. For economy of notation, we subsume these partial effects in the total derivative; e.g. $\frac{d}{d\nu_h^f}\left(\frac{dr_h^f}{dp^f}\right) = \frac{\partial^2 r_h^f(p^f,\vec{\nu}^f)}{\partial p^f \partial \nu_h^f} + \frac{\partial^2 r_h^f(p^f,\vec{\nu}^f)}{\partial {p^f}^2}\frac{d\tilde{p}^f}{d\nu_h^f}$.

A.2.1 Set-up

The structure of the model follows the set up described in Section 2.1, with identical notation and assumptions except where noted below.

Functional Form Assumption 1. *Preferences are described by the following utility function:*

$$U(d_y^c, d_x^c) \;=\; \alpha d_y^c + \beta^c d_x^c - \frac{1}{2} d_x^{c\,2} \tag{A10}$$

for $c \in \{h, f\}$, where $\alpha, \beta^c > 0$ are exogenous parameters.

Functional Form Assumption 2. *Technology is given by the production functions:*

$$q_x^c = (2\gamma l_x^c V^c)^{\frac{1}{2}} \qquad\qquad q_y^c = l_y^c \tag{A11}$$

for $c \in \{h, f\}$, where $\gamma > 0$ is an exogenous technology parameter and $V^c = \nu_h^c + \nu_f^c$ represents the total composite value added used in production of good x in country $c \in \{h, f\}$.

The next assumption defines the division of quasi-rents between locally- and foreign-sourced value added inputs.

Functional Form Assumption 3. *Let $r_h^c = r_f^c \equiv r^c$ for $c \in \{h, f\}$; i.e. the (pre-tax) per-unit price paid to value added-inputs is the same for domestically- and foreign-sourced inputs.*

This assumption is a sensible benchmark in our setting where Home and Foreign GVC inputs are perfect substitutes in production.[2]

The final assumption ensures that x is Home's natural import good – or equivalently, Foreign has a (preference-derived) comparative advantage in production of good x:

Functional Form Assumption 4. *Let $\beta^h > \beta^f$ and $V^h = V^f \equiv V$.*

Focusing on demand-side drivers of trade simplifies the derivation of the closed-form tariff expression. It also serves a valuable expositional role in our later comparative statics exercises. In our later comparative statics, we will hold the total level of composite value added input (V) fixed in each country while varying the *composition* of GVC inputs used in production across sources; this approach allows us to clearly identify the direct, first-order influence of GVC production linkages on optimal tariff setting apart from potential second-order effects via generic disruptions in production and trade volumes.

A.2.2 Solution

Production. Together, profit maximization and labor market clearing determine the supply functions for each good in each country $c \in \{h, f\}$:

$$q_x^c(p^c) = \gamma V p^c \qquad\qquad q_y(p^c) = L^c - \frac{1}{2}\gamma V p^{c2}. \tag{A12}$$

[2]As noted earlier, in specific factors settings, the division of quasi-rents among multiple specific factors is generally indeterminate. Our key results obtain under alternative rent-sharing assumptions as long as the pass-through rate from local prices to GVC-inputs is strictly positive.

The following zero profit condition pins down GVC income and the return to domestically-sourced value-added inputs in each country, as a function of the local price:

$$r^c(p^c)(\nu_h^c + \nu_f^c) = p^c q_x(p^c) - l_x^c(p^c) = \frac{1}{2}\gamma V p^{c2}. \tag{A13}$$

Thus, $r^c(p^c) = \frac{1}{2}\gamma p^{c2}, c \in \{h, f\}$ and $\varepsilon_j^{rc} \equiv \frac{dr_j^c}{dp^c}\frac{p^c}{r_j^c} = 2,\ c, j \in \{h, f\}$.

Consumption. The (inverse) demand for each good is given by the (constrained) maximization of the utility function in (A10):

$$d_x^c(p^c) = \beta^c - \alpha p^c \qquad d_y(p, I^c) = I^c - \beta^c p^c + \alpha p^{c2}, \tag{A14}$$

where income in Home and Foreign are given in equation (2.11).

Market Clearing. The international market clearing condition in (2.13) pins down equilibrium prices. Substituting (A12), and (A14) into (2.13) and solving yields:

$$\tilde{p}^f(\tau) = \frac{\beta^h + \beta^f}{(\alpha + \gamma V)}\frac{1}{(\tau + 1)} \qquad p^h(\tau) = \tau\tilde{p^f}(\tau) = \frac{(\beta^h + \beta^f)}{(\alpha + \gamma V)}\frac{\tau}{(\tau + 1)}. \tag{A15}$$

Notice $\tilde{p}^f(\tau)$ is decreasing in τ and $p^h(\tau)$ is increasing in τ, consistent with Assumption 2.2.

The Optimal Tariff The expressions for supply, demand, and equilibrium prices described above deliver parsimonious expressions for the equilibrium trade volume, export supply elasticity, pass-through rates, and λ as a function of the tariff:[3]

$$E^f(\tau) = \frac{\beta^h - \beta^f\tau}{\tau + 1} \qquad \epsilon^f(\tau) = \frac{\beta^h + \beta^f}{\beta^h - \beta^f\tau} \qquad \lambda(\tau) = -1 \qquad \varepsilon_h^{rf}(\tau) = \varepsilon_f^{rh}(\tau) = 2$$

Substituting these expressions and the prices in (A15) into equation (2.19), then solving for τ, yields a closed-form solution for the optimal tariff:

$$\tau^o = \frac{2\beta^h + \beta^f - \gamma A\nu_h^f}{\beta^h + 2\beta^f + \gamma A\nu_f^h}, \tag{A16}$$

where $A \equiv \frac{(\beta^h + \beta^f)}{\alpha + \gamma V} > 0$.

Absent the influence of GVC linkages, the optimal tariff is strictly positive and follows the standard terms-of-trade inverse-elasticity rule: $\tau^{tot} = \frac{2\beta^h + \beta^f}{\beta^h + 2\beta^f} > 1$.GVC linkages drive the optimal tariff below this benchmark. Taking the derivative of (A16) with respect to ν_h^f and ν_f^h yields the comparative statics analog to Proposition 1:[4]

[3] ${E_x}^f(\tau) \equiv E_x^f(\tilde{p}^f(\tau)) = [q_x^f(\tilde{p}^f(\tau)) - d_x^f(\tilde{p}^f(\tau))]$; Likewise, let $\epsilon_x^f(\tau) \equiv \frac{dE_x^f}{dp^f}\frac{\tilde{p}^f(\tau)}{E_x^f(\tau)}$ and $\frac{dr^f}{dp^f}(\tau) \equiv \frac{dr^f}{dp^f}\big|_{\tilde{p}^f(\tau)}$; $\frac{dr^h}{dp^h}(\tau) \equiv \frac{dr^h}{dp^h}\big|_{p^h=\tau\tilde{p}^f(\tau)}$; and $\lambda(\tau) = \frac{dp^f/d\tau}{dp^h/d\tau}\big|_{p^f=\tilde{p}^f(\tau);p^h=\tau\tilde{p}^f(\tau)}$.

[4] From Assumption 4, $V = \nu_h^h + \nu_f^h = \nu_h^f + \nu_f^f$. Holding V fixed, therefore implies: $dV = 0 \rightarrow d\nu_h^f = -d\nu_f^f$

Lemma 1. *Subject to Functional Form Assumptions 1-4, Home's optimal tariff is decreasing in the share of GVC-inputs used in production:*

$$\left.\frac{d\tau^o}{d\nu_f^h}\right|_{dV=0} < 0 \qquad \textit{and} \qquad \left.\frac{d\tau^o}{d\nu_h^f}\right|_{dV=0} < 0.$$

Proof. With $dV = 0$,

$$\frac{d\tau^o}{d\nu_f^h} = -\frac{\gamma A \nu_h^f \tau^o}{\beta^h + 2\beta^f + \gamma A \nu_f^h} < 0 \qquad\qquad \frac{d\tau^o}{d\nu_h^f} = -\frac{\gamma A \nu_h^f}{\beta^h + 2\beta^f + \gamma A \nu_f^h} < 0.$$

A.3 The Optimal Tariff with Endogenous GVCs

This appendix generalizes the model to allow for endogenous changes in the use of value-added inputs across sectors and countries in response to price changes. As noted in the main text, we allow frictions to limit the substitutability of inputs across end-use sectors or destinations, so that the equilibrium returns to inputs may differ non-systematically across countries. We assume only that (i) the return to, and the use of, the value-added inputs are weakly increasing in the local price of the final good that they are used to produce, and (ii) the vector of final goods prices uniquely pins down the global distribution and returns to value-added inputs.

Assumption A.1. *Let:*

1. $r_j^c = r_j^c(p^c, \vec{\nu}^c(\vec{p})) \equiv r_j^c(\vec{p})$ *where* $\frac{\partial r_j^c(p^h,p^f)}{\partial p^c} \geq 0$ *for* $c, j \in \{h, f\}$,

2. $\nu_j^c = \nu_j^c(\vec{r}(\vec{p})) \equiv \nu_j^c(\vec{p})$ *where* $\frac{\partial \nu_j^c(p^h,p^f)}{\partial p^c} \geq 0$ *for* $c, j \in \{h, f\}$,

To streamline analysis, we adopt quasi-linear preferences, which removes potential income effects that otherwise complicate exposition:

$$U^c = d_0^c + u_x(d_x^c), \; c \in \{x, y\}. \tag{A17}$$

As before, national income is given by:

$$I^h = q_y + p^h q_x^h(p^h, \vec{\nu}) + (p^h - p^f) M_x(p^h, \vec{\nu}) + \underbrace{r_h^f(\vec{p})\nu_h^f(\vec{p})}_{\equiv DVA_h(\vec{p})} - \underbrace{r_f^h(\vec{p})\nu_f^h(\vec{p})}_{\equiv FVA^h(\vec{p})}. \tag{A18}$$

The Home government chooses its optimal tariff to maximize aggregate indirect utility, subject to the arbitrage and market clearing conditions in (2.12)-(2.13), which together pin down the equilibrium prices $\tilde{p}^f$ and $\tilde{p}^h = \tau \tilde{p}^f$ as a function of the tariff.

The first order condition of the optimal tariff problem is largely unchanged from (2.16), with one important exception. Now, since the pattern of value-added use depends on prices,

and $d\nu_f^h = -d\nu_h^h$. Under the functional forms adopted in this example, neither ν_h^h nor ν_f^f enter the optimal tariff expression (i.e. demand and supply for good x are independent of the composition of input sourcing), so the results in Lemma 1 are immediate.

any change in the tariff may disrupt the pattern of production and trade through $\vec{\nu}$ in addition to the typical price mechanism (holding $\vec{\nu}$ fixed). Using Roy's identity and collecting terms, the first order condition may be written:

$$V_\tau = V_I\left[(\tau^o - 1)p^f\frac{dM_x}{d\tau} - M_x\frac{d\tilde{p}^f}{d\tau} + p^h\nabla_{\vec{\nu}}\, q_x^h \cdot D_\tau\vec{\nu} - \frac{dFVA^h}{d\tau} + \frac{dDVA_h}{d\tau}\right] = 0, \qquad \text{(A19)}$$

where we use $\nabla_{\vec{\nu}} q_x^h$ to denote the (partial) gradient of $q_x^h(p^h, \vec{\nu})$ with respect to the value-added inputs in $\vec{\nu}$ and $D_\tau\vec{\nu}$ for the derivative of $\vec{\nu}$ with respect to the tariff.[5]

The first two terms in brackets reflect the terms-of-trade motive, while the third term captures any change in Home's production of the final good as a result of the endogenous change in the pattern of value-added input use. The last two terms capture the effect of a change in the tariff on GVC income via FVA and DVA. Applying the market clearing condition ($M_x = E_x^f$), decomposing the change in trade volume into the local-price effect versus "GVC relocation effect",[6] expanding the DVA and FVA terms, and rearranging yields:

$$\Big((\tau^o - 1)\epsilon_x^f - 1\Big)E_x^f\frac{d\tilde{p}^f}{d\tau} - p^f\nabla_{\vec{\nu}}E_x^f \cdot D_\tau\vec{\nu} + \underbrace{\nabla DVA_h \cdot D_\tau\vec{p}}_{\equiv\frac{dDVA_h}{d\tau}} - \underbrace{\nabla FVA^h \cdot D_\tau\vec{p}}_{\equiv\frac{dFVA^h}{d\tau}} = 0, \qquad \text{(A20)}$$

where $\epsilon_x^f = \frac{\partial E_x^f(p^f,\vec{\nu})}{\partial p^f}\frac{p^f}{E_x^f}$ is foreign export supply (price) elasticity, ∇DVA_h and ∇FVA^h represent the gradients of each GVC income term with respect to the world price vector, and $D_\tau\vec{p} = (\frac{d\tilde{p}^h}{d\tau}, \frac{d\tilde{p}^f}{d\tau})$ is the derivative of the price vector with respect to the tariff. Dividing through by the trade volume and $\frac{d\tilde{p}^f}{d\tau}$ yields:

$$(\tau^o - 1)\epsilon_x^f = 1 + \frac{\nabla FVA^h \cdot \vec{\Lambda}}{E_x^f} - \frac{\nabla DVA_h \cdot \vec{\Lambda}}{E_x^f} + \eta, \qquad \text{(A21)}$$

where $\vec{\Lambda} \equiv \frac{D_\tau\vec{p}}{dp^f/d\tau} = \left(\frac{1}{\lambda}, 1\right)$ and we use $\eta \equiv \frac{p^f}{E_x^f}\nabla_{\vec{\nu}}E_x^f\frac{\partial\vec{\nu}}{\partial\vec{p}}\Lambda^\intercal$ to capture the change in final goods trade as a result of the endogenous change in input use.

Decomposing the GVC terms into pass-though elasticities and GVC income, we can write:

$$\frac{\nabla FVA^h \cdot \vec{\Lambda}}{E_x^f} = \frac{1}{E_x^f}\left(\nu_f^h\nabla r_f^h + r_f^h\nabla\nu_f^h\right)\cdot\vec{\Lambda} = \left(\frac{r_f^h\nu_f^h}{p^hE_x^f}\right)\Bigg(\underbrace{\frac{p^h}{r_f^h}\nabla r_f^h \cdot \vec{\Lambda}}_{\equiv -\tilde{\varepsilon}_f^{rh}} + \underbrace{\frac{p^h}{\nu_f^h}\nabla\nu_f^h \cdot \vec{\Lambda}}_{\equiv -\tilde{\varepsilon}_f^{\nu h}}\Bigg) \qquad \text{(A22)}$$

[5] In terms of notation, we use ∇b to represent the (complete) (1×2) gradient of $b(\vec{p})$ with respect to the world price vector $\vec{p} = (p^h, p^f)$; $\nabla_{\vec{\nu}}a$ to represent the (partial) (1×4) gradient of $a(p, \vec{\nu})$ with respect to $\vec{\nu} \equiv (\nu_h^h, \nu_f^h, \nu_f^f, \nu_h^f)$; and $\frac{\partial\vec{\nu}}{\partial\vec{p}}$ for the (4×2) Jacobian of $\vec{\nu}(\vec{p})$. Thus, $\nabla_{\vec{\nu}}\, q_x^h \cdot D_\tau\vec{\nu} = \nabla_{\vec{\nu}}\, q_x^h\frac{\partial\vec{\nu}}{\partial\vec{p}} \cdot D_\tau\vec{p}$.

[6] $\frac{dM_x}{d\tau} = \frac{dE_x^f}{d\tau} = \frac{\partial E_x^f(p^f,\vec{\nu})}{\partial p^f}\frac{d\tilde{p}^f}{d\tau} + \nabla_{\vec{\nu}}\, E_x^f \cdot D_\tau\vec{\nu}$, where $\nabla_{\vec{\nu}}E_x^f$ is the (partial) gradient of $E_x^f(p^f, \vec{\nu})$ with respect to the arguments in vector $\vec{\nu}$. Since there are no income effects, $\nabla_{\vec{\nu}}E_x^f \cdot D_\tau\vec{\nu} = -\nabla_{\vec{\nu}}q_x^h \cdot D_\tau\vec{\nu}$.

$$\frac{\nabla DVA_h \cdot \vec{\Lambda}}{E_x^f} = \frac{1}{E_x^f}\left(\nu_h^f \nabla r_h^f + r_h^f \nabla \nu_h^f\right) \cdot \vec{\Lambda} = \left(\frac{r_h^f \nu_h^f}{p^f E_x^f}\right)\left(\underbrace{\frac{p^f}{r_h^f}\nabla r_h^f \cdot \vec{\Lambda}}_{\equiv \tilde{\varepsilon}_h^{rf}} + \underbrace{\frac{p^f}{\nu_h^f}\nabla \nu_h^f \cdot \vec{\Lambda}}_{\equiv \tilde{\varepsilon}_h^{\nu f}}\right). \tag{A23}$$

The terms $\tilde{\varepsilon}_f^{rh}$ and $\tilde{\varepsilon}_h^{rf}$ are analogs to the pass-through elasticity terms in the baseline specific factors model, capturing the change in the (per-unit) return to GVC inputs. The terms $\tilde{\varepsilon}_f^{\nu h}$ and $\tilde{\varepsilon}_h^{\nu f}$ are new, and reflect respectively the change in the use of foreign GVC inputs in Home production, and Home GVC inputs used in foreign production. We have defined these augmented pass-through elasticities to include the tariff-to-price mappings in $\vec{\Lambda}$, written to maintain the sign conventions in the main text. Thus, these elasticities capture the change in DVA and FVA as a result of a tariff change, allowing both the price and the quantity of GVC inputs to respond to the *complete* vector of world prices.

Substituting the decompositions in (A22)-(A23) into (A21) yields the implicit solution for Home's optimal tariff on final goods:

$$\tau^o = 1 + \frac{1}{\epsilon_x^f}\left(1 - (\tilde{\varepsilon}_h^{rf} + \tilde{\varepsilon}_h^{\nu f})\frac{DVA_h}{p^f E_x^f} - (\tilde{\varepsilon}_f^{rh} + \tilde{\varepsilon}_f^{\nu h})\frac{FVA^h}{p^h E_x^f} + \eta\right). \tag{A24}$$

As discussed in the main text, the pass-through elasticity terms that govern the relationship between GVC income and the optimal final goods tariff depend critically on the model primitives that determine structure of GVCs. *These pass-through elasticities will be positive as long as GVC income is more sensitive to the price of final goods where the inputs are used, than to the price of final goods elsewhere in the world.* In this two-country two-good setting:

$$\tilde{\varepsilon}_h^{\nu f} + \tilde{\varepsilon}_h^{\nu f} > 0 \iff \frac{\partial DVA(p^h, p^f)}{\partial p^f} > \frac{\partial DVA(p^h, p^f)}{\partial p^h}\frac{1}{|\lambda|} \tag{A25}$$

Likewise,

$$\tilde{\varepsilon}_f^{\nu h} + \tilde{\varepsilon}_f^{\nu h} > 0 \iff \frac{\partial FVA(p^h, p^f)}{\partial p^h}\frac{1}{|\lambda|} > \frac{\partial FVA(p^h, p^f)}{\partial p^f}. \tag{A26}$$

Sufficient international segmentation in input markets will ensure that these conditions obtain.

Depending on the assumptions about the underlying market structure governing input use, some of all of the η term may cancel with the endogenous input reallocation components of the DVA and FVA terms. For instance, if inputs are paid their value marginal product at Home, and as the absence of barriers to input trade drives the return to Home's value-added inputs to converge across countries, then η will cancel with the $\tilde{\varepsilon}^{\nu}$ terms. Formally:

Lemma 2. *If* $r^h_f = p^h \frac{\partial q^h_x}{\partial \nu^h_f}$ *and* $r^h_h = p^h \frac{\partial q^h_x}{\partial \nu^h_h}$*, then as* $r^h_h \to r^f_h$ *and if* $d\nu^f_h \to -d\nu^h_h$*, then:*

$$\tau^o \to 1 + \frac{1}{\hat{\epsilon}^f_x}\left(1 - \tilde{\varepsilon}^{rf}_h \frac{DVA_h}{p^f E^f_x} - \tilde{\varepsilon}^{rh}_f \frac{FVA^h}{p^h E^f_x}\right),$$

where $\hat{\epsilon}^f_x \equiv \left[\frac{\partial E^f_x(p^f,\vec{\nu})}{\partial p^f} + \nabla_{\vec{\nu}}\, E^f_x \cdot \left(D_{p^f}\vec{\nu} + D_{p^h}\vec{\nu}\frac{1}{\lambda}\right)\right]\frac{p^f}{E^f_x}$ *is the elasticity of export supply allowing for endogenous changes in value-added input use across countries.*

Proof. Substituting the conditions $r^h_f = p^h \frac{\partial q^h_x}{\partial \nu^h_f}$ and $r^f_h = r^h_h = p^h \frac{\partial q^h_x}{\partial \nu^h_h}$ and $d\nu^f_h = -d\nu^h_h$ into the first order condition in (A19), cancelling terms, and solving yields the result.

A.4 Endogenous Input Tariffs with Endogenous GVCs

We now introduce input tariffs to the general equilibrium model with endogenous GVCs. The model and assumptions are as described in Appendix A.3, with one change. We now permit the home country to levy an ad-valorem tax on foreign-sourced inputs used in domestic production: $g \in [0, 1]$, applied to the local price of imported inputs, r^h_f, so that trade tax revenue is now:

$$R^h = (p^h - p^f)M^h_x + gFVA^h_s. \tag{A27}$$

National income is given by:

$$I^h = q_y + p^h q^h_x(p^h,\vec{\nu}) + (p^h - p^f)M_x(p^h,\vec{\nu}) + \underbrace{r^f_h(\vec{p})\nu^f_h(\vec{p})}_{\equiv DVA_h(\vec{p})} - (1-g)\underbrace{r^h_f(\vec{p})\nu^h_f(\vec{p})}_{\equiv FVA^h(\vec{p})}. \tag{A28}$$

The Home government (again) chooses its optimal tariffs to maximize aggregate indirect utility, subject to the arbitrage and market clearing conditions in (2.12)-(2.13).

The Optimal Tariff on Final Goods Given any arbitrary input tariff g, the optimal tariff on final goods is described implicitly by the first order condition:

$$V_\tau = V_I\left[(\tau^o - 1)p^f \frac{dM_x}{d\tau} - M_x \frac{d\tilde{p}^f}{d\tau} + p^h \nabla_{\vec{\nu}}\, q^h_x \cdot D_\tau \vec{\nu} - (1-g)\frac{dFVA^h}{d\tau} + \frac{dDVA_h}{d\tau}\right] = 0. \tag{A29}$$

The only difference between this expression and that in (A19) is the introduction of the coefficient $(1-g)$ on the FVA term. Consistent with the discussion in Section 2.5, this new term reflects the fact that an input tariff allows the Home government to recapture some of the protectionist rents associated with its final goods tariff that would otherwise flow to foreign-owned GVC inputs. Following the same solution methodology in Appendix A.3, it is straightforward to show the the optimal final goods tariff in the presence of an arbitrary input tax on foreign-sourced value-added inputs is given by:

$$\tau^o = 1 + \frac{1}{\epsilon^f_x}\left(1 - (\tilde{\varepsilon}^{rf}_h + \tilde{\varepsilon}^{\nu f}_h)\frac{DVA_h}{p^f E^f_x} - (1-g)(\tilde{\varepsilon}^{rh}_f + \tilde{\varepsilon}^{\nu h}_f)\frac{FVA^h}{p^h E^f_x} + \eta\right). \tag{A30}$$

The Optimal Input Tariff The optimal input tariff is defined implicitly by the following first order condition:

$$V_g = V_I\left[(\tau-1)p^f\frac{dM_x}{dg} - M_x\frac{d\tilde{p}^f}{dg} + p^h\nabla_{\vec{\nu}}q_x^h\cdot D_g\vec{\nu} + \frac{dDVA_h}{dg} - (1-g^o)\frac{dFVA^h}{dg} + FVA\right] = 0. \quad \text{(A31)}$$

Applying the market clearing condition and reorganizing terms, we then have:

$$(g^o-1)\underbrace{\left[r_f^h\frac{d\nu_f^h}{dg} + \nu_f^h\frac{dr_f^h}{dg}\right]}_{\equiv\frac{dFVA^h}{dg}} - r_f^h\nu_f^h - p^h\nabla_{\vec{\nu}}q_x^h\cdot D_g\vec{\nu} = (\tau-1)p^f\frac{E_x^f}{dg} - E_x^f\frac{d\tilde{p}^f}{dg} + \underbrace{\nabla DVA_h\cdot D_g\vec{p}}_{\equiv\frac{dDVA_h}{dg}},$$

If value-added inputs used in Home production are paid their value marginal product, so that $r_j^h = p^h\frac{\partial q_x^h(p^h,\vec{\nu})}{\partial\nu_j^h}, j\in\{h,f\}$, we can further simplify this first order condition to:

$$\left(g^o\xi_f^h - 1\right)\frac{dr_f^{h*}}{dg}\nu_f^h = (\tau-1)p^f\frac{E_x^f}{dg} - E_x^f\frac{d\tilde{p}^f}{dg} + \nabla DVA_h\cdot D_g\vec{p} + r_h^h\frac{d\nu_h^h}{dg}, \quad \text{(A32)}$$

where $r_f^{h*}\equiv(1-g)r_f^h$ and $\xi_f^h\equiv\frac{r_f^h}{\nu_f^h}\nabla_{\vec{r}}\nu_f^h\cdot D_g\vec{r}\frac{1}{dr_f^h/dg}$ is the elasticity of foreign GVC inputs used in Home production with respect to the change in the rates of return paid to Foreign GVC inputs. From here, we make two observations. First, the optimal input tariff (like the optimal final goods tariff) follows an own inverse elasticity rule, moderated by GVC cross-linkages (how final goods trade, and therefore tariff revenue associated with final goods trade, changes with g; how DVA responds to g, and how the return to home's domestically-used value-added inputs (ν_h^h) changes with g). Second, the behavior and sign of these cross-effects will depend on model primitives, including whether home and foreign value-added inputs are complements or substitutes in production of final goods and whether the induced reallocation of GVC inputs makes global production of final goods more or less efficient (so that $\frac{dp^f}{dg}\lesseqgtr 0$).

As a final point, note that if both the optimal tariff on final goods and the optimal input tariff are characterized by interior solutions, they are described by the system of equations in (A29) and (A31). In the resulting optimal tariff solutions, some (but not all) of the cross-effects in (A32) may be be eliminated envelope conditions *if there are no other frictions to input trade and input markets are perfectly competitive*. Even so, general results are elusive, as Antràs and Chor (2021) make clear in Section 6.3 of their recent Handbook chapter. Note that considerable caution must be exercised in this environment, since many standard modelling assumptions about the nature of GVCs (including specific factors) lead to corner solutions where the first order condition for input tariffs will not obtain.

A.5 Many-Country, Many-Good, Political Economy Model

This appendix derives the many-country many-good specific-factors version of the baseline model with political economy influences presented in Section 3.1 of the paper.

A.5.1 Set-up

Consider a many-country world in which a given home country, h, trades with C trading partners. Define the of countries by $\mathcal{C} = \{0, 1, ..., C\}$. There are $S + 1$ final goods. The numéraire is indexed by 0; all other (non-numéraire) final goods are described by the set $\mathcal{S} = \{1, ..., S\}$. Final goods prices in each country $c \in \mathcal{C}$ are denoted by p_s^c, where s designates the final goods sector. The numéraire good is freely traded, so that $p_0^c = 1 \forall c \in \mathcal{C}$. We use $\vec{p}^c = (p_1^c, ..., p_S^c)$ to denote the $(1 \times S)$ vector of (non-numéraire) final goods prices in country c, $\vec{p}_s = (p_s^0, ..., p_s^C)$ to denote the $(1 \times C + 1)$ vector of sector s prices in each country, and $\vec{p} = (\vec{p}^0, ..., \vec{p}^C)$ to represent the complete $(1 \times S(C + 1))$vector of non-numéraire final goods prices in every country world-wide.[7]

Preferences Each country is populated by a continuum of identical agents with identical quasi-linear preferences, represented by the aggregate utility function:

$$U^c(d_0^c, \vec{d}_s^{\,c}) = d_0^c + \sum_{s \geq 1} u_s(d_s^c) \qquad \forall c \in \mathcal{C}, \tag{A33}$$

where d_s^c represents aggregate consumption of final good s in country c and sub-utility over each non-numéraire good, $u_s(\cdot)$, is increasing, continuously differentiable, and strictly concave. We assume that every individual has sufficient income to consume a strictly positive quantity of the numéraire so that preferences over non-numéraire goods satisfy Gorman form.

Endowments Every country $c \in \mathcal{C}$ is endowed with a homogeneous factor, L^c,

Technology. Atomistic firms produce final goods in perfectly competitive markets. Technology is summarized by the constant returns to scale production functions:

$$q_s^c = f_s^c(l_s^c, \nu_{sc}^c, \vec{\nu}_{s*}^c) \qquad\qquad q_0^c = l_o^c \tag{A34}$$

where q_s^c is the quantity of final good s produced in country c using l_s^c units of (homogeneous) labor, ν_{sc}^c units of domestically-sourced value-added input, and a $(1 \times C)$ vector of GVC inputs sourced from from every country $j \neq c \in \mathcal{C}$: $\vec{\nu}_{s*}^c$. As in the benchmark model, we proceed without specifying the the exact division of quasi-rents across the (many) value-added inputs used to make each final good; we assume only that the price paid to value-added input is increasing in the local price of the final good that it is used to produce. Consistent with Assumption 2.1, we adopt:

Assumption A.2.

$$r_{sj}^c \equiv r_{sj}^c(p_s^c; \vec{\nu}_s^c) \qquad \textit{where} \qquad \frac{\partial r_{sj}^c(p_s^c; \vec{\nu}_s^c)}{\partial p_s^c} > 0 \qquad \forall c \in \mathcal{C}, s \in \mathcal{S}. \tag{A35}$$

[7] It later proves useful to partition price vectors into domestic and foreign components [Bagwell and Staiger (1999)]. From the perspective of a given country $h \in \mathcal{C}$, $\vec{p} \equiv (\vec{p}^h, \vec{p}^*)$, where $\vec{p}^*$ is the $(1 \times SC)$ vector of prices in every country $j \neq h \in \mathcal{C}$. Likewise, let $\vec{p}_s \equiv (p_s^h, \vec{p}_s^*)$ where $\vec{p}_s^*$ is the $(1 \times C)$ vector of prices for good s in every country other than country h.

Tariffs and Timing. As before, we focus attention on import tariffs and rule out export taxes. A given Home government may impose discriminatory bilateral ad-valorem tariffs on its imports from each of its potential trading partners, applied to the foreign selling price.

Following the literature, we introduce political economy influences by assuming that the Home government maximizes the sum of aggregate indirect utility and a set of "special interest factors" associated with the quasi-rents from production in different sectors:[8]

$$G^h = V^h + \sum_s [\delta_s^{PE} \pi_s^h + \delta_s^{DVA} DVA_{sh} + \delta_s^{FVA} FVA_s^h], \quad \text{(A36)}$$

where V^h is (endogenous) aggregate indirect utility and δ_s^{PE}, δ_s^{FVA}, and δ_s^{DVA} are exogenous political economy weights associated with each final goods sector $s \in \mathcal{S}$ at Home. The parameter δ_s^{PE} captures the additional consideration that the Home government affords rents earned in domestic final goods production of good s at Home (π_s^h) when it sets tariffs. Similarly, δ_s^{DVA} is the extra political value the Home government places on rents accruing to Home GVC income from the use of domestic value-added inputs in foreign final goods production (DVA_{sh}) in tariff setting.[9] δ_s^{FVA} represents the political weight (if any) given to *foreign* GVC income associated with the use of foreign value-added inputs used in Home's production (FVA_s^h). We do not impose *a priori* restrictions on these weights, but standard arguments would imply positive values for politically active constituencies.[10]

The government chooses the vector of its tariffs on every imported good against every trading partner to maximize its objective function in (A36) subject to balanced budget and market clearing conditions, with perfect foresight and no uncertainty, and taking any other countries' policies as given. Firms then maximize profits and consumers maximize welfare, taking tariffs as given. We invoke a multi-country analog to Assumption 2.2 to rule out the possibility of the Metzler and Lerner paradoxes. Using τ_{sc} to denote (one-plus) the 'home' ad-valorem tariff on good s imported from country $c \neq h \in \mathcal{C}$ and $\tilde{p}_s^c$ ($\tilde{p}_s^h$) for the equilibrium price of good s in country c (h), then for any non-prohibitive tariff, let:

Assumption A.3.

$$\frac{d\tilde{p}_s^c}{d\tau_{sc}} \leq 0 \leq \frac{d\tilde{p}_s^h}{d\tau_{sc}}. \quad \text{(A37)}$$

[8] 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.

[9] Since both $\sum_s \pi_s^h$ and $\sum_D VA_{sh}$ are included in Home's national income, they are already included in V^h with a weight of 1; thus, δ_s^{PE} and δ_s^{DVA} capture any *additional* weight afforded to these rents by the Home government – for instance, because of industry lobbying – above and beyond their direct contribution to aggregate welfare.

[10] These weights can capture a range political economy forces. The restriction $\delta_s^{PE} = \delta_s^{FVA} = \delta_s^{DVA} = 0$ yields a national welfare maximizing government. Standard protection-for-sale lobbying would imply $\delta_x^{PE} > 0$ for a politically active industry, $x \in \mathcal{S}$ [Grossman and Helpman (1994)]. δ_s^{DVA} would be positive if domestic value-added input suppliers advocate for better market access on behalf of their downstream buyers located overseas. To the extent that the government responds to the interests of (or lobbying by) foreign suppliers δ_s^{FVA} might also be positive [Gawande, Krishna and Robbins (2006)]. Alternatively, foreign suppliers of value-added inputs could be represented in domestic politics by downstream buyers, as in tariff jumping foreign investors that earn "political goodwill" and *quid pro quo* tariff cuts, in the spirit of Bhagwati et al. (1987).

A.5.2 Solution

Production, consumption, and market clearing conditions are direct analogs to the two-by-two model presented in Section 2.1. The only substantive change is the additional simplification afforded by quasi-linear preferences: with sufficient income (as assumed), demand for each non-numéraire good is independent of national income.[11]

Production In every country $c \in \mathcal{C}$, profit maximization by atomistic firms and local labor market clearing determine the supply function for each final good $s \in \mathcal{S}$ as a function of local final goods prices, taking value-added inputs and total labor endowment as given:

$$\begin{aligned} q_s^c(p_s^c; \vec{\nu}_s^c) &= f_s^c(l_s^c(p_s^c), \nu_{sc}^c, \vec{\nu}_{s*}^c)\ \forall s & \text{(A38)} \\ q_0^c(\vec{p}^c; \vec{\nu}^c) &= L^c - \sum_s l_s^c(p_s^c; \vec{\nu}_s^c), & \text{(A39)} \end{aligned}$$

where $l_s^c(p_s^c; \vec{\nu}_s^c) = \arg\max_{l_s^c} \ p_s^c f_s^c(l_s^c, \nu_{sc}^c, \vec{\nu}_{s*}^c) - l_s^c\ \forall s \in \mathcal{S}$.

The zero profit condition in each sector $s \in \mathcal{S}$ implies that the total quasi-rent associated with production of good s in country c, π_s^c, is divided among the set of value-added inputs used to make the good:

$$\pi_s^c(p_s^c) = p_s^c q_s^c(p_s^c) - l_s^c(p_s^c) = \sum_{j \in \mathcal{C}} r_{sj}^c \nu_{sj}^c. \tag{A40}$$

where, by Assumption A.3 $r_{sj}^c \equiv r_{sj}^c(p_s^c; \vec{\nu}_s^c)$ and $\frac{\partial r_{sj}^c(p_s^c; \vec{\nu}_s^c)}{\partial p_s^c} > 0\ \forall s \in \mathcal{S}$ and $c, j \in \mathcal{C}$.

Consumption. With quasi-linear preferences, aggregate demand for non-numéraire goods is independent of income. In every country $c \in \mathcal{C}$:

$$\begin{aligned} d_s^c(p_s^c, I^c) &\equiv d_s^c(p_s^c) = u_s'^{-1}(p_s^c) \qquad \forall s \in \mathcal{S} & \text{(A41)} \\ d_0^c(\vec{p}^c, I^c) &= I^c - \sum_s p_s^c d_s^c & \text{(A42)} \\ V(\vec{p}^c, I^c) &= \zeta^c(\vec{p}^c) + I^c, & \text{(A43)} \end{aligned}$$

where $V(\vec{p}^c, I^c)$ is aggregate indirect utility and $\zeta^c \equiv \sum_s [u_s(d_s^c) - p_s^c d_s^c]$ is total consumer surplus in country c. National income (measured in the numéraire) is given by the total value of final goods production at local prices, plus any tariff revenue, plus GVC income from domestic value-added inputs used in foreign production (DVA), less any GVC income paid to foreign value-added inputs used in local production (FVA). For each country $c \in \mathcal{C}$:

$$I^c = q_0^c + \vec{p}^c \cdot \vec{q}^c(\vec{p}^c, \vec{\nu}^c) + R^c + \sum_s \underbrace{\sum_{j \neq c} r_{sc}^j(p_s^j; \vec{\nu}_s^j)\nu_{sc}^j}_{\equiv DVA_{sc}} - \sum_s \underbrace{\sum_{j \neq c} r_{sj}^c(p_s^c; \vec{\nu}_s^c)\nu_{sj}^c}_{\equiv FVA_s^c}, \tag{A44}$$

[11] Thus, $d_s^c(p_s^c, I^c) \equiv d_s^c(p_s^c) \forall s \in \mathcal{S}$, which simplifies foreign export supply elasticity which must otherwise incorporate potential income effects via Foreign GVC income, as noted in footnote 16.

where tariff revenue is and $R^c = \sum_s \sum_{j \neq c}(p^c_s - p^j_s)M^c_{sj}(\vec{p}_s; \vec{\nu}_s)$ and $M^c_{sj}(\cdot)$ is country $c's$ imports of good s from country j.

Market Clearing. Prices are disciplined by a set of SC no-arbitrage conditions: $p^h_s \leq \tau^h_{sc} p^c_s, \forall c \neq h \in \mathcal{C}, s \in \mathcal{S}$.[12] Equilibrium prices are then determined by the set of S market clearing conditions that ensure global demand equals global supply for each non-numéraire good:

$$\sum_{c \in \mathcal{C}} d^c_s(\tilde{p}^c_s) = \sum_{c \in \mathcal{C}} q^c_s(\tilde{p}^c_s; \vec{\nu}^c_s) \qquad \forall\, s \in \mathcal{S}. \tag{A45}$$

Balanced budget conditions for each country clear the market for the numéraire.

A.5.3 Politically-Motivated Bilateral Tariffs

Home's politically optimal tariff schedule, $\vec{\tau}^o$, maximizes its government objective function in (A36) subject to market clearing conditions in (A45):

$$\begin{aligned} \vec{\tau}^o = \arg\max_{\vec{\tau}}\ G^h \quad &\equiv \quad V^h + \sum_s [\delta^{PE}_s \pi^h_s + \delta^{DVA}_s DVA_{sh} + \delta^{FVA}_s FVA^h_s] \\ &s.t. \quad p^h_s \leq \tau^h_{sc} p^c_s \ \text{ and } \ p^c_s = \tilde{p}^c_s\ \forall\, c \neq h \in \mathcal{C}, s \in \mathcal{S} \end{aligned}$$

Home has SC first order conditions, one for every (non-numéraire) sector $s \in \mathcal{S}$ and trading partner $c \neq h \in \mathcal{C}$. Notice that with quasi-linear preferences and a numériare good, there are no cross-price effects across sectors. For a given bilateral, sector-specific tariff applied to imports of good x from trading partner j, τ^h_{xj} the first order condition implicitly defines the optimal tariff:

$$G^h_{\tau^h_{xj}} = (\tau^h_{xj} - 1) p^j_x \frac{dM^h_{xj}}{d\tau^h_{xj}} \quad - \quad M^h_{xj} \frac{dp^j_x}{d\tau^h_{xj}} + \delta^{PE}_x q^h_x \frac{dp^h_x}{d\tau^h_{xj}} + \Omega^R_{xj} \tag{A46}$$

$$+ \quad (1 + \delta^{DVA}_x) \frac{dDVA_{xh}}{d\tau^h_{xj}} - (1 - \delta^{FVA}_x) \frac{dFVA^h_x}{d\tau^h_{xj}} = 0. \tag{A47}$$

The term Ω^R_{xj} captures the potential for trade diversion to change Home's tariff revenue from trade with countries other than j.[13] Apart from this trade diversion term, extra notation, and the addition of political economy weights to the DVA and FVA terms, the only substantive change from the first order condition in (2.16) is the introduction of the domestic political economy term weighted by δ^{PE}_s, which reflects well-understood "protection-for-sale" motivations in tariff setting [Grossman and Helpman (1994)].

In preparation for the empirical application, we now decompose the two GVC terms into pass-through elasticities and directly-observable measures of GVC income. Consider first the role of foreign value added embodied in domestic final goods (FVA). The bilateral tariff

[12] These bilateral arbitrage relationships hold with equality in the presence of trade: $M^h_{sc} > 0 \Rightarrow p^h_s = \tau^h_{sc} p^c_s$.

[13] For any $s \in \mathcal{S}$, $\Omega^R_{sj} \equiv \sum_{c \neq j,h} (\tau_{sc} - 1) \left[\frac{d\tilde{p}^c_s}{d\tau_{sj}} M_{sc} + p^c_s \frac{dM_{sc}}{d\tau_{sj}} \right]$. These trade diversion effects, which are typical in multi-country trade models, are generally ambiguous absent and plausibly negligible (e.g. when trade diversion is minimal; see Freund and Ornelas (2010)).

raises the local final goods price at Home (p_x^h), which in turn increases the returns to foreign value-added inputs embodied in Home's domestic production via $r_{xc}^h(p_x^h; \vec{\nu}_x^h)$. We decompose this effect as follows:

$$\frac{dFVA_x^h}{d\tau_{xj}^h} = \sum_{c \neq h} \left[\frac{r_{xc}^h \nu_{xc}^h}{p_x^h} \underbrace{\left(\frac{dr_{xc}^h}{dp_x^h} \frac{p_x^h}{r_{xc}^h} \right)}_{\equiv \varepsilon_{xc}^{rh} \geq 0} \right] \frac{dp_x^h}{d\tau_{xj}^h} = \varepsilon_{x*}^{rh} \sum_{c \neq h} \frac{r_{xc}^h \nu_{xc}^h}{p_x^h} \frac{dp_x^h}{d\tau_{sj}^h} = \varepsilon_{x*}^{rh} \frac{FVA_x^h}{p_x^h} \frac{dp_x^h}{d\tau_{xj}^h} \tag{A48}$$

The term $\varepsilon_{xc}^{rh} \equiv \frac{dr_{xc}^h}{dp_x^h} \frac{p_x^h}{r_{xc}^h}$ is the elasticity of foreign value-added input prices with respect to local final goods prices at Home. This elasticity is positive by Assumption A.3: 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 $\varepsilon_{xc}^{rh} = \varepsilon_{x*}^{rh} \; \forall c \neq h \in \mathcal{C}$ (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:

$$\frac{dDVA_{xh}}{d\tau_{xj}^h} = \frac{r_{xh}^j \nu_{xh}^j}{p_x^j} \underbrace{\left(\frac{dr_{xh}^j}{dp_x^j} \frac{p_x^j}{r_{xh}^j} \right)}_{\equiv \varepsilon_{xh}^{rj} \geq 0} \frac{dp_x^j}{d\tau_{xj}^h} + \underbrace{\sum_{c \neq h,j} \frac{dDVA_{xh}^c}{dp_x^c} \frac{dp_x^c}{d\tau_{xj}^h}}_{\equiv \Omega_{xj}^{DVA}} = \underbrace{\varepsilon_{xh}^{rj} \frac{DVA_{xh}^j}{p_x^j} \frac{dp_x^j}{d\tau_{xj}^h}}_{\text{direct effect}} + \Omega_{xj}^{DVA} \tag{A49}$$

The direct effect captures the impact of an increase in τ_{xj}^h on the return to Home's GVC inputs used by the country (j) on which the tariff is imposed. We collect any potential indirect effects – how the Home's tariff on country j might impact the return of Home's GVC inputs used in third countries – in Ω_{xj}^{DVA}.[14] The strength of this direct effect is governed by the elasticity ε_{xh}^{rj}, which is positive by Assumption A.3: a higher price of good x in country j implies a higher price for Home's value-added inputs used in production of that good.

Substituting Equations (A48) and (A49) into the first order condition in (A47) and solving yields the following expression for the politically-motivated bilateral tariff:

$$\tau_{xj}^h = 1 + \frac{1}{\epsilon_{xh}^j} \left(1 + \frac{\delta_x^{PE} q_x^h}{|\lambda_{xj}^h| E_{xh}^j} - (1 + \delta_x^{DVA}) \varepsilon_{xh}^{rj} \frac{DVA_{xh}^j}{p_x^j E_{xh}^j} - \frac{(1 - \delta_{x*}^{FVA}) \varepsilon_{x*}^{rh}}{|\lambda_{xj}^h|} \frac{FVA_x^h}{p_x^h E_{xh}^j} - \tilde{\Omega}_{xj} \right). \tag{A50}$$

Where $\lambda_{xj}^h \equiv \frac{d\tilde{p}_x^j}{d\tau_{xj}^h} / \frac{dp_x^h}{d\tau_{xj}^h} < 0$, E_{xh}^j is country j's exports of x to Home, $\epsilon_{xh}^j \equiv \frac{dE_{xh}^j}{dp_x^j} \frac{p_x^j}{E_{xh}^j} > 0$ represents bilateral, sector-specific export supply elasticity between country j and Home, and $\tilde{\Omega}_{xj} \equiv \frac{\Omega_{xj}^R + \Omega_{xj}^{DVA}}{(dp_x^j / d\tau_{xj}^h) E_{xh}^j}$ captures any potential third-country effects of trade diversion.[15]

[14] $\Omega_{xj}^{DVA} \equiv \sum_{c \neq h,j} \frac{dDVA_{xh}^c}{dp_x^c} \frac{dp_x^c}{d\tau_{xj}^h} = \sum_{c \neq h,j} \varepsilon_{xh}^{rc} \frac{DVA_{xh}^c}{p_x^c} \frac{dp_x^c}{d\tau_{xj}^h}$. As noted earlier, such third-country effects are generally ambiguous and depend on trade diversion.

[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 (A50) evaluated at the world tariff vector for

A.6 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:[16]

$$\lim_{\frac{dp_x^j}{d\tau_{xj}^i} \to 0} G_{\tau_{xj}^i} = \frac{\partial M_{xj}^i(\vec{p}_x)}{\partial p_x^i} \frac{dp_x^i}{d\tau_{xj}^i}(\tau_{xj} - 1)^i p_x^j + \delta_x^{DPE} q_x^i \frac{dp_x^i}{d\tau_{xj}^i} - (1 - \delta_x^{FVA}) \frac{dFVA_x^i}{d\tau_{xj}^i} = 0. \quad \text{(A51)}$$

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

$$\tau_{xj}^i \to 1 + \frac{1}{\tilde{\epsilon}_{xj}^i} \left(\frac{\delta_x^{DPE}}{\tilde{\lambda}_{xj}^i} \frac{q_x^i}{M_{xj}^i} - \frac{(1 - \delta_x^{FVA})}{\tilde{\lambda}_{xj}^i} \varepsilon_{x*}^{ri} \frac{FVA_x^i}{p_x^i M_{xj}^i} \right), \quad \text{(A52)}$$

where we define $\tilde{\lambda}_{xj} \equiv \frac{p_x^j}{p_x^i} > 0$, and $\tilde{\epsilon}_{xj}^i$ is the elasticity of country i's import demand.[17] 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.(Recent theoretical work by DeRemer (2016) develops an augmented definition of reciprocity in the presence of local price externalities.) 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 (behind the border) price externalities between signatories.

which every country's tariff reaction curves intersect.

[16]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, $\Omega_{xj}^R \to 0$.

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

B Empirical Appendix

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

B.1 Data Details

B.1.1 Value-Added Content

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 income' decomposition of final goods developed in Los, Timmer and de Vries (2015). 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 briefly describe the computation here.

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 $FVA^i_{xt} \equiv \sum_{c \neq i \in \mathcal{C}} VA^i_{xct}$.

We obtain data to implement these calculations from the World Input-Output Database. The data is available at http://www.wiod.org and documented in Dietzenbacher et al. (2013) and Timmer et al. (2015). One complication in using these data is that there are two vintages of the database. The WIOD Release 2013 database contains an annual sequence of global input-output tables for the 1995-2011 period covering 35 industries across 27 EU countries and 13 other major countries.[18] We augment this base data set using the WIOD Release 2016 data, which covers 2000-2014 period.

Because the Release 2013 and Release 2016 data are not fully compatible in terms of underlying definitions and data sources, they do not agree exactly in overlapping years. We compute value-added contents using the Release 2013 data, and treat these as the baseline data for 1995-2010. We then also separately compute value-added contents for 2010-2014 using the using data from Release 2016. Using growth rates from this Release 2016 data, we then extrapolate levels from the Release 2013 data forward in time. In executing this linkage procedure, we also map Release 2016 industries into Revision 2013. While Release 2016 has slightly more disaggregated data than Release 2013, such that the sector mapping is many to one in almost all cases, there is one case where it is not. In Release 2016, the Textiles and Leather and Footwear sectors are pooled together, while they are reported separately in Release 2013. We thus apply growth rates for the pooled sector to extrapolate forward the two individual sectors in the Release 2013 data.

A second technical issue concerns the EU. In both data sets, EU members are reported as individual countries. We compute value added content using the fully disaggregated country data, and then we aggregate value-added contents across EU countries to form the EU composite in our data.

B.1.2 Tariffs

As noted in Section 3.5, we draw our data from UNCTAD (TRAINS) and the WTO via the WITS website [http://wits.worldbank.org]. Multilateral MFN applied tariffs are typically available in the WTO data, while bilateral applied tariffs are from TRAINS. 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

[18] Two industries – Mining and Quarrying, Coke, Refined Petroleum and Nuclear Fuel – are excluded as downstream industries in our tariff analysis sample, since they are comprised entirely (or nearly so) of commodity input categories. These industries are included as upstream industries in value-added content calculations, however.

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.

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.[19]

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 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.[20] Second, we compute tariff average using all HS 6-digit categories for which there are ad valorem tariffs at a given point in time, regardless of whether these categories enter or exit the data over time (i.e., we use the full, unbalanced panel of tariffs). We have verified that our results are similar if we instead retain only HS 6-digit categories for which we have a fully-balanced panel of tariffs.

To identify final goods tariffs in the data and link HS categories to WIOD industries, we use a correspondence developed by the OECD. We use the "BTDIxE conversion key" from the Structural Analysis (STAN) Databases.[21] It builds on the Broad Economic Categories (BEC) classification to link HS codes to end use categories, and we retain HS 6-digit categories classified as consumption and capital goods. We also retain specialized mixed use categories defined by the OECD for mobile phones, medical goods, computers, and autos, since these have important final use segments. Roughly forty 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. We concord HS categories to WIOD industries using a cross-walk from HS codes to the ISIC Revision 3 industries (from the OECD) to WIOD industry codes.

We aggregate 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

[19]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.

[20]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.

[21]See https://stats.oecd.org/Index.aspx?DataSetCode=BTDIxE_i4.

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 There are preferential tariffs in 30-40% of the importer-exporter-industry-year cells in our data (see Figure 1). Conditional on receiving preferences, the mean (median) difference between the applied bilateral tariff and the applied MFN tariff is about -3.2 (-2.2) percentage points, with a 10th-90th percentile range of $[-8.06, -0.09]$. We plot the distribution of preferences in Figure B1.

The GSP program accounts for the largest share of preferences. 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.

In our data, there are three primary sources of 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.[22] Each of these decisions is updated over time, as countries introduce or renew their GSP programs.[23] One important point is that the way GSP is recorded in our data understates the actual degree of discretion with which the GSP program is applied in practice.[24] 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, partial scope agreements adopted under the WTO's Enabling Clause, 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 "Australia Tariff" in Canada's tariff schedule, under which Canada affords Australia preferential treatment for roughly 300 HS 6-digit categories.[25] Other idiosyncratic preference schemes are more

[22]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.

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

[24]Specifically, importers may 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.

[25]Though a legacy of British colonial tariff preferences, this program was amended and re-authorized

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 3.2.2: *potentially* reciprocal trade agreements (RTAs) and non-reciprocal trade agreements.[26] 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 and is symmetrically phased in.[27] 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.

We classify remaining trade agreements as non-reciprocal. These agreements are exclusively struck between developing countries, and most are notified to the WTO under the Enabling Clause. 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, often having 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, years they are in force, years they are asymmetrically phased in, and the way in which they are notified to the WTO. Again, we code $RTA_{ijt} = 1$ if country i has an Article XXIV trade agreement with country j that is symmetrically phased in at date t, and zero otherwise.[28]

B.1.3 Temporary Trade Barriers

We draw our data from the World Bank's Temporary Trade Barriers Database [Bown (2016)], which is available at https://www.chadpbown.com/temporary-trade-barriers-database/. In the raw data, antidumping and countervailing duties (CVDs) are explicitly partner- and product-specific. While safeguards are applied at the product level, they take on an exporter-

during our sample period, in 1998.

[26]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.

[27]Some agreements that enter into force appear as unilateral preferences in the data, where country i grants preferences to country j under the agreement but not vice versa. Typically j then grants preferences to i in a later year, making the agreement reciprocal. 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. We consider the asymmetric phase-in as a discretionary decision, so treat it as unilateral conferral of preferences. Results are robust to re-coding the agreements as full RTAs for years in which they are asymmetrically phased in.

[28]For example, $RTA_{EUN,MEX,2000} = 0$ and $RTA_{EUN,MEX,2005} = 1$.

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.

As in the tariff data, we begin with TTB data at the product-level, aggregate to the HS 6-digit level, extract HS categories that correspond to final goods, 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 in a given year.

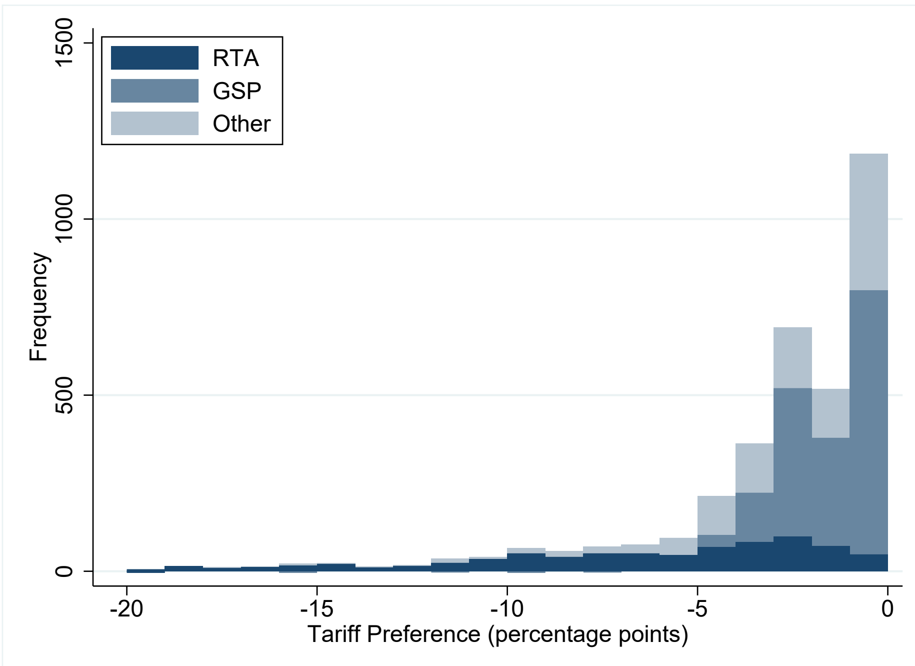
Coverage ratios are a convenient tool for aggregating TTBs across products and measuring their overall intensity, which avoids needing to convert heterogeneous TTB measures (e.g., ad valorem duties, specific duties, price undertakings, or quantitative restrictions) into ad valorem equivalents. For emphasis, 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.

Table B1: Classifying Trade Agreements

	Years in Force	Asymmetric Phase-in	WTO Notification
Bilateral Agreements			
Australia-Indonesia	2015	2015	Art. XXIV
Australia-Japan	2015	2015	Art. XXIV
Australia-South Korea	2015	2015	Art. XXIV
Australia-United States	2005, 2010, 2015	2005	Art. XXIV
Brazil-Mexico	2005, 2010, 2015		Enabling Clause
Canada-South Korea	2015		Art. XXIV
China-Indonesia	2005, 2010, 2015		Enabling Clause
European Union-Mexico	2000, 2005, 2010, 2015	2000	Art. XXIV
European Union-South Korea	2015	2015	Art. XXIV
European Union-Turkey	2000, 2005, 2010, 2015		Art. XXIV
India-Indonesia	2010, 2015	2010	Enabling Clause
India-Japan	2015		Art. XXIV
India-South Korea	2015		Article XXIV/Enabling Clause
Indonesia-Japan	2010, 2015	2010, 2015	Art. XXIV
Indonesia-South Korea	2010, 2015	2010	Art. XXIV/Enabling Clause
Japan-Mexico	2005, 2010, 2015	2005	Art. XXIV
South Korea-Turkey	2015		Art. XXIV
South Korea-United States	2015		Art. XXIV
Regional Agreements			
Asia-Pacific Trade Agreement	2005, 2010, 2015		Enabling Clause
Global System of Trade Preferences	1995, 2000, 2005, 2010, 2015		Enabling Clause
NAFTA (Canada-Mexico-United States)	1995, 2000, 2005, 2010, 2015		Art. XXIV

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.

Figure B1: 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 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.

B.2 Supplemental Appendix: Empirical Strategy and Results

In this appendix, we provide supplemental discussion of the empirical results. First, we discuss details about how we measure upstream production differentiation for use in Section 4.2.2. Second, we explore several variations on the instrumental variables results presented in the main text, which make use of different instruments and empirical specifications.

B.2.1 Measuring Upstream Differentiation

In Section 4.2.2, we discuss heterogeneity in coefficient estimates, depending on the degree of upstream differentiation. We include details related to these exercises here.

To formalize the argument for measuring upstream differentiation, we defined the pass-through elasticity as $\varepsilon^j_{xh} \equiv \frac{dr^j_{xh}}{dp^j_x}\frac{dp^j_x}{r^j_{xh}}$. This is the elasticity of the price of value added from country h used by sector x in country j. Extending the theory to distinguish upstream input supply sectors, suppose that v^j_{xh} is a bundle of factors $\{v^{zj}_{xh}\}$, where z distinguishes underlying factor types, with associated prices r^{zj}_{xh} and pass-through elasticities $\varepsilon^{zj}_{xh} \equiv \frac{dr^{zj}_{xh}}{dp^j_x}\frac{dp^{zj}_x}{r^{zj}_{xh}}$. Then the aggregate, bilateral pass-through elasticity is: $\varepsilon^j_{xh} = \sum_z \left(\frac{DVA^{zj}_{xh}}{DVA^j_{xh}}\right)\varepsilon^{zj}_{xh}$, where $DVA^{zj}_{xh} \equiv r^{zj}_{xh}v^{zj}_{xh}$.

Then, suppose there are two types of factors, those with high (H) pass-through elasticities and others with low (L) pass-through elasticities: $\{\varepsilon^{Hj}_{sh}, \varepsilon^{Lj}_{sh}\}$. Then we decompose the aggregate elasticity as follows:

$$\varepsilon^j_{xh} = \varepsilon^{Hj}_{xh}\left(\frac{DVA^{Hj}_{xh}}{DVA^j_{xh}}\right) + \varepsilon^{Lj}_{xh}\left(\frac{DVA^{Lj}_{xh}}{DVA^j_{xh}}\right), \tag{B1}$$

where $DVA^{Hj}_{xh} \equiv \sum_{z\in H} DVA^{zj}_{xh}$ and $DVA^{Lj}_{xh} = \sum_{z\in L} DVA^{zj}_{xh}$. With this decomposition, the DVA-specific term in the optimal bilateral tariff becomes:

$$\begin{aligned}(1+\delta^*_{xh})\varepsilon^j_{xh}\frac{DVA^j_{xh}}{p^j_x M^h_{xj}} &= (1+\delta^*_{xh})\left[\varepsilon^{Hj}_{xh}\left(\frac{DVA^{Hj}_{xh}}{DVA^j_{xh}}\right) + \varepsilon^{Lj}_{xh}\left(\frac{DVA^{Lj}_{xh}}{DVA^j_{xh}}\right)\right]\frac{DVA^j_{xh}}{p^j_x M^h_{xj}} \\ &= (1+\delta^*_{xh})\varepsilon^{Hj}_{xh}\frac{DVA^{Hj}_{xh}}{p^j_x M^h_{xj}} + (1+\delta^*_{xh})\varepsilon^{Lj}_{xi}\frac{DVA^{Lj}_{xh}}{p^j_x M^h_{xj}}.\end{aligned} \tag{B2}$$

This decomposition motivates our effort to measure DVA^{Hj}_{xh} and DVA^{Lj}_{xh} separately, and then construct $\ln\left(\frac{DVA^{Hj}_{xh}}{p^j_x M^h_{xj}}\right)$ and $\ln\left(\frac{DVA^{Lj}_{xh}}{p^j_x M^h_{xj}}\right)$. Coefficients attached to these separate DVA ratios then shed light on underlying pass-through elasticities ε^{Hj}_{xh} versus ε^{Lj}_{xh}.

As discussed in the text, we take two different approaches. The first approach is is to classify manufacturing sectors as differentiated, high pass-through sectors (H) and all other sectors as low pass-through sectors L. Then DVA^{Hj}_{xh} is value added that originates in the manufacturing sector of country h that is used by industry x in country j, and DVA^{Lj}_{xh} is value added from non-manufacturing sectors.

The second approach uses the Rauch classification [Rauch (1999)]. Rauch classifies commodities as differentiated or non-differentiated at the SITC 4-digit level. We concord these to WIOD industries, where there are many SITC industries (k) in each WIOD industry. Letting $diff_k = 1$ if SITC category k is differentiated, and 0 otherwise, we the construct the share of underlying SITC categories that are differentiated within each WIOD industry, denoted by z: $diff_z \equiv \frac{1}{K_z}\sum_{k\in z} diff_k$. Then we decompose DVA as follows: $DVA^j_{xh} = DVA^{Rj}_{xh} + DVA^{(-R)j}_{xh}$, where $DVA^{Rj}_{xh} = \sum_z diff_z DVA^{zj}_{xh}$ is value added that originates in Rauch differentiated sectors, and $DVA^{-Rj}_{xh} = DVA^j_{xh} - DVA^{Rj}_{xh}$ is value added that originates in non-differentiated sectors.

B.2.2 Supplemental IV Results

As noted at the end of Section 4.3, we examine several alternative approaches to instrumental variables estimation, which supplement the analysis in the text. First, we swap out the instrument for imports, replacing the instrument based on heterogeneous distance effects with an alternative instrument based on predetermined values of imports. Second, we consider an alternative instrument for domestic GVC income in foreign production (DVA^h_{xjt}), similarly based on predetermined values. Third, we examine an alternative regression specification in which imports are treated as a nuisance control, absorbed by decile fixed effects that non-parametrically control for the volume of imports. This final exercise is closely related to a specification we used in Blanchard, Bown and Johnson (2016) to estimate the influence of domestic GVC income on tariffs. We describe these approaches in greater detail below. The takeaway is that these alternative IV strategies all yield results consistent with the IV estimation presented in the main text, which supports the causal interpretation of our results.

Alternative Instrument for Imports Recall that the endogeneity concern for imports is that they are simultaneously determined by tariffs, so that residual variation in tariff preferences that is not accounted for by the model may be correlated with imports. One approach to resolving this concern would be to use imports from periods prior to the introduction of the tariff preferences in our data as an instrument for current imports. Since these predetermined import values cannot mechanically be a function of residual tariff preferences, this resolves the simultaneity problem.

Since no preference programs in our data were in force in 1970, then imports from 1970 would satisfy the necessary exclusion restriction. To construct the instrument, we obtain bilateral trade data for 1970 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.[29] This process gives us imports of final goods by importer,

[29]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.

exporter, and industry in 1970.

With this data in hand, we construct three instruments, one for each of the ratios in Equation (3.7). The first is the log difference between DVA-in-Services and the value of imports in 1970 by country pair and industry. The second and third are the log differences between the shift-share instruments (described in Section 4.3) for final goods production and FVA and the value of imports in 1970 by country pair and industry.[30]

The benchmark IV results are replicated with this instrument set in Table B2.[31] We find the same signs for the main coefficients as in OLS and Table 6. The coefficient for the DVA ratio is similar in magnitude to that in Table 6. The coefficients on the FVA and IP Ratios are pushed away from zero, though they are imprecisely estimated, so we hesitate to over-interpret the magnitude of the point estimates.

Alternative Instrument for DVA In Table 6, we used DVA in an outside sector (the services sector) as the instrument. Now we consider a different instrument, based on a distinct identification argument. Specifically, we again note that the identification concern in the model centers on the simultaneity problem, in which DVA^h_{xjt} may be endogeneously related to residual variation in tariff preferences (e_{xhjt}). As in the discussion above, predetermined values of DVA^h_{xjt} would serve as a valid instrument; since they are determined to introduction of the preferences in our data, they cannot mechanically be a function of them, and thus would satisfy the exclusion restriction.

To construct this instrument, we use data on the level of domestic value-added content in foreign production in 1970, which we denote $DVA^h_{sj,1970}$ and verbally refer to as DVA-in-1970. Drawing on the data set developed in Johnson and Noguera (2017), we measure 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; this instrument isolates different exogenous variation than does the DVA-in-Services instrument. The final cost of this instrument is that is generally weak in the specifications we used in Table 6. However, it does potentially contain useful information to corroborate the main analysis.

In Table B3, we replicate results from Panel A of Table 6 using DVA-in-1970 as the instrument, where we use the same instrument for imports as in the main text. Looking at the Weak-Identification Test statistic, it is evident that the instruments are sufficiently weak to be concerned about using conventional standard errors for inference. Thus, while we report conventional standard errors in parentheses, we omit stars associated with significance tests. We also caution against parsing the point estimates.

More reassuringly, the DVA-in-1970 instrument is powerful enough in this specification to

[30]Note here that we avail ourselves of the ability to use the log ratios as instruments, which was not possible with the heterogeneous distance instrument used in the main text. In practice, this improves the power of the instrument set, relative to including log levels of these variables separately as instruments.

[31]We focus on the main IV results, omitting auxiliary controls. The reason is that this instrument set is again weak when controls are added, likely because the controls absorb variation in imports in 1970. Further, as in the main text, adding controls does not qualitatively change the results.

make statistical inferences. Specifically, we construct and report weak-IV robust confidence intervals for the key coefficient attached to the log DVA ratio in brackets in the table. These are based on inversion of the Anderson-Rubin test static with 10% nominal size, under the assumption that $\gamma^{IP} + \gamma^{FVA}$ is strongly identified.[32] The key point is that these confidence intervals contain only negative values, so we can again conclude that higher DVA is associated with lower tariffs. Though the estimates are imprecise, this instrument corroborates the causal interpretation of the main results.

Alternative IV Specification to Estimate DVA Effects The final exercise we conduct changes the way in which we control for bilateral imports. Referring back to Equation (3.5), we note that the imports enter the expression evaluated at the baseline no-GVC equilibrium. We introduce observed imports into the estimation framework [Equations (3.6)-(3.7)] as a proxy for these unobserved values. However, we could alternatively attempt to simply control for unobserved imports in a nonparameteric way.

To implement this idea, 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 can then include these indicators as control variables to proxy for unobserved variation in imports in the no-GVC equilibrium, along with the log levels of the other independent variables. As in Blanchard, Bown and Johnson (2016), we focus on estimating DVA effects in this specification, so the empirical estimation includes importer-industry-year fixed effects. This yields the following empirical specification:

$$t^h_{xjt} - t^{h,MFN}_{xt} = \phi_{xht} + \phi_{xjt} + D_{xijt} + \gamma^{DVA} \ln \left(DVA^j_{xht} \right) + e_{xhjt}, \tag{B3}$$

We then instrument $\ln \left(DVA^j_{xht} \right)$ using either the DVA-in-Services instrument from the main text, or the DVA-in-1970 instrument discussed above.

In Panel A of Table B4, we report results that use DVA-in-Services as the instrument. In Panel B of Table B4, we then repeat the estimation with DVA-in-1970 as the instrument. For both instruments, estimates for the coefficient on the log DVA ratio are negative, they are robust across specifications with varying control variables, and they generally consistent in magnitude with those reported elsewhere. We conclude that this evidence again supports the causal interpretation of the estimates in the main body of the paper.

[32] This assumption seems reasonable, based on the fact that the heterogeneous distance elasticity instrument for imports does not appear weak in specifications reported in the main text, when combined with the DVA-in-Services instrument. If we drop this assumption and assume both are weak, then the confidence intervals for the log DVA ratio are unbounded on the left (for reasonable minimum grid search values), though they are still bounded on the right by negative values – i.e., we can reject that the coefficient is zero or positive. The unboundedness of the confidence set is a common issue in construction of weak-IV confidence intervals based on the AR statistic, which suffers from poor power. Conditioning on the strong identification of $\gamma^{IP} + \gamma^{FVA}$ serves to enhance the power of the test. See Section 5.3 of Andrews, Stock and Sun (2019) for a concise discussion of these issues.

Table B2: IV Estimates using Alternative Instruments for Imports

	OLS		Instrumental Variables	
	(1)	(2)	(3)	(4)
DVA ratio: $\ln(DVA^{j}_{xht}/IM^{h}_{xjt})$	-0.98***	-1.09***	-1.49**	-1.47**
	(0.27)	(0.30)	(0.66)	(0.68)
FVA ratio: $\ln(FVA^{h}_{xt}/IM^{h}_{xjt})$	-0.97***		-14.41**	
	(0.23)		(5.76)	
IP ratio: $\ln(FG^{h}_{xt}/IM^{h}_{xjt})$	2.13***		15.85**	
	(0.48)		(6.09)	
IP ratio + FVA ratio ($\gamma^{IP} + \gamma^{FVA}$)		1.29***		1.43***
		(0.33)		(0.38)
Observations	11,281	11,281	11,281	11,281
Under-Identfication Test (rk LM statistic)			29.12	20.22
Weak-Identfication Test (Wald rk F statistic)			11.92	11.77
Conditional F-Stat (DVA ratio)			25.18	23.78
Conditional F-Stat (FVA ratio)			48.78	
Conditional F-Stat (FG ratio)			48.49	
Conditional F-Stat (IP ratio + FVA Ratio)				51.27
Column Fixed Effects				
Importer-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: Columns (1)-(2) repeat OLS results from Table 2 for reference. Instrumental variables results are obtained via two-stage least squares, where instruments are constructed using imports in 1970 to construct the ratios; see section titled "Alternative Instrument for Imports." Standard errors (in parentheses) are clustered by importer-exporter pair. Significance levels: * $p < .1$, ** $p < .05$, *** $p < .01$. Under/Weak-Identification Tests are based on Kleinbergen and Paap (2006) and conditional F-statistics are based on Sanderson and Windmeijer (2016).

Table B3: IV Estimates with Alternative Instrument for DVA

	OLS	Instrumental Variables		
	(1)	(2)	(3)	(4)
DVA ratio: $\ln(DVA^{j}_{xht}/IM^{h}_{xjt})$	-0.95***	-8.85	-8.57	-7.85
	(0.32)	(4.63)	(4.46)	(4.15)
		[-27.58,-5.38]	[-26.61,-5.23]	[-25.88,-4.74]
IP ratio + FVA ratio ($\gamma^{IP} + \gamma^{FVA}$)	1.13***	5.02	4.78	4.18
	(0.35)	(2.96)	(2.87)	(2.66)
Log Bilateral Distance	0.81**	-0.66	-0.33	-0.89
	(0.37)	(1.91)	(2.03)	(1.72)
Colony			2.17	-0.12
			(2.96)	(2.53)
Common Language			-0.31	0.14
			(1.38)	(1.22)
Contiguity			-0.01	1.13
			(2.31)	(2.34)
Reciprocal Trade Agreement: RTA_{hjt}				-4.58
				(1.37)
Observations	8,520	8,520	8,520	8,520
Under-Identfication Test (rk LM statistic)		5.662	5.896	5.726
Weak-Identfication Test (Wald rk F statistic)		2.793	2.947	2.845
Conditional F-Stat (DVA ratio)		6.951	7.291	7.181
Conditional F-Stat (IP ratio + FVA ratio)		6.661	6.944	6.821

Note: Columns (1) includes OLS result for the sub-sample for which the DVA-in-1970 instrument is available. Instrumental variables results are obtained via two-stage least squares. Under/Weak-Identification Tests are based on Kleinbergen and Paap (2006) and conditional F-statistics are based on Sanderson and Windmeijer (2016). For all columns, conventional standard errors (in parentheses) are clustered by importer-exporter pair. For columns (1), significance levels: * $p < .1$, ** $p < .05$, *** $p < .01$. For columns (2)-(4) stars to indicate significance levels are omitted, due to concerns about weak instruments. For the DVA ratio, weak-IV robust confidence intervals are reported in brackets, based on inversion of the Anderson-Rubin test static with 10% nominal size under the assumption that $\gamma^{IP} + \gamma^{FVA}$ is strongly identified.

Table B4: Alternative IV Specification: Decile Indicator Controls for Imports

Panel A: DVA-in-Services				
	(1)	(2)	(3)	(4)
DVA: $\ln(DVA^j_{xht})$	-1.26***	-0.81**	-0.63**	-0.43**
	(0.35)	(0.33)	(0.27)	(0.20)
Log Bilateral Distance		0.77**	0.95***	0.25
		(0.30)	(0.33)	(0.22)
Colony			2.28***	0.37
			(0.72)	(0.38)
Common Language			0.21	0.54
			(0.53)	(0.47)
Contiguity			-1.30	0.34
			(1.12)	(1.06)
Reciprocal Trade Agreement: RTA_{hjt}				-5.57***
				(0.89)
Observations	11,281	11,281	11,281	11,281
Under-Identification Test (rk LM statistic)	61.46	62.14	58.31	56.39
Weak-Identfication Test (Wald rk F statistic)	2497	1213	1076	1048

Panel B: DVA-in-1970				
	(5)	(6)	(7)	(8)
DVA: $\ln(DVA^j_{xht})$	-2.14***	-2.16**	-2.16**	-1.65*
	(0.48)	(0.90)	(1.02)	(0.85)
Log Bilateral Distance		-0.03	0.12	-0.49
		(0.75)	(0.98)	(0.72)
Colony			2.84**	0.28
			(1.23)	(0.79)
Common Language			0.03	0.49
			(0.71)	(0.61)
Contiguity			-0.69	0.58
			(1.33)	(1.33)
Reciprocal Trade Agreement: RTA_{hjt}				-5.07***
				(0.96)
Observations	8,520	8,520	8,520	8,520
Under-Identfication Test (rk LM statistic)	34.28	15.61	13.61	13.54
Weak-Identfication Test (Wald rk F statistic)	62.98	22.37	20.61	20.03

Note: Instrumental variables results are obtained via two-stage least squares. Under/Weak-Identification Tests are based on Kleinbergen and Paap (2006) and conditional F-statistics are based on Sanderson and Windmeijer (2016). Standard errors (in parentheses) are clustered by importer-exporter pair. Significance levels: * $p < .1$, ** $p < .05$, *** $p < .01$.