Global Value Chains and Trade Policy*

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Abstract

How do global value chain (GVC) linkages modify countries' incentives to impose import protection? Are these linkages important determinants of trade policy in practice? 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 data for 14 countries between 1995 and 2015, we show that governments set lower tariffs and curb their use of temporary trade barriers where GVC linkages are strongest, consistent with theory. Turning to quantitative model counterfactuals, we find that severing GVC linkages would lead to the disappearance of tariff preferences. Further, targeted policies to decouple China from GVCs would increase the optimal tariff set by G7 countries on Chinese exports.

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In the modern global economy, most final goods are "made in the world" by combining inputs from many countries via global value chains (GVCs). The rising importance of GVCs has attracted widespread interest among business leaders and policy makers. For example, the World Trade Organization is exploring how trade policy institutions can be modernized to suit this new reality.[1] Value chain concerns were also prominent in debates about the United Kingdom's exit from the European Union and the re-design of the North American Free Trade Agreement. 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, theoretical and empirical analyses of the role for GVCs in shaping trade policy are scarce. One reason is that data sources and methods for measuring GVC linkages and trade in value added have only been developed over the past decade. A second reason is that GVCs take many 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 bilateral, others involve many countries; and so on. This variety in the structure of GVCs frustrates policy analysis, by making it difficult to obtain general predictions for policy.

In this paper, we leverage 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 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 tariffs on final goods can be characterized 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 advances in measuring trade in value added to connect theory with trade policy empirics.

Embedding this production structure into workhorse models 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

[1] See the WTO's Made in the World Initiative and the 2014 World Trade Report [WTO (2014)]. See also Baldwin (2012) and Hoekman (2014).

[2] As in models of task trade [Grossman and Rossi-Hansberg (2008)] and factor exchange [Adão, Costinot and Donaldson (2017)], we abstract from trade at intermediate stages of processing.

by production of domestic final goods. We assemble rich data on bilateral applied tariffs, temporary trade barriers (TTBs), and value-added contents to document that observed trade policies are systematically correlated with GVC linkages, consistent with this theory. We then evaluate the impact of GVC linkages on policy via counterfactuals in a quantitative version of the model.

We develop the theory in several steps. In Section 1, we first characterize the relationship between GVC linkages and unilaterally-optimal tariffs on final goods in a benchmark two-good, two-country model with specific factors, wherein the pattern of factor trade via GVCs is exogenous. We then demonstrate that the key insights are robust to allowing for endogenous reorganization of GVCs in response to tariffs, and we assess the mechanics of input tariffs in the model. Preparing to engage data in Section 2, we extend the model to include many countries and goods, as well as political economy motives for policy, to analyze optimal *bilateral* tariffs.[3] Finally, in Section 3, we provide a version of this many country model that is suitable for quantitative analysis.

In all these settings, final goods tariffs deviate from the standard "inverse export supply elasticity rule" for two key reasons. First, when foreign producers use inputs from the home country in production, the home (importing) country's incentive to manipulate the terms of trade is diminished. Put simply, an importer's tariff pushes down the price that foreign producers receive for their output, which hurts upstream domestic input suppliers to that foreign industry. Thus, the home government optimally sets a lower tariff on imports that contain more home-country content. Second, when home producers use foreign inputs in production, foreigners capture some of the protectionist rents from higher home tariffs. So, the home government's desire to apply import protection is again diminished.[4]

In addition to these two basic forces, our theory allows for political economy concerns to interact with GVC linkages in important ways. 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. The model also delivers 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)].

[3]Here we also describe how the empirical analysis accounts for two important institutional features of the world trading system – the GATT most-favored-nation (MFN) rule and Article XXIV regional trade agreements (RTAs).

[4]Note that this second effect arises even if the government has no ability (or motive) to manipulate its terms of trade; this constitutes a distinct international externality that travels through domestic prices.

Building on this foundation, we examine the empirical relationship between GVC linkages and bilateral trade policies. We first investigate bilateral tariff preferences: downward deviations in applied bilateral tariffs from multilateral MFN levels. Then, we study the use of temporary trade barriers (antidumping, safeguard, and countervailing duties), which are an increasingly active policy domain.

Using data from the World Input-Output Database, we measure the domestic value-added content embodied in foreign-produced final goods and foreign value-added content embodied in domestically-produced final goods. These data correspond to the GVC income flows generated by global production. The ratio of these values to bilateral imports are the key right-hand side variables in the empirical analysis. Guided by theory, our empirical specifications control for confounding factors, including domestic political economy forces and export supply elasticities, via observable proxies and flexible fixed effects. We attend to the institutional environment in which policy is set, by accounting for censoring of applied bilateral tariffs due to the MFN rule and controlling for the presence of RTAs.[5] We also explore how upstream and downstream product differentiation mediate the relationship between GVC linkages and observed tariffs.

We find results consistent with theoretical predictions: higher domestic content in foreign final goods, and higher foreign content in domestic goods, are associated with systematically lower applied bilateral tariffs, and thus larger tariff preferences. Further, the estimated influence of GVC linkages on tariffs is stronger when we correct for censoring induced by the MFN rule. Our estimates suggest that within a typical industry, a given importer imposes tariffs that are roughly 5 percentage points lower for its trading partners whose products include the highest levels of the importer's own value-added content, compared to tariff levels imposed on otherwise-similar trading partners whose exports contain the lowest levels of the importer's content. Moreover, domestic content is more strongly correlated with tariffs when it originates in highly-differentiated upstream sectors, indicative of a strong pass-through from final goods prices to returns to upstream factors.[6] Finally, we show that the use of temporary trade barriers (TTBs) is systematically related to GVC linkages in much the same way as bilateral applied tariffs. Honing in on an important segment of this data, we find that domestic content in Chinese goods appears to deter countries from imposing TTBs on China.

In Section 3, we turn to a quantitative version of the model, in which we use counterfactual analysis to assess the impact of GVC linkages on optimal tariffs. To this end, we develop

[5] In supplemental results, we explore how the results differ across trade policy regimes, whether tariffs are set via regional trade agreements or other policy regimes (e.g., the Generalized System of Preferences).

[6] Domestic content also is also more strongly negatively correlated with tariffs in final goods sectors that are differentiated, which likely feature lower export supply elasticities.

a novel Roy-Frèchet mechanism to describe how GVC input suppliers sort into global value chains, in which comparative advantage controls the effective supply of factors by upstream countries to each value chain. We then adopt standard functional form and parametric assumptions to obtain a gravity-type structure for trade in both final goods and GVC inputs.

Calibrating the model to match an initial observed trade equilibrium, we evaluate how optimal tariffs change when GVC linkages are exogenously severed, whether globally or at the bilateral level. We find that removing all GVCs almost completely eliminates preferential tariffs in the model. Moreover, the measured degree of responsiveness of applied tariffs in the model is broadly consistent in with our reduced form results. A second experiment considers a 'decoupling' scenario, wherein G7 countries cease supplying GVC inputs to China. We find that the subsequent reduction in G7 content in Chinese goods would induce the G7 countries to optimally impose higher tariffs on Chinese exports of final goods. Put differently, downstream G7 import tariffs are complementary to upstream restrictions on the supply of G7 inputs to Chinese producers. Lastly, in a retrospective exercise, the model indicates that the observed reductions in exogenous (iceberg) GVC frictions between 1995 and 2015 imply a reduction in global mean tariffs of about 2 percentage points; this estimate is sizable relative to the 4.5 percentage point decline in mean observed tariffs over this period.

Our study is related to several branches of the trade policy literature. Our framework complements work by Ornelas and Turner (2008, 2012) and Antràs and Staiger (2012), who analyze how bilateral bargaining under incomplete contracts among value chain partners alters the mapping from tariffs to prices, and therefore optimal trade policy for both final goods and inputs. Caliendo et al. (2023) and Antràs et al. (2024) study optimal tariffs in quantitative models with roundabout production and imperfect competition, while Beshkar and Lashkaripour (2020) conduct related analysis of optimal policy in a quantitative Ricardian framework with perfect competition. One takeaway from these contributions is that optimal input tariffs depend critically on the precise modelling assumptions one adopts, as recognized by Antràs and Chor (2022). In contrast, the core theoretical findings for final goods tariffs that we emphasize hold in various contexts, as we discuss below.

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.[7] In contrast to this work on ownership, our theory directs attention to the most important dimension of GVC activity: the implicit trade in factors that accompanies trade in physical inputs via GVCs. Because these GVC linkages are both pervasive and large

[7] Our paper speaks to related empirical work on the influence of multinational firms on trade policy. Blanchard and Matschke (2015) show that the United States offers preferential market access to destinations that host affiliates of US multinationals, and Jensen, Quinn and Weymouth (2015) find that US multinationals refrain from filing antidumping disputes against countries with which they conduct intrafirm trade.

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 GVC linkages is fruitful, yet previously unexplored, territory for both theoretical and empirical analysis.

Our results also contribute to 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)]. Drawing on this work, we examine how trade in value-added content modifies policy setting, and we are the first (to our knowledge) to demonstrate the relevance of terms-of-trade concerns for *bilateral* tariff policy. Relatedly, two recent papers leverage the value-added approach we develop in this paper in different contexts. Using data on Chinese processing trade with Asian partners, Ludema et al. (2021) 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 protection after the creation of the WTO, Bown, Erbahar and Zanardi (2021) find that higher domestic value added embodied in foreign goods raises the probability that duties will be removed, consistent with our findings.

1 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 1.1, in which we assume that the final good is produced by combining domestic and foreign specific factors. In Section 1.2, we characterize the implicit function that links optimal final goods tariffs to the (potentially observable) domestic value-added content of foreign goods and the foreign value-added content of domestic goods. We then discuss two extensions of the baseline model. First, in Section 1.3, we relax the specific factors assumptions to allow for endogenous changes in GVC input use in response to tariffs. Second, we describe how input tariffs can be incorporated into the theory in Section 1.4.

1.1 The 2x2 Benchmark Model

We start by describing the economic environment, and then we characterize the economic equilibrium as a function of the tariff.

1.1.1 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 Let preferences in each country be represented by the aggregate utility function: $U(d_x^c, d_y^c)$, where d_s^c denotes total 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:

$$q_x^c = f_x^c(l_x^c, \nu_h^c, \nu_f^c), \qquad \text{and} \qquad q_y^c = l_y^c, \tag{1.1}$$

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. We discuss how payments to these specific factors are determined via cooperative bargaining below.

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.[8] The Home government chooses its tariff to maximize aggregate indirect utility of its citizens, 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 Metzler 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.[9]

1.1.2 Model Solution

Production By choice of units, 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:

$$l_x^c(p^c;\vec{\nu}^c) = \arg\max_{l_x^c} \; p^c f_x^c(l_x^c, \nu_h^c, \nu_f^c) - l_x^c, \tag{1.2}$$

$$l_y^c(p^c;\vec{\nu}^c) = L^c - l_x^c(p^c;\vec{\nu}^c), \tag{1.3}$$

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

$$q_x^c(p^c;\vec{\nu}^c) = f_x^c(l_x^c(p^c;\vec{\nu}^c);\vec{\nu}^c) \tag{1.4}$$

$$q_y^c(p^c;\vec{\nu}^c) = l_y^c(p^c;\vec{\nu}^c). \tag{1.5}$$

Consistent with perfect competition, GVC inputs capture all residual profit (quasi-rent) from local final good production. For producers in c, residual profit is defined as $\pi_x^c(p^c;\vec{\nu}^c) \equiv$

[8] Export taxes are ruled out, since they are seldom used in practice, and even unconstitutional in the United States. Beshkar and Lashkaripour (2020) offer an elegant theoretical characterization of optimal trade taxes allowing for both import and export taxes.

[9] Using τ to represent one plus the Home tariff rate and $\tilde{p}^c$ to represent the equilibrium price of good x in country c, we assume $\frac{d\tilde{p}^f}{d\tau} \leq 0 \leq \frac{d\tilde{p}^h}{d\tau}$.

$p^c q_x^c(p^c;\vec{\nu}^c) - l_x^c(p^c;\vec{\nu}^c)$, where $\frac{\partial \pi_x^c(p^c;\vec{\nu}^c)}{\partial p^c} > 0$ as long $q_x^c(p^c;\vec{\nu}^c) > 0$, by Hotelling's lemma.

We assume these profits are split among owners of the specific factors via a cooperative game according to a weighted Nash bargaining solution (see Appendix A.1 for details). Let payments by the downstream producer to GVC input suppliers from d be π_{xd}^c, where these payments exhaust total profits: $\pi_x^c(p^c;\vec{\nu}^c) = \sum_d \pi_{xd}^c$. If the constant Nash bargaining weights are denoted $\alpha_d^c > 0$, then payments are given by: $\pi_{xd}^c \equiv \pi_{xd}^c(p^c;\vec{\nu}^c) = \alpha_d^c \pi_x^c(p^c;\vec{\nu}^c)$. The return per unit of factor supplied is then $r_d^c(p^c;\vec{\nu}^c) \equiv \frac{\pi_{xd}^c(p^c;\vec{\nu}^c)}{\nu_d^c}$. Further, it is straightforward to see that $\frac{\partial r_d^c(p^c;\vec{\nu}^c)}{\partial p^c} > 0$, so payments to GVC input suppliers are increasing in the price of downstream output.[10]

Consumption Given preferences, aggregate demand and indirect utility depend only on local prices and aggregate national income according to:

$$d_x^c(p^c, I^c) = \arg\max_{d_x^c} \quad U(d_x^c, d_y^c) \quad s.t. \quad d_y^c + p^c d_x^c \leq I^c, \tag{1.6}$$

$$d_y^c(p^c, I^c) = I^c - p^c d_x^c(p^c, I^c), \tag{1.7}$$

$$V(p^c, I^c) = U(d_x^c(p^c, I^c), d_y^c(p^c, I^c)), \tag{1.8}$$

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

National Income National income is the sum of factor payments plus tariff revenue (R^c):

$$I^c = L^c + r_c^h(p^h;\vec{\nu}^h)\nu_c^h + r_c^f(p^f;\vec{\nu}^f)\nu_c^f + R^c. \tag{1.9}$$

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 and $\vec{p} \equiv (p^h, p^f)$.[11] Because income depends on tariff revenue, and tariff revenue depends on income, Equation (1.9) 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

[10] While we have adopted a Nash bargaining approach to splitting the surplus for concreteness here, any micro-foundation in which payments to GVC input suppliers are increasing in price of downstream output would suffice.

[11] Since Foreign practices free trade, $R^f = 0$.

inputs used in foreign production (DVA):

$$I^c = p^c q_x^c(p^c;\vec{\nu}^c) + q_y^c(p^c;\vec{\nu}^c) + R^c - FVA^c + DVA_c, \tag{1.10}$$

$$\text{where } FVA^c \equiv r_j^c(p^c;\vec{\nu}^c)\nu_j^c \text{ and } DVA_c \equiv r_c^j(p^j;\vec{\nu}^j)\nu_c^j. \tag{1.11}$$

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 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:

$$p^h(\tau, p^f) = \tau p^f. \tag{1.12}$$

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

$$d_x^h(p^h(\tau,\tilde{p}^f),\tilde{p}^f;\vec{\nu}) + d_x^f(p^h(\tau,\tilde{p}^f),\tilde{p}^f;\vec{\nu}) = q_x^h(p^h(\tau,\tilde{p}^f);\vec{\nu}^h) + q_x^f(\tilde{p}^f;\vec{\nu}^f), \tag{1.13}$$

where supply and demand are given by Equations (1.4), (1.6), and (1.10).[12] The equilibrium foreign price is a thus a function of Home's tariff and the allocation of GVC inputs: $\tilde{p}^f \equiv \tilde{p}^f(\tau;\vec{\nu})$.

1.2 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:

$$\tau^o = \arg\max_{\tau} \quad V\big(p^h, I(p^h, p^f)\big) \tag{1.14}$$
$$\text{s.t.} \quad p^h = \tau p^f = \tilde{p}^h(\tau) \quad \text{and} \quad p^f = \tilde{p}^f(\tau).$$

[12]Combining (1.6) and (1.10) yields: $d^c(p^c, I^c(\vec{p};\vec{\nu})) = d^c(\vec{p};\vec{\nu}), c \in \{h, f\}$, as written in (1.13). By Walras' law, the market for y also clears according to the national balanced budget conditions embedded in (1.7).

The associated first order condition is:

$$V_\tau = V_p \frac{d\tilde{p}^h}{d\tau} + V_I \left\{ \frac{\partial I(p^h, p^f)}{\partial p^h} \frac{d\tilde{p}^h}{d\tau} + \frac{\partial I(p^h, p^f)}{\partial p^f} \frac{d\tilde{p}^f}{d\tau} \right\} = 0, \tag{1.15}$$

where $V_p \equiv \frac{\partial V(p^h, I^h)}{\partial p^h}$ and $V_I \equiv \frac{\partial V(p^h, I^h)}{\partial I^h}$.[13] Applying Roy's identity, using the derivatives of Equation (1.10) with respect to p^h and p^f, and collecting terms yields:

$$V_\tau = V_I \Bigg[\underbrace{(\tau^o - 1) p^f \frac{dM_x}{d\tau} - M_x \frac{d\tilde{p}^f}{d\tau}}_{\text{terms-of-trade motive}} - \frac{dFVA^h}{d\tau} + \frac{dDVA_h}{d\tau} \Bigg] = 0. \tag{1.16}$$

The expression above the underbrace captures the standard terms-of-trade cost-shifting motive [Johnson (1951-1952)] for large countries. The remaining two terms in (1.16) 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).

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

$$\frac{dFVA^h}{d\tau} = \frac{dFVA^h}{dp^h} \frac{d\tilde{p}^h}{d\tau} = \underbrace{\left(\frac{dr_f^h}{dp^h} \frac{p^h}{r_f^h} \right)}_{\equiv \varepsilon_f^{rh} > 0} \underset{+}{\frac{r_f^h \nu_f^h}{p^h}} \underset{+}{\frac{dp^h}{d\tau}} = \varepsilon_f^{rh} \frac{FVA^h}{p^h} \frac{d\tilde{p}^h}{d\tau} > 0, \tag{1.17}$$

$$\frac{dDVA_h}{d\tau} = \frac{dDVA_h}{dp^f} \frac{d\tilde{p}^f}{d\tau} = \underbrace{\left(\frac{dr_h^f}{dp^f} \frac{p^f}{r_h^f} \right)}_{\equiv \varepsilon_h^{rf} > 0} \underset{+}{\frac{r_h^f \nu_h^f}{p^f}} \underset{-}{\frac{dp^f}{d\tau}} = \varepsilon_h^{rf} \frac{DVA_h}{p^f} \frac{d\tilde{p}^f}{d\tau} < 0. \tag{1.18}$$

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.

Substituting Equations (1.17) and (1.18) into the first order condition, applying the market-clearing condition, and isolating τ^o, we arrive at an implicit function that defines Home's optimal tariff on imported final goods:

$$\tau^o = 1 + \frac{1}{\epsilon_x^f} \left(1 - \varepsilon_h^{rf} \frac{DVA_h}{p^f E_x^f} - \varepsilon_f^{rh} \frac{FVA^h}{p^h E_x^f} \frac{1}{|\lambda|} \right), \tag{1.19}$$

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.[14]

[13] The assumption made above to rule out the Metzler and Lerner paradoxes ($\frac{d\tilde{p}^f}{d\tau} \leq 0 \leq \frac{d\tilde{p}^h}{d\tau}$) ensures that the second order condition is satisfied for small tariffs.

[14] We define the export supply elasticity to include income effects from changes in Foreign GVC income:

This expression delivers the canonical solution for the optimal tariff of a national-income maximizing government, modified to incorporate GVC linkages. As in Johnson (1951-1952), the inverse foreign export supply elasticity captures the importer's terms-of-trade motive for tariff setting: when foreign export supply is less elastic, the Home government will set a higher tariff to exploit its market power; in the absence of GVCs, the optimal tariff collapses to this familiar result. More generally, however, GVC linkages alter this terms-of-trade motive in two ways.

First, the use of Home GVC inputs in foreign production dampens the terms-of-trade cost-shifting motive by forcing the Home country to internalize some of the costs its tariff imposes on foreign exporters. That is, $\frac{dDVA_h}{d\tau} = \frac{dDVA_h}{dp^f}\frac{d\tilde{p}^f}{d\tau} < 0$ because an increase in Home's tariff lowers the price of foreign-produced final goods, which in turn depresses the returns to Home's suppliers of GVC inputs used in foreign production. In effect, some of the losses incurred by foreign exporters due to a tariff are passed back through the value chain to Home's constituents. As in Equation (1.18), the strength of this mechanism is increasing with the pass-through elasticity from foreign final goods prices to domestic GVC 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 the local price received by domestic import-competing final goods producers, at the cost of Home's consumer constituents; 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, so that $\frac{dFVA^h}{d\tau} = \frac{dFVA}{dp^h}\frac{d\tilde{p}^h}{d\tau} > 0$. 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 another externality that also serves to drive down the optimal tariff, all else equal.[15] 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 (1.19), 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 (1.19) offers valuable insights into the equilibrium relationship between the tariff level and the elasticity of trade, trade values, pass-

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$\epsilon_x^f \equiv \epsilon_x^f(\tau, \vec{\nu}) = \frac{p^f}{E_x^f}\frac{dE_x^f(p^f, I^f)}{dp^f} + \frac{\partial E_x^f(p^f, I^f)}{\partial I^f}\frac{dFVA}{dp^h}\frac{p^f}{\lambda E_x^f}$. The first term is the direct analog to the trade elasticity in conventional models without GVC income.

[15] Moreover, because the FVA-effect operates through domestic (rather than foreign) prices, this FVA mechanism would obtain even for 'small' countries too small to influence world prices.

through elasticities, and GVC income. The key 'directional' result follows the intuition above: the optimal tariff is decreasing in the (exogenous) endowment of Home GVC inputs used in Foreign production (ν_h^f), and Foreign GVC inputs used in Home production (ν_f^h), provided basic regularity conditions obtain. (See Section A.2 of the Appendix for the formal comparative statics proposition and proof.) Further, by linking optimal tariffs to GVC income and thus value-added content (DVA and FVA), this expression provides structure for our empirical investigation to follow.

Before proceeding to the empirics, however, we pause to consider two related extensions to the basic model, allowing first for endogenous reorganization of global value chains in Section 1.3, then input tariffs in Section 1.4. Previewing key results, we will demonstrate that the basic structure of the optimal final goods tariff expression in (1.19) is robust to allowing for both endogenous GVCs and the level of input tariffs. In contrast, we show that the directional relationship between optimal *input* tariffs and GVCs is fundamentally model-dependent in a way that the relationship between optimal final goods tariffs and GVCs is not. Together, these extensions of the theory underpin our decision to focus the empirical investigation on final goods tariffs. Readers eager to skip to Section 2 are welcome to do so.

1.3 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 the global pattern of input use ($\vec{\nu}$) to respond to prices. To distinguish effects that operate through prices versus quantities, we assume that the substitutability of GVC inputs across destinations is limited, 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.4) is a natural extension the specific factors case. To streamline analysis, we also adopt quasi-linear preferences.

As before, Home's national income is given by Equation (1.10), and the government maximizes aggregate indirect utility subject to the arbitrage and market clearing conditions described in Equation (1.14). The optimal tariff takes the form:

$$\tau^o = 1 + \frac{1}{\epsilon_x^f}\left(1 - (\tilde{\varepsilon}_h^{rf} + \tilde{\varepsilon}_h^{\nu f})\frac{DVA_h}{p^f E_x^f} - (\tilde{\varepsilon}_f^{rh} + \tilde{\varepsilon}_f^{\nu h})\frac{FVA^h}{p^h E_x^f} + \eta\right), \tag{1.20}$$

where ϵ_x^f is the foreign export supply elasticity for final goods (for a given $\vec{\nu}$), 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.4 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 (1.19)) is that the pass-through terms attached to DVA and FVA now account 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 our specific factors model, the analogous pass-through terms were unambiguous: the fixed GVC structure effectively set the $\tilde{\varepsilon}_j^{\nu c}$ terms to zero, while the $\tilde{\varepsilon}_j^{rc}$ terms were positive.

Allowing for endogenous reorganization of GVCs, however, it is possible that pass-through from tariffs to GVC income could work in the opposite direction under certain model primitives. Intuitively, an increase in Home's tariff raises the price of the domestically-produced final good and depresses the price of the foreign-produced final good. These competing local-price effects exert offsetting pressure on demand for tradable GVC inputs from each country, and thus GVC income.[16] Notwithstanding this caveat, pass-through effects from tariffs to DVA and FVA will work as before – i.e. $\tilde{\varepsilon}_h^{rf} + \tilde{\varepsilon}_h^{\nu f} > 0$ and $\tilde{\varepsilon}_f^{rh} + \tilde{\varepsilon}_f^{\nu h} > 0$ – as long as GVC income responds more to changes in the local price of final goods where those GVC inputs are used than to prices elsewhere. Sufficient international segmentation in input markets will ensure that these conditions hold; we provide a specific model in which they do in Section 3. Further, the empirical correlation of tariffs with value-added content will be informative about whether these conditions align with reality.

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.4.)

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

[16] To fix ideas, consider an example drawn from Ludema et al. (2021). If inputs are highly substitutable across end-uses and countries, and inelastically demanded by downstream producers, it is possible that an increase in the Home's tariff could increase Home's GVC income. For this to happen, an increase in Home's tariff would need to drive up Home's demand for the (tradeable) GVC input so much that the positive increase in demand for the input at Home outweighs the negative impact of lower demand for the input overseas. These conditions are special, but not impossible.

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.

1.4 Input Tariffs

In analyzing tariffs for final goods, we have abstracted from the simultaneous analysis of input tariffs. We now explain why it is both reasonable and prudent to do so. We begin by introducing input tariffs into the benchmark model.[17] 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.

1.4.1 Input Tariffs in the Benchmark Model

Returning to the specific factors model in Section 1.1, 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 Equation (1.10), but tariff revenue is now:

$$R^h = (p^h - p^f)M_x^h + g r_f^h \nu_f^h. \tag{1.21}$$

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

$$V_\tau = V_I \left[(\tau^o - 1)p^f \frac{dM_x}{d\tau} - M_x \frac{d\tilde{p}^f}{d\tau} - (1-g)\frac{dFVA^h}{d\tau} + \frac{dDVA_h}{d\tau} \right] = 0. \tag{1.22}$$

[17] We introduce the input tariff as a tax on the income from domestic production that accrues to foreign factors, which may be thought of as a tax on foreign value-added content. We leave the mapping between taxes on traded intermediate inputs and the effective tax on foreign value-added content unspecified; this would depend on the particular model of value chains that one adopts.

Applying the market-clearing condition, using the same tariff decompositions in Equations (1.17) and (1.18), and isolating τ^o, yields the augmented optimal tariff expression:

$$\tau^o = 1 + \frac{1}{\epsilon_x^f}\left(1 - \varepsilon_h^{rf}\frac{DVA_h}{p^f E_x^f} - (1-g)\varepsilon_f^{rh}\frac{FVA^h}{p^h E_x^f}\frac{1}{|\lambda|}\right). \tag{1.23}$$

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). 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.[18]

1.4.2 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. As we will see below, 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 final goods tariff would still be given by Equation (1.23), 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 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 is as counterfactual as it is

[18] Adding an exogenous input tax to the model with endogenous GVC input use (Section 1.3) yields the general equilibrium analog to Equation (1.23). See Appendix A.5. The qualitative conclusions are the same.

obvious; in practice, tariffs on intermediate inputs are systematically lower than final goods tariffs, and they are also low in absolute terms [Bown and Crowley (2016); Shapiro (2021)].

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 1.3, we analyze the optimal input tariff in Appendix A.5. For a given final good tariff τ, the first order condition for the optimal input tariff, g^o, is given by:

$$V_g = V_I\left[(g^o-1)\frac{dFVA^h}{dg} + FVA + p^h\nabla_{\vec{\nu}}q_x^h\cdot D_g\vec{\nu} + (\tau-1)p^f\frac{dM_x}{dg} - M_x\frac{d\tilde{p}^f}{dg} + \frac{dDVA_h}{dg}\right] = 0 \quad (1.24)$$

On examination, it is clear that optimal input tariffs, like final goods tariffs, will be characterized by an (own) inverse elasticity rule, moderated by value chain linkages. The first two terms in (1.24) parallel analogous terms in the first order condition of the optimal final goods tariff in (1.16), and capture Home's 'direct' terms-of-trade motive to tax imports of GVC inputs: the greater the elasticity of foreign-sourced GVC inputs, the lower the optimal input tax on those inputs, all else equal. The remaining terms capture how a change in the input tariff affects the pattern of input use and thus final goods production, prices, trade and the associated tax revenue, and DVA. As before, such linkages can be described by a series of cross-elasticities governing these GVC relationships.

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 or generically 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. We refer the reader to Antràs and Chor (2022) for further discussion of the complexity of these issues.

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 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.

2 Theory to Data

This section explores the relationship between GVCs and trade policy in practice. We conduct the exercise in four steps. Preparing to take theory to data, Section 2.1 modifies the benchmark model to allow for many countries and sectors, as well as political economy considerations customary in the endogenous trade policy literature; we also address the implications of the GATT most-favored-nation (MFN) rule and Article XXIV regional trade agreements (RTAs). Using this extended framework, Section 2.2 presents our regression-based empirical strategy. Finally, Sections 2.3 and 2.4 describe the data and document the empirical relationship between GVCs and trade policy, first for bilateral tariff preferences and then for temporary trade barriers.

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

Building on Section 1.1, 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.6 for a complete exposition.

First, we adopt quasi-linear preferences, as in Grossman and Helpman (1994):

$$U^c(d_0^h, \vec{d_s}^{\,h}) = d_0^h + \sum_{s \in \mathcal{S}} u_s(d_s^h) \qquad \forall h \in \mathcal{C}, \tag{2.1}$$

where $\vec{d_s}^{\,h}$ is a 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 also assume that the representative consumer has sufficient income to consume a strictly positive quantity of the numéraire.

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:

$$G^h = V^h + \sum_{s \in \mathcal{S}} [\delta_s^{DPE} \pi_s^h + \delta_s^{DVA} DVA_{sh} + \delta_s^{FVA} FVA_s^h], \tag{2.2}$$

where V^h is Home's (endogenous) aggregate indirect utility, π_s^h is the residual profit from Home's production of good s, $DVA_{sh} = \sum_{j \neq h} r_{sh}^j (p_s^j; \vec{\nu}_s^j) \nu_{sh}^j$ is the return to Home's GVC inputs used in 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 foreign GVC 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. The parameter δ_s^{DPE} captures any additional consideration that the Home government affords to rents earned in domestic final goods production (π_s^h). Similarly, δ_s^{DVA} reflects any extra political value that the Home government places on the returns to Home's GVC inputs used in foreign final goods production (DVA_{sh}).[19] Finally, δ_s^{FVA} represents the political weight (if any) given to foreign GVC 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 [Grossman and Helpman (1994)].

Endowments, technology, and remaining model structure are the same as in the 2x2 model, with straightforward extensions to the multi-country, multi-industry setting. 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. 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 every $s \in \mathcal{S}$. 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 (2.2), subject to balanced budget, market clearing, and no arbitrage constraints, taking other countries' policies as given. Referring to Appendix A.6 for the derivation, we present the implicit solution for Home's optimal tariffs (analogous to Equation (1.19)) here:

$$\tau_{xj}^h = 1 + \frac{1}{\epsilon_{xh}^j}\left(1 + \frac{\delta_x^{DPE}}{|\lambda_{xj}^h|}\frac{p_x^h q_x^h}{p_x^h E_{xh}^j} - (1+\delta_x^{DVA})\varepsilon_{xh}^{rj}\frac{DVA_{xh}^j}{p_x^j E_{xh}^j} - \frac{(1-\delta_{x*}^{FVA})\varepsilon_{x*}^{rh}}{|\lambda_{xj}^h|}\frac{FVA_x^h}{p_x^h E_{xh}^j} - \tilde{\Omega}_{xj}\right). \quad (2.3)$$

Outside the parentheses, $\epsilon_{xh}^j \equiv \frac{dE_{xh}^j}{dp_x^j}\frac{p_x^j}{E_{xh}^j} > 0$ is the export supply elasticity for x imported by h from j. Inside the parentheses, q_x^h is the quantity of good x produced in h, and E_{xh}^j is the quantity of country j's exports of x to h. DVA_{sh}^j is the return to GVC inputs from h used by j in industry s, given by $r_{sh}^j(p_s^j; \vec{\nu}_s^j)\nu_{sh}^j$, and FVA_s^h is defined above. ε_{xh}^{rj} is the elasticity of the return to h's GVC inputs used by industry x in country j with respect to p_x^j, and ε_{x*}^{rh} is the elasticity of the return to (all) foreign GVC inputs used by industry x in home with

[19]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.

respect to p_x^h. Finally, $\lambda_{xj}^h \equiv \frac{d\tilde{p}_x^j}{d\tau_{xj}^h} / \frac{d\tilde{p}_x^h}{d\tau_{xj}^h} < 0$, and $\tilde{\Omega}_{xj}$ captures potential third-country effects of trade diversion (see the appendix for the full characterization of this term).

As compared to Equation (1.19), there are several new features in Equation (2.3). First, there is a term that captures how a politically-motivated government trades off the interests of import-competing domestic producers against social welfare, which depends both on the inverse import penetration ratio ($p_x^h q_x^h / p_x^h E_{xh}^j$) and the parameter δ_s^{DPE}. 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 shown to be empirically important determinants of tariff policy [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 its upstream suppliers of GVC inputs, as in $\delta_x^{DVA} > 0$, then the trade-liberalizing potential of DVA will be stronger, all else equal. Conversely, if the government responds to the interests of the foreign GVC input suppliers to its downstream producers, as in $\delta_x^{FVA} > 0$, 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 decrease in FVA.

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.[20] In contrast, τ_{xj}^h depends 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.

Trade Policy Institutions In practice, governments set bilateral applied tariffs subject to constraints imposed by trade policy institutions. One important constraint is the most-favored-nation (MFN) rule, which dictates that WTO members may not discriminate in their applied tariffs across their WTO-member trading partners, but for defined exceptions specified in the GATT's Article XXIV and Enabling Clause. Further, while countries may offer lower-than-MFN preferential tariffs to selected WTO-partners under these exceptions,

[20] In deriving Equation 2.3, we impose a common pass-through elasticity across foreign input suppliers (ε_{x*}^{rh}), reflecting this multilateral argument and how we have modeled returns to specific GVC inputs. Relaxing this assumption, one would replace FVA_x^h with an elasticity-weighted average of bilateral foreign GVC income.

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.

To incorporate this constraint, we define the government's applied tariff problem, as distinct from its optimal tariff problem. The government sets applied tariffs $\{\tau_{xj}^h\}$ to maximize is objective function in Equation (2.2) subject to to the additional constraint that $\tau_{xj}^h \leq \tau_x^{h,MFN}$, where $\tau_x^{h,MFN}$ denotes (one plus) its MFN tariff, along with balanced budget, market clearing, and no-arbitrage conditions. Following Grossman and Helpman (1995*a*), we take MFN tariffs as given when analyzing politically-optimal applied bilateral tariffs.[21] With slight modifications to accommodate the constraint, the logic of the constrained optimal tariff continues to conform to that in Equation (2.3), so we do not provide a full analytical treatment of it here. We will solve for constrained optimal tariffs in numerical analysis of the model, however.

With an eye toward data, applied tariffs are bound above by each country's MFN tariff rate. That is, countries offer tariff preferences, given by $t_{xjt}^{h,applied} - t_{xt}^{h,MFN}$, where $t_{xjt}^{h,applied}$ is the observed bilateral tariff rate. The MFN rule implies that these preferences take on negative values, censored above by zero. We will account for this censoring in the empirical analysis below.

In a different vein, while most 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 cost-shifting externalities [Grossman and Helpman (1995*b*), Bagwell and Staiger (1999)]. As a result, cooperation between RTA members could change the relationship between value-added content and applied tariffs set within RTAs. We address this possibility in the empirical analysis that follows, by controlling for whether country pairs have an RTA in force in some specifications. We further examine how value-added content influences tariffs set under different preference regimes in Appendix B.

2.2 Empirical Strategy

To guide our empirical investigation, we take a linear approximation of Equation (2.3) around a baseline equilibrium in which there are no GVC linkages ($\vec{\nu} = 0$, such that $DVA_{xh}^j = 0$

[21] Grossman and Helpman (1995*a*) appeal to GATT Article XXIV to justify this assumption, which prohibits countries that adopt bilateral agreements from raising their external (MFN) tariffs. Further, MFN tariffs for many countries were set under the Uruguay Round, which concluded before the start of the period for which we examine data below.

and $FVA_x^h = 0 \; \forall x \in \mathcal{S}, j \in \mathcal{C}$). The result is:

$$t_{xj}^h = \frac{1}{\bar{\epsilon}_{xh}^j} + \gamma_{xhj}^{IP}\left(\frac{FG_{xt}^h}{\bar{p}_x^h \bar{E}_{xh}^j}\right) + \gamma_{xhj}^{DVA}\left(\frac{DVA_{xh}^j}{\bar{p}_x^j \bar{E}_{xh}^j}\right) + \gamma_{xh}^{FVA}\left(\frac{FVA_x^h}{\bar{p}_x^h \bar{E}_{xh}^j}\right) + \omega_{xhj}, \tag{2.4}$$

where $t_{xj}^h \equiv \tau_{xj}^h - 1$, bars denote equilibrium objects evaluated at the point of approximation, $FG_{xt}^h \equiv p_x^h q_x^h$, $\gamma_{xhj}^{IP} \equiv \frac{\delta_x^{PE}}{\bar{\epsilon}_{xh}^j |\bar{\lambda}_{xj}^h|}$, $\gamma_{xhj}^{DVA} \equiv -\frac{(1+\delta_x^{DVA})\bar{\varepsilon}_{xh}^{rj}}{\bar{\epsilon}_{xh}^j}$, $\gamma_{xhj}^{FVA} \equiv -\frac{(1-\delta_x^{FVA})\bar{\varepsilon}_{x*}^{rh}}{\bar{\epsilon}_{xh}^j |\bar{\lambda}_{xj}^h|}$, and ω_{xhj} includes approximation errors and potential trade diversion effects.[22]

This expression is a mix of observable variables and parameters. The three key observables are the levels of final goods production (FG_{xt}^h), foreign GVC income generated by home production (FVA_{xt}^h), and domestic GVC income from foreign production (DVA_{xht}^j). Each of these is measurable in our data, with the value-added content of final goods as a proxy for GVC income. Each of these observables enters Equation (2.4) as a ratio, divided by bilateral imports in the no-GVC equilibrium, which we do not observe. We use realized bilateral imports as a proxy for these unobserved values to compute the ratios. Further, to address concerns about measurement error in the denominator, we take logs of these ratios to construct an estimating equation.[23]

The remaining parameters in Equation (2.4), including the inverse export supply elasticity ($1/\epsilon_{xj}^h$) and parameters in the γ-terms, are not directly observed. In prior empirical work on optimal tariffs, the inverse export supply elasticity has typically been assumed to be importer and industry specific.[24] Following this work, we make the same assumption and use importer-industry fixed effects to control for it.[25]

We treat the coefficients attached to the ratios in Equation (2.4) as parameters to be estimated. We start by assuming that each coefficient is homogeneous, as in $\gamma^{IP} = \gamma_{xhj}^{IP}$, $\gamma^{FVA} = \gamma_{xhj}^{FVA}$, and $\gamma^{DVA} = \gamma_{xhj}^{DVA}$. Building on this baseline, we then explore coefficient heterogeneity, along economically meaningful dimensions (discussed below).

Building on these refinements, plus discussion of the MFN rule above, we will embed

[22] $\omega_{xhj} \equiv u_{xhf} - \tilde{\Omega}_{xj}$, 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.

[23] The observed values the ratios are positively skewed with a long right tail. This tail variation is difficult to reconcile with observed variation in tariffs. Compounding this issue, most ratios in the right tail of the data have small values for imports in the denominator, and imports are measured with error. As such, we suspect variation among observations in the right tail of the ratio distribution is largely driven by the measurement error itself. Taking logs serves to down-weight these observations.

[24] Among others, see Broda, Limão and Weinstein (2008), Ludema and Mayda (2013), and Nicita, Olarreaga and Silva (2018). Soderbery (2018) estimates bilateral trade elasticities and reports that almost three-quarters of the variation is explained by importer-product fixed effects.

[25] Because we include importer-year, importer-industry-year fixed effects, and exporter-industry-year fixed effects in various specifications, these also serve as additional controls for the export supply elasticity.

Equation 2.4 within an empirical framework with censoring as follows:

$$t_{xjt}^{h,applied} - t_{xt}^{h,MFN} = \min\{t_{xjt}^{h} - t_{xt}^{h,MFN}, 0\}, \text{ with} \tag{2.5}$$

$$t_{xjt}^{h} - t_{xt}^{h,MFN} = \Phi_{xhjt} + \gamma^{FG} \ln\left(\frac{FG_{xt}^{h}}{IM_{xjt}^{h}}\right) + \gamma^{DVA} \ln\left(\frac{DVA_{xht}^{j}}{IM_{xjt}^{h}}\right) + \gamma^{FVA} \ln\left(\frac{FVA_{xt}^{h}}{IM_{xjt}^{h}}\right) + e_{xhjt}, \tag{2.6}$$

where $t_{xjt}^{h,applied}$ is the applied bilateral tariff (vis-a-vis partner i and $t_{xt}^{h,MFN}$ is the MFN tariff rate for country j.[26] In the subscripts, t denotes the time period. Further, 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 (discussed below), and e_{xhjt} is a regression residual.

Equations 2.5 and 2.6 provide a regression framework for investigating data. To be clear, our initial aim is to document correlations in the data that are consistent with the underlying theory. 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 will then use correlations of this sort to discipline parameters in the quantitative analysis in Section 3.

2.3 Evidence for Tariff Preferences

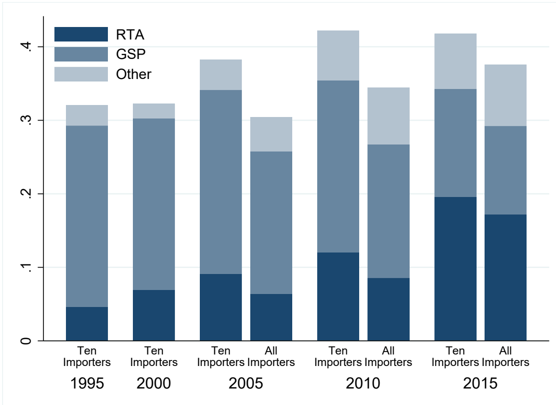
We begin this section by briefly describing sources and methods for compiling our data on bilateral tariffs and value-added content, with full details in Appendix B. We then discuss sources of variation in the bilateral tariff data and examine an illustrative case study to fix ideas. Finally, we present the main regression-based results on the relationship between GVC income and observed tariff preferences.

2.3.1 Data

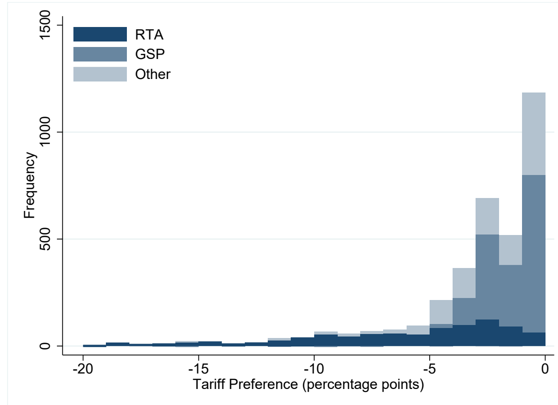
We construct bilateral, industry-level tariffs on final goods for five benchmark years: 1995, 2000, 2005, and 2010, and 2015. We start with product-level tariff schedules collected by UNCTAD (TRAINS) and the WTO, which we obtain via the World Bank's WITS website. Combining these sources and aggregating 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

[26] Note that the dependent variable here is the tariff preference: $t_{xjt}^{h,applied} - t_{xt}^{h,MFN}$. A uniform reduction in all tariffs leaves this dependent variable unchanged. Further, if only MFN tariffs change, then tariff preferences would be compressed (i.e., the censoring bound is tightened). In OLS specifications that do not adjust for censoring, this compression pushes the coefficients toward zero, working against rejecting the null.

Figure 1: Tariff Preferences



(a) Tariff Preferences over Time



(b) Distribution of Tariff Preferences

Note: Sub-figure (a) reports the share of importer-exporter-industry cells (with non-zero MFN tariffs) that have preferential tariffs in place by year. Bars labelled "Ten Importers" report data for a balanced panel of 10 importing countries with data available in all years. The histogram in Sub-figure (b) includes only observations for which applied bilateral tariffs are lower than MFN, and excludes observations with preferences < -20 for legibility. Bin width is set to 1 percentage point. In both figures, preferences are broken down by whether they occur under a regional trade agreement (RTA), the Generalized System of Preferences (GSP), or other preferential agreements.

to measure industry-level applied bilateral and MFN tariffs.

To compute the national origin of value added contained in the final goods that each country produces, we use data from the World Input-Output Database (WIOD). 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 B1, that cover the 1995-2014 period.[27] We use value-added contents from 2014 in our analysis of tariffs in 2015.

Background on Tariff Preferences There are four main policy regimes under which countries grant tariff preferences. The first regime is the Generalized System of Preferences (GSP), under which developing countries receive preferential treatment from high-income importers. 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. Despite their name, these

[27]The countries are: Australia, Brazil, Canada, China, the European Union, India, Indonesia, Japan, Mexico, Russia, South Korea, Taiwan, Turkey, and the United States.

agreements do not entail completely free trade: almost half of tariffs imposed on RTA partners are greater than zero in our data. 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 1a, we track the prevalence of tariff preferences, by type. Tariff preferences are widespread: between 30-40% of all importer-exporter-industry cells have preferential tariffs. Moreover, the prevalence of tariff preferences has been increasing over time, rising by about ten percentage points from 1995 to 2015. At the same time, many preferences remain in place throughout our sample period, so cross-section variation (across sectors and trading partners) is an important dimension of the data. Lastly, the composition of preferences changes over time. RTAs and partial scope agreements have become more important sources of preferences over time, and they seem to progressively displace GSP preferences.

To illustrate the depth of preferences by regime, we plot the distribution of preferences in Figure 1b.[28] Since the magnitude of tariff preferences is generally larger under RTAs and partial scope agreements than the GSP, the rise of RTAs and displacement of non-RTA preferences over time represents a deepening of preferences over time.

Case Study: Textiles, Leather, and Footwear To illustrate variation in the data, we present a few figures for the Textiles, Leather, and Footwear sector, where value chain linkages are salient to policymakers, and the scope for and use of tariff discretion is high.

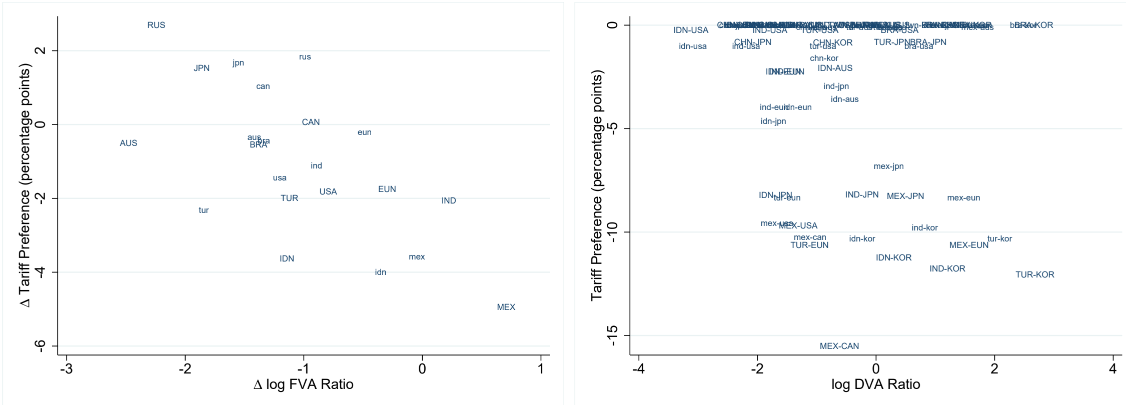
We start by examining the relationship between changes in FVA and average tariff preferences, within importer-industry cells. Figure 2a plots the change in the mean tariff preference by importer and industry against the log changes in the ratio of foreign value added to imports between 1995 and 2015. 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.[29]

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 2b plots bilateral tariff preferences against the log ratio of DVA to bilateral imports, $\ln\left(DVA^i_{xjt}/IM^i_{xt}\right)$, in 2015. There is a negative correlation between applied tariffs and the DVA ratio overall, consistent with

[28]Conditional on receiving preferences, the mean (median) preference is about -3.2 (-2.2) percentage points, with a 10th-90th percentile range of $[-8.06, -0.09]$.

[29]Most importers experience declines in their FVA ratios over time in the Textiles, Leather, and Footwear sector, because imports rise faster than FVA (which is also rising for most countries). Like the figure, our regression framework leverages *differences* in these changes across sectors and countries.

Figure 2: Textiles, Leather, and Footwear Case Study



(a) Changes Tariff Preference vs. log FVA Ratio by Importer and Industry: 1995-2015

(b) Tariff Preferences vs. log DVA Ratio in 2015: High Income Importers & 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 B1, 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.

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 content in production. Note also that there is an obvious censoring problem in the figure, as there are many country pairs clustered at zero preference. This censoring likely biases the simple correlation toward zero, so we will adjust for it below.

2.3.2 Results

We present estimates of Equations (2.5)-(2.6) in Table 1. In all columns, the dependent variable is the observed tariff preference: $t^{h,applied}_{xjt} - t^{h,MFN}_{xt}$. 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 all columns, we present standard errors that are clustered by importer-exporter pair.

We include importer-year and importer-industry fixed effects in columns (1) and (3). Here the coefficients attached to the ratio of FVA to bilateral imports (γ^{FVA}) and the import

Table 1: Bilateral Tariffs and Value-Added Content

Panel A: Baseline				
	OLS		Tobit	
	(1)	(2)	(3)	(4)
DVA ratio: $\ln(DVA^{j}_{xit}/IM^{i}_{xjt})$	-1.00***	-1.08***	-2.39***	-2.53***
	(0.27)	(0.30)	(0.51)	(0.53)
FVA ratio: $\ln(FVA^{i}_{xt}/IM^{i}_{xjt})$	-0.98***		-1.60***	
	(0.23)		(0.43)	
IP ratio: $\ln(FG^{i}_{xt}/IM^{i}_{xjt})$	2.16***		4.56***	
	(0.49)		(0.91)	
IP ratio + FVA ratio ($\gamma^{IP} + \gamma^{FVA}$)		1.27***		3.14***
		(0.32)		(0.59)
Observations	11,385	11,385	11,385	11,385
R-Squared	0.364	0.387		

Panel B: Controlling for RTAs				
	OLS		Tobit	
	(1)	(2)	(3)	(4)
DVA ratio: $\ln(DVA^{j}_{xit}/IM^{i}_{xjt})$	-0.43**	-0.47**	-1.03***	-1.09***
	(0.17)	(0.20)	(0.37)	(0.40)
FVA ratio: $\ln(FVA^{i}_{xt}/IM^{i}_{xjt})$	-0.71***		-1.16***	
	(0.19)		(0.34)	
IP ratio: $\ln(FG^{i}_{xt}/IM^{i}_{xjt})$	1.23***		2.44***	
	(0.34)		(0.66)	
IP ratio + FVA ratio ($\gamma^{IP} + \gamma^{FVA}$)		0.57***		1.36***
		(0.21)		(0.44)
Reciprocal Trade Agreement: RTA_{ijt}	-4.35***	-4.30***	-7.72***	-7.63***
	(0.60)	(0.61)	(1.06)	(1.05)
Observations	11,385	11,385	11,385	11,385
R-Squared	0.499	0.517		

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: * $p < .1$, ** $p < .05$, *** $p < .01$.

penetration ratio (γ^{IP}) are primarily identified by multilateral variation in average tariff preferences and foreign value added by importer and industry over time. In columns (2) and (4), we include importer-industry-year fixed effects, which remove multilateral variation in tariff preferences and regressors.[30] In this specification, we are able to estimate the composite coefficient $\gamma^{FG} + \gamma^{FVA}$, using variation in bilateral imports across partners within a given importer-industry-year cell.[31] Further, the DVA coefficient is now identified only by bilateral variation across partners within importer-industry-year cells. Lastly, exporter-industry-year fixed effects are included in all specifications.

In Panel A, column (1), we see that the OLS coefficient on the DVA ratio is negative: tariff preferences are larger (applied bilateral tariffs are lower) 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, 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.

In column (1), tariff preferences are also larger (applied bilateral tariffs are 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 (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 the empirical importance of domestic political economy considerations is consistent with findings in Goldberg and Maggi (1999) and Gawande and Bandyopadhyay (2000).

[30] Because the importer-industry-year fixed effect absorbs all variation in MFN tariffs, it is immaterial whether the dependent variable is the applied tariff rate, or the tariff preference in this specification.

[31] 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. 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.

Turning to Tobit estimates of the same two specifications in columns (3) and (4), 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 about twice as sensitive to value-added content as actual applied tariffs.

In Panel B, we repeat the baseline estimation including an additional indicator variable RTA_{hjt} that takes the value one when countries h and j have a regional trade agreement (under WTO Article XXIV) 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. Though adding this control absorbs variation in bilateral tariffs, 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).[32]

Upstream and Downstream Differentiation We now explore heterogeneity in the role of DVA across partners, where we can use bilateral variation for identification. Referring back to Equation (2.4), the response of the optimal tariff to DVA depends on the elasticity of pass-through from downstream price changes to the price of upstream GVC inputs (ε_{xh}^{rj}). 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. Further, the extent of product differentiation in upstream GVC inputs may be a proxy for input specificity, and thus the strength of pass-through from downstream output prices to upstream input prices.

To construct an empirical measure of upstream differentiation, we decompose domestic value-added in foreign production (DVA_{xh}^{j}) based on whether it originates in upstream industries that are differentiated or non-differentiated.[33] We do this two ways (see Appendix B.4 for details). First, we simply treat value added originating in the manufactur-

[32] Reflecting the fact that there is diminished residual variation after controlling for RTAs, the estimated coefficients are smaller (in absolute value) in Panel B than in Panel A. The RTA indicator substantially negates any role for DVA in predicting which bilateral pairs form RTAs, and it also removes the average reduction in applied tariffs due to increasing RTA prevalence over time. Thus, by including the RTA indicator we discard important variation for pinning down both DVA and FVA effects.

[33] Pass-through elasticities may differ across country pairs due compositional effects. For example, suppose that country h supplies a commodity (e.g., oil) and a differentiated manufactured input (e.g., electronics) to downstream industry x in countries j and k. Further, assume that returns to the commodity input are insensitive to the price of downstream output, while returns to specialized inputs are more sensitive to downstream output prices. Then, if country h supplies mostly commodity inputs to industry x in country j, then the pass-through from p_x^j to h's GVC income would be relatively low. In contrast, if country h supplies mostly differentiated inputs to industry x in country k, the pass-through from p_x^k to h's GVC income would be high. That is, we expect $\varepsilon_{xh}^{rj} < \varepsilon_{xh}^{rk}$ in the aggregate, due to these compositional effects.

ing sector as differentiated and value added originating in the non-manufacturing 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 non-differentiated. In both cases, adding up over upstream industries yields bilateral measures for DVA originating in differentiated ($DVA_{xh}^{j,Diff}$) versus non-differentiated upstream sectors ($DVA_{xh}^{j,NonDiff}$). 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 2, 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.

Turning our attention to downstream industries, note that the export supply elasticity dampens the impact of DVA on the optimal tariff in Equation (2.4). Since export supply elasticities (ϵ_{xh}^{j}) also tend to be correlated with measures of product differentiation [Broda, Limão and Weinstein (2008)], we then expect that tariffs in differentiated downstream sectors should be more responsive to DVA. We again consider two alternative classifications. We first allow for heterogeneous coefficients on the DVA ratio depending on whether the downstream industry is classfied as manufacturing versus non-manufacturing. With the prior that manufacturing is differentiated while non-manufacturing is not, we expect tariffs to respond more strongly to DVA in manufacturing. We then also classify downstream 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 2, we re-estimate the baseline model with importer-industry-year fixed effects, splitting coefficients across sectors based on whether they are differentiated or non-differentiated. 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.

2.4 Evidence for Temporary Trade Barriers

In addition to bilateral applied tariffs, governments use non-tariff barriers to restrict imports. In this section we examine whether GVC linkages influence a specific class of non-

Table 2: Heterogeneity by Upstream and Downstream Differentiation

Panel A: Upstream Differentiation				
	Manuf. vs. Non-Manuf.		Rauch Classification	
	OLS (1)	Tobit (2)	OLS (3)	Tobit (4)
DVA ratio (differentiated)	-1.20**	-2.34**	-2.40*	-4.78**
	(0.57)	(0.97)	(1.33)	(2.31)
DVA ratio (non-differentiated)	0.11	-0.19	1.38	2.45
	(0.43)	(0.92)	(1.20)	(2.28)
IP ratio + FVA ratio ($\gamma^{IP} + \gamma^{FVA}$)	1.26***	3.06***	1.20***	2.88***
	(0.31)	(0.57)	(0.28)	(0.52)
Observations	11,385	11,385	11,385	11,385
R-Squared	0.395		0.398	

Panel B: Downstream Differentiation				
	Manuf. vs. Non-Manuf.		Rauch Classification	
	OLS (5)	Tobit (6)	OLS (7)	Tobit (8)
DVA ratio (differentiated)	-1.09***	-2.64***	-1.27***	-1.27***
	(0.29)	(0.54)	(0.32)	(0.29)
DVA ratio (non-differentiated)	-1.02***	-2.06***	-0.74**	-0.74***
	(0.38)	(0.58)	(0.29)	(0.26)
IP ratio + FVA ratio (differentiated)	1.28***	3.22***	1.50***	1.50***
	(0.31)	(0.59)	(0.34)	(0.31)
IP ratio + FVA ratio (non-differentiated)	1.25***	2.77***	0.90***	0.90***
	(0.42)	(0.64)	(0.31)	(0.28)
Observations	11,385	11,385	11,385	11,385
R-Squared	0.387		0.392	

Note: See Section 2.3.2 for definitions of differentiated and non-differentiated 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: * $p < .1$, ** $p < .05$, *** $p < .01$.

tariff barrier: temporary trade barriers (TTBs), which include antidumping, safeguard, and countervailing duties. In addition to being directly observable and politically salient trade policy instruments, temporary trade barriers are a natural testing ground for the theory. Countries have wide latitude under WTO rules to use TTBs, and they can be targeted at particular trading partners and products.[34] 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.[35]

2.4.1 Data and Empirical Strategy

We obtain data 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 TTBs. See Appendix B.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 that 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.

[34] 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)].

[35] 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)].

2.4.2 Results

Table 3 presents ordinary least squares estimates for TTB coverage ratios.[36] 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.[37] 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.

In our data, China is the exporter in approximately 30 percent of the importer-exporter-industry-year cells in which TTBs have been applied, roughly three times as many as the next highest exporter. Further, during our sample period, countries rarely impose TTBs in a given sector without also including China among the set of exporters on which barriers are imposed [Bown (2010), Prusa (2010)]. At face value, these observations suggest that most of the TTB use during this period is aimed at China. Recognizing this, we separately examine how bilateral value-added content influences TTB use depending on whether China is the exporting country, by interacting the DVA measure with an indicator for whether China is the exporter.[38] In Panel B of Table 3, we find 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.

3 Quantitative Exploration of Tariff Preferences

The empirical investigation above points to an important role for GVC linkages in shaping tariff preferences. In this section, we elaborate on the model in Section 2.1 to make it amenable to quantitative analysis. Our goal is to evaluate the quantitative impact of changes

[36] 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 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.

[37] 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.

[38] Since both FVA and FG are multilateral (not bilateral), we have no expectation that they should impact TTB use against China differently from TTB use writ large.

Table 3: Temporary Trade Barriers and Value-Added Content

	(1)	(2)	(3)	(4)
DVA ratio	-0.22***	-0.19***		
	(0.061)	(0.066)		
DVA ratio (exporter = China)			-0.72***	-0.65***
			(0.25)	(0.24)
DVA ratio (exporter ≠ China)			-0.16***	-0.14**
			(0.054)	(0.061)
FVA ratio	-1.28***		-1.28***	
	(0.39)		(0.39)	
IP ratio	1.46***		1.43***	
	(0.40)		(0.40)	
IP ratio + FVA ratio		0.18***		0.14***
		(0.057)		(0.052)
Observations	10,098	10,098	10,098	10,098
R-Squared	0.235	0.477	0.239	0.480
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: 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 by 5 years 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. Standard errors (in parentheses) are clustered by importer-exporter-industry. Significance levels: * $p < .1$, ** $p < .05$, *** $p < .01$.

in GVC linkages on tariff setting in salient counterfactual scenarios.

3.1 Model Framework

We adopt standard assumptions as necessary to provide the necessary structure for quantitative analysis. On the consumer side, we assume there is a unit continuum of agents in each country; each agent has identical Gorman polar form preferences, so we describe preferences for the representative consumer. The consumer in country h has quasi-linear preferences over consumption of a homogeneous good and Armington-differentiated goods, which take the form:

$$U(d_0^h, \vec{d}^h) = d_0^h + \delta^h \left(d^h\right)^{\psi} \quad \text{with} \quad d^h = \left(\sum_{c=1}^{C} \left(d_c^h\right)^{(\sigma-1)/\sigma}\right)^{\sigma/(\sigma-1)}, \tag{3.1}$$

where d_0^h is country h's consumption of the homogeneous good and d_c^h is the quantity of the differentiated good sourced by h from country c.[39] The parameter $\psi < 1$ governs the elasticity of demand for the composite d^h, $\delta_s^h > 0$ is a demand shifter, and $\sigma > 0$ is the elasticity of demand across sources for the differentiated good. The consumer's budget constraint is: $I^h = d_0^h + \sum_c p_c^h d_c^h$, where I^h is income (defined below), p_c^h is the price of the good from country c for consumers in country h inclusive of tariff and non-tariff trade costs, and the price of the numeraire good is normalized to one.

Each agent $i \in (0, 1)$ is endowed with $l^h(i)$ units of homogeneous labor and $N^h(i)$ units of factor inputs that are used to produce differentiated goods, at home or abroad, which correspond to the GVC inputs discussed above. Aggregate factor endowments are then $L^h = \int_0^1 l^h(i)di$ and $N^h = \int_0^1 N^h(i)di$.

The productivity with which the GVC input supplied by agent i from country h may be used by producers in country c is $z_h^c(i)$. We assume this productivity is stochastic, as in the Roy-type models. Further, efficiency draws are independent across destinations and agents, taken from Fréchet probability distributions: $F_h^c(z) = \exp\left(-A_h^c z^{-\theta}\right)$, where $\theta > 1$ and $A_h^c \geq 0$. This Roy-Fréchet setup is an extension of Lagakos and Waugh (2013) and Galle, Rodríguez-Clare and Yi (2023); whereas they analyze the allocation of factors across sectors, we study factor allocation within global value chains.

Optimizing agents supply their GVC input to the country in which it yields the highest income. We assume that efficiency units supplied by a given country are perfectly substitutable in a given destination, so all agents from h earn the same return per effective unit supplied to c, which we denote $\bar{r}_h^c$. The probability that the agent has the highest payoff in destination c is:

$$\pi_h^c = \Pr\left(\bar{r}_h^c z_h^c \geq \max_{d \neq c}\left\{\bar{r}_h^d z_h^d\right\}\right). \tag{3.2}$$

The effective units of the input supplied by all agents to destination c is then:

$$\bar{\nu}_h^c \equiv N^h \pi_h^c \mathbf{E}\left[z_h^c | \bar{r}_h^c z_h^c \geq \max_{d \neq h}\left\{\bar{r}_h^d z_h^d\right\}\right]. \tag{3.3}$$

Total income accruing to each agent is the sum of labor income $(w^h l^h(i))$, GVC income given by $\frac{1}{N^h}\sum_c \bar{r}_h^c \bar{\nu}_h^c$, a lump sum rebate of tariff revenue $(R^h(i))$, and a per capita transfer

[39] In the numerical analysis, we consider tariffs in a single sector, so we drop the sector notation here.

from abroad ($B^h(i)$), which allows for trade imbalances in the data. Adding up across agents, income accruing to the representative consumer is: $I^h = w^h L^h + \sum_c \bar{r}_h^c \bar{\nu}_h^c + R^h + B^h$ where $R^h = \int_0^1 R^h(i)di = \sum_{c \neq h} \left(\frac{t_c^h}{1+t_c^h} \right) p_c^h d_c^h$ is tariff revenue, $B^h \equiv \int_0^1 B^h(i)di$, and transfers sum to zero across countries $\sum_c B^c = 0$.

Competitive producers in country h combine GVC inputs sourced from different countries with (local) homogenous labor to produce output, via the production function:

$$q^h = z^h \left(\sum_{c=1}^{C} \left(\nu_c^h \right)^{(\varrho-1)/\varrho} \right)^{\alpha\varrho/(\varrho-1)} \left(l^h \right)^{1-\alpha}, \tag{3.4}$$

where l^h is use of the homogeneous input, $\alpha \in (0,1)$ is the Cobb-Douglas share of the composite GVC input in production, and $\varrho \geq 0$ is the elasticity of substitution between the effective quantity of GVC inputs sourced from different countries (ν_c^h). Further, we assume there are iceberg frictions ($\kappa_c^h \geq 1$) that drive a wedge between buyer and seller prices, such that $r_c^h = \kappa_c^h \bar{r}_c^h$, where r_c^h is the buyer's price and $\bar{r}_c^h$ is the price received by the supplier. Market clearing for GVC inputs is given by: $\bar{\nu}_c^h = \kappa_c^h \nu_c^h$.

Turing to policy, the government's problem is the same as articulated in Section 2.1. Country h's government government chooses unilaterally optimal tariffs $\left\{ t_c^h \right\}_{c \neq h}$ to maximize objective function $G^h = V^h + \delta^{DPE}\pi^h + \delta^{DVA} DVA^h + \delta^{FVA} FVA^h$, given tariffs set by other countries, the MFN constraint, and model equilibrium conditions. Because definitions of the elements in the objective function follow the prior model, we relegate them to the appendix.

3.1.1 Discussion

This setup has a number of desirable features for our analysis. First, though it is a rich quantitative model, it preserves the standard partial equilibrium structure of models used above, and the trade policy literature more generally. As a result, one can re-derive prior results using this model. Second, due to the parametric assumptions we have made, the model is amenable to calibration and simulation. For example, the model features standard gravity-type relationships for flows of consumer goods and value-added inputs.

In contrast to standard gravity models, however, the model features upward sloping supply curves for bilateral GVC inputs. This is a third desirable feature, which nests the specific factors models we considered previously. To explain, we show in the appendix that the supply of effective units of the GVC input by h to c can be written as:

$$\bar{\nu}_h^c = \Gamma \left(1 - \frac{1}{\theta} \right) A_h^c \left(\frac{\bar{r}_h^c}{\Phi^h} \right)^{\theta-1} N^h, \tag{3.5}$$

where $\Phi^h = \left(\sum_d A_h^d \left(\bar{r}_c^d\right)^\theta\right)^{1/\theta}$ is a CES-type supply price index and $\Gamma(\cdot)$ denotes the gamma function. Then, the partial elasticity of bilateral factor supply is $\frac{\partial \ln \bar{\nu}_h^c}{\partial \ln \bar{r}_h^c} = \theta - 1$. As θ rises, bilateral factor supply becomes more elastic, and vice versa. The case $\theta \to \infty$ corresponds to the case where GVC inputs are completely fungible across destinations, while $\theta \to 1$ corresponds to a model with specific GVC inputs at the bilateral level, as in Section 2.1.[40]

Lastly, note that equilibrium prices for GVC inputs are determined by equating supply and demand for them in the model.[41] As such, a host of parameters matter for pass-through of downstream output prices to GVC input prices. Both supply-side (θ) and demand-side (ϱ) substitution parameters matter, as well as auxiliary parameters (α) that govern the overall supply elasticity of downstream output. Further, the structure of trade linkages across countries also plays a role by mediating how demand-side (r^h) and supply-side (Φ^c) price indexes depend on input prices. Given this complexity, we turn to quantitative evaluation of model mechanisms.

3.1.2 Solution and Calibration

Following Ossa (2014, 2016), we solve for optimal tariffs using a mathematical programming subject to equilibrium constraints (MPEC) routine, after rewriting the model to express the equilibrium and objective using exact hat algebra techniques. Details regarding the equilibrium conditions, solution procedure, and calibration are included in Appendix C.

We use data on applied bilateral and MFN tariffs, trade flows for final goods and GVC inputs, aggregate GDP, and aggregate expenditure to set parameters needed to solve for optimal tariffs and simulate counterfactuals in the model. We aggregate data for a selected benchmark year (2005) to form a composite goods sector, for which measured tariffs are simple averages of applied bilateral and MFN tariffs across underlying sectors. We then externally calibrate several structural parameters. We set $\sigma = \varrho = 4$, based on standard values for trade elasticities from the literature. We assume $\alpha = 0.9$, so GVC inputs account for most of the value of output of the differentiated good. And we set $\psi = 0.5$, so the elasticity of demand for composite differentiated good is 2.

Parameters in the government's objective function are more difficult to calibrate a priori,

[40] In taking the limit $\theta \to 1$, one needs to normalize productivity so that $\Gamma\left(1 - \frac{1}{\theta}\right) A_h^c$ remains constant.

[41] Equating supply and demand for GVC inputs, and holding parameters fixed ($\hat{\kappa}_c^h = \hat{A}_c^h = \hat{N}^c = 1$), one can show that: $\ln \hat{\bar{r}}_c^h = \left(\frac{\varrho-1}{(\theta-1)+\varrho}\right) \ln \hat{r}^h + \left(\frac{\theta-1}{(\theta-1)+\varrho}\right) \ln \hat{\Phi}^c + \frac{1}{(\theta-1)+\varrho} \ln\left(\hat{\bar{p}}^h \hat{q}^h\right)$, where r^h is the price index for the CES composite GVC input and $\bar{p}^h$ is the price the producer receives for its output. For a given value of ϱ, suppose that we take $\theta \to 1$. Then, this expression collapses to collapses to: $\ln \hat{\bar{r}}_c^h = \left(\frac{\varrho-1}{\varrho}\right) \ln \hat{r}^h + \frac{1}{\varrho} \ln\left(\hat{\bar{p}}^h \hat{q}^h\right)$, which corresponds to a specific factors model, in which specific factors are paid their marginal product in production. As $\theta \to \infty$, then input supply becomes more elastic, and the prices for GVC inputs supplied to different destinations move in lock-step across destinations.

so we proceed as follows. We set $\delta^{FVA} = 0$ based on introspection; recall that this is the weight the domestic government places on foreigners in its objective, which we think is plausibly small (consistent with the negative correlation between observed tariffs and FVA documented above). We then choose δ^{DPE} and δ^{DVA} by matching moments. The first two moments are regression coefficients, like those presented in Table 1; we regress applied tariffs for the composite goods sector on the log DVA ratio and log imports, with importer and exporter fixed effects. The third moment is the correlation between model-simulated tariff preferences and observed tariff preferences, conditional on observed preferences being non-zero, where the objective is to maximize this correlation. This procedure yields values $\delta^{DPE} = 1$ and $\delta^{DVA} = 9$. Thus, the political weight needed to match observed tariff preferences (given other parameters) is substantial.

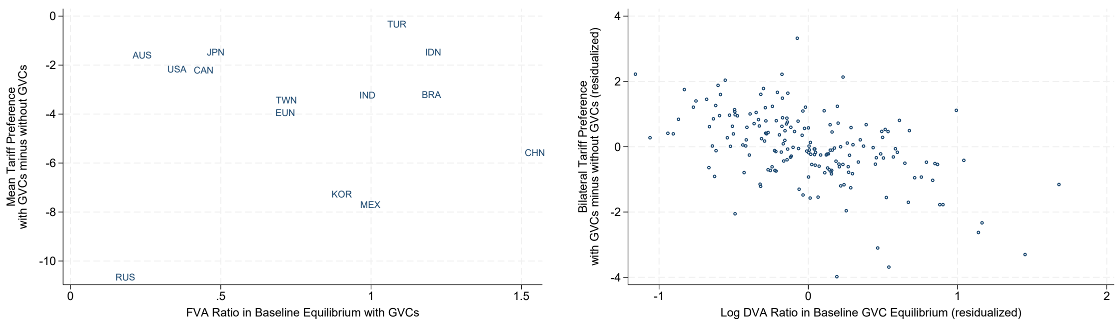
3.2 Results

Applying the calibrated model, we now examine counterfactual experiments to gauge the responsiveness of tariffs to GVC linkages. The first experiment examines how constrained optimal tariffs (i.e., applied tariffs) change as we raise the costs of trading GVC inputs. For illustration, we examine a scenario in which GVC input trade is completely eliminated, by taking $\hat{\kappa}_c^d \to \infty$, which we refer to as "GVC autarky." Naturally, GVC autarky raises tariffs on average: the global mean applied tariff is 5 percent in the baseline equilibrium, and it rises to 9.25 percent when GVC autarky is imposed. Correspondingly, the mean optimal tariff preference is 4.9 percentage points in the baseline equilibrium, and it falls to 0.7 percentage points under GVC autarky. Thus, eliminating GVC linkages wipes out countries' desire to offer tariff preferences.

Under the surface, the effects of reduced GVC linkages are naturally heterogeneous across countries. We illustrate this in Figures 3a and 3b by plotting the difference between optimal tariff preferences with GVCs versus without them. In Figure 3a, we plot the difference in the mean tariff preference by importer versus the level of the FVA ratio for that country with GVCs.[42] Overall, there is a negative correlation, consistent with the theory. Further, the responsiveness of applied tariffs to GVC linkages is broadly consistent with those we recovered from the regression estimates in Section 2.3.2. At the same time, there is considerable heterogeneity, as endogenous responses of trade patterns, export supply elasticities, and pass-through elasticities to the GVC autarky experiment cut in different directions depending on the country.

[42] In GVC autarky, the FVA ratio is zero, so the x-axis can be thought of as representing the difference in the FVA ratio between the equilibrium with GVCs and the equilibrium without GVCs.

Figure 3: Increasing GVC Input Trade Costs to Impose GVC Autarky



(a) Changes in Mean Tariff Preferences (b) Changes in Bilateral Tariff Preferences

Note: In each figure, we examine the difference between optimal tariff preference (at the baseline equilibrium with GVC linkages) and the counterfactual optimal tariff preference with GVC autarky. Because the MFN tariff constraint is held constant, values on the y-axis can be interpreted as changes in applied tariffs. On the x-axis, we plot measures of GVC linkages in the optimal tariff equilibrium with GVCs. In Sub-figure (b), we residualize the bilateral data by regressing it on importer and exporter fixed effects and log bilateral imports, using values from the optimal tariff equilibrium with GVCs.

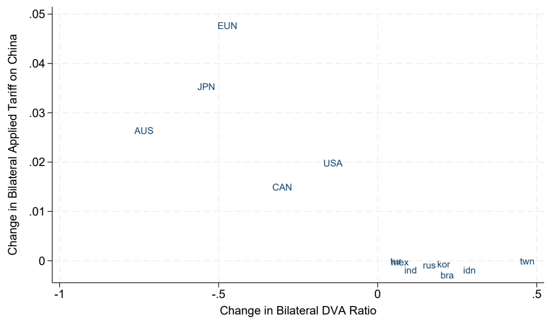
In Figure 3b, we present a related figure for bilateral tariffs and DVA. For visual presentation, we partial out the influence of multilateral determinants on optimal tariffs, as well as non-DVA political economy forces, by regressing simulated data on importer fixed effects, exporter fixed effects, and log imports as right-hand side variables (mimicking our prior empirical work). On the y-axis, we plot the residualized gap between bilateral tariffs in the equilibrium with GVCs and the equilibrium without them. We then plot the residualized log DVA ratio in the equilibrium with GVCs on the x-axis. As is evident, applied tariffs with GVCs are lower relative to tariffs under GVC autarky for pairs that have high bilateral ratios of DVA to imports in the GVC trade equilibrium.

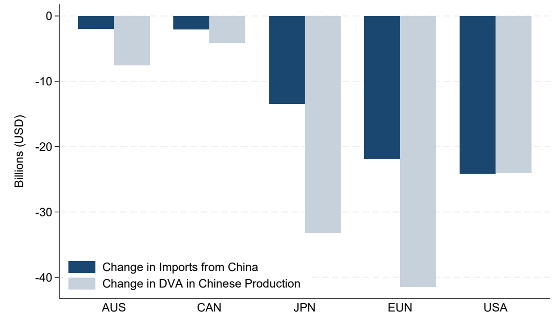
In a second experiment, we simulate a more targeted change in GVC links. Motivated by pervasive policy discussion about decoupling GVCs from China, for both national and economic security reasons, we examine the impact of removing China as a downstream partner in G7 value chains.[43] That is, for the G7 countries in our data, we restrict the supply of inputs to China, by taking A_c^{China} to zero for $c \in$ {Australia, Canada, EU, Japan,US}.

The effects of this change on applied tariffs are illustrated in Figure 4a. On the y-axis, we plot the change in each country's final goods tariff applied to China. The x-axis records the change in the bilateral DVA ratio for that country vis-á-vis China. The G7 countries

[43]Recall that the model is parameterized using data for 2005, so the tariff change here is the constrained optimal tariff after decoupling from China less the constrained optimal tariff in 2005, given the structure of trade and MFN constraints in 2005. We maintain this baseline for consistency across counterfactuals.

Figure 4: Decoupling China from G7 Supply Chains





(a) Change in Bilateral Applied Tariffs on China versus Change in Bilateral DVA Ratio

(b) Changes in Imports from China and Domestic Value Added in Chinese Production

Note: This counterfactual restricts the supply of GVC inputs from G7 countries (Australia, Canada, the EU, Japan, and the US) to China. In Sub-figure (a), the y-axis is the change in the applied tariff, which is the constrained optimal tariff given MFN tariffs in the baseline equilibrium (2005). In Figure 4a, G7 countries are indicated by capital letters.

have large declines in their DVA ratios, so they raise their tariffs. Put differently, there is a degree of policy complementarity between measures to cut China off from G7 GVC inputs and tariffs on downstream imports from China.

Turning to Figure 4b, changes in DVA ratios for the G7 countries are a mixture of changes in DVA in Chinese goods (due to the policy itself) and the endogenous response of imports from China to those upstream policies. In particular, imports from China fall for all the G7 countries, because cutting off China's access to inputs raises China's production costs. This has heterogeneous effects among the G7 countries, depending on their initial trade exposure to China. For example, the US sees roughly equal decreases in its DVA in Chinese goods and imports from China. In contrast, the decline in DVA exceeds the decline in imports for China and Japan, which implies that they have larger declines in the DVA ratios and thus larger increases in their optimal tariffs.

As a final point, we note that tariffs are little changed by non-G7 countries, despite changes in their own DVA ratios against China. This lack of tariff response for the non-G7 countries speaks to non-linearities in the model, where these small countries have either lower pass-through elasticities and/or less market power against China than does the G7 block, leaving them with little incentive to use policy to manipulate their bilateral terms of trade.

In both counterfactual scenarios so far, we have entirely severed multilateral or bilateral GVC links. As such, these counterfactuals shed light on the total impact of GVCs on constrained optimal tariffs. As an intermediate case, recall that GVC integration has risen over time, from a lower level (though not autarky) at the beginning of our sample period (1995) to the end (2015). To assess this historical change in GVC linkages, we consider a third set of counterfactuals.

Using data on changes in final goods and GVC input trade, together with observed tariffs, we invert the model to recover changes in iceberg trade costs ($\{\hat{\kappa}_c^d, \hat{\tau}_c^d\}$ for $c \neq d$), GVC input supply ($\hat{N}^c$) and demand for differentiated goods $\hat{\delta}^c$ over time. With these inputs, we simulate the effects of changing GVC frictions ($\hat{\kappa}_c^d$) and input supply ($\hat{N}^c$) over time. To isolate these supply-side forces, we hold all other parameters fixed across years, including the MFN tariff bounds, which we set to their 1995 values. See Appendix C for further details on model inversion and simulation.

Focusing on first on aggregate tariffs, reductions in GVC frictions alone reduce the global mean applied tariff by about 2 percentage points between 1995 and 2015. Adding changes in GVC input supply in addition to GVC frictions actually shrinks the global decline slightly, because the smaller supply of GVC inputs in 1995 lowers applied tariffs relative to what they would have been if the supply of GVC inputs is held at its 2005 level. The decline in tariffs due to changing GVC frictions is equal to just under half of the change implied by moving to GVC autarky, reported above. It is also equal to just under half of the observed decline in mean global tariffs over this period (about 4.5 percentage points). Again, these global results naturally obscure heterogeneity across trading partners, as the rise of GVC activity has been highly uneven. At the 25th percentile across countries pairs, tariffs fall by 11 percentage points, and these large declines are concentrated where increases in GVC activity are largest. Overall, we judge these results to be reasonable in magnitude relative to observed historical tariff changes.

4 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' mercantilist incentive to manipulate the (final goods) terms-of-trade is eroded, leading to lower import tariffs, all else equal. 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, which also argues for lower tariffs. We find evidence in support of both of these predictions in two distinct empirical settings: when countries discriminate across trading partners using bilateral tariff preferences, and when countries discriminate through the imposition of temporary trade barriers. These results indicate the empirical importance of specific channels through which global value chains shape governments' trade policy choices. Further, through the analysis of quantitative counterfactuals, we show that these channels help us understand the structure of trade protection and changes in it over time.

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 additional work on the determination of input tariffs themselves. As we discussed in Section 1.4, 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 recent work by Beshkar and Lashkaripour (2020), Caliendo et al. (2023), and Antràs et al. (2024) make early advances in this direction. The quantitative framework we have provided in this paper should prove useful in further applications in this vein.

Second, our analysis has focused on *bilateral* tariff preferences and TTB use. This setting distinguishes our work from the bulk of the 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.

Data Availability Statement The data and code underlying this article are available on Zenodo, at `https://doi.org/10.5281/zenodo.14171972`.

References

Adão, Rodrigo, Arnaud Costinot, and Dave Donaldson. 2017. "Nonparametric Counterfactual Predictions in Neoclassical Models of International Trade." *American Economic Review*, 107(3): 633–689.

Antràs, Pol, and Davin Chor. 2022. "Global Value Chains." In *Handbook of International Economics.* , ed. Gita Gopinath, Elhanan Helpman and Kenneth Rogoff, Chapter 5, 297–376. Elsevier.

Antràs, Pol, and Robert W. Staiger. 2012. "Offshoring and the Role of Trade Agreements." *American Economic Review*, 102(7): 3140–83.

Antràs, Pol, Teresa Fort, Agustín Gutiérrez, and Felix Tintelnot. 2024. "Trade Policy and Global Sourcing: A Rationale for Tariff Escalation." *Journal of Political Economy Macroeconomics*, 2(1): 1–44.

Bagwell, Kyle, and Robert W. Staiger. 1990. "A Theory of Managed Trade." *American Economic Review*, 80(4): 779–95.

Bagwell, Kyle, and Robert W. Staiger. 1999. "An Economic Theory of the GATT." *American Economic Review*, 89(1): 215–48.

Bagwell, Kyle, and Robert W. Staiger. 2011. "What Do Trade Negotiators Negotiate About? Empirical Evidence from the World Trade Organizaion." *American Economic Review*, 101(4): 1238–1273.

Baldwin, Richard. 2012. "WTO 2.0: Global Governance of Supply-Chain Trade." Centre for Economic Policy Research Policy Insight No. 64.

Beshkar, Mostafa, and Ahmad Lashkaripour. 2020. "The Cost of Disolving the WTO: The Role of Global Value Chains." Unpublished Manuscript, University of Indiana.

Blanchard, Emily J. 2007. "Foreign Direct Investment, Endogenous Tariffs, and Preferential Trade Agreements." *B.E. Journal of Economic Analysis and Policy - Advances*, 7(1): Article 54.

Blanchard, Emily J. 2010. "Reevaluating the Role of Trade Agreements: Does Investment Globalization Make the WTO Obsolete?" *Journal of International Economics*, 82(1): 63–72.

Blanchard, Emily J., and Shushanik Hakobyan. 2014. "The U.S. Generalized System of Preferences: In Principle and Practice." *World Economy*, 38(3): 399–424.

Blanchard, Emily J., and Xenia Matschke. 2015. "U.S. Multinationals and Preferential Market Access." *Review of Economics and Statistics*, 97(4): 839–854.

Bown, Chad, Aksel Erbahar, and Maurizio Zanardi. 2021. "Global Value Chains and the Removal of Trade Protection." *European Economic Review*, 140: 103937.

Bown, Chad P. 2010. "China's WTO Entry: Antidumping, Safeguards, and Dispute Settlement." In *China's Growing Role in World Trade.* , ed. R C Feenstra and S J Wei, 281–337. University of Chicago Press for the NBER.

Bown, Chad P. 2011. "Taking Stock of Antidumping, Safeguards and Countervailing Duties, 1990-2009." *The World Economy*, 34(12): 1955–1998.

Bown, Chad P. 2016. "Temporary Trade Barriers Database." The World Bank. Available at https://www.chadpbown.com/temporary-trade-barriers-database/.

Bown, Chad P., and Meredith A. Crowley. 2013. “Self-Enforcing Trade Agreements: Evidence from Time-Varying Trade Policy.” *American Economic Review*, 103(2): 1071–90.

Bown, Chad P., and Meredith A. Crowley. 2016. “The Empirical Landscape of Trade Policy.” In *Handbook of Commercial Policy*. Vol. 1A, , ed. Kyle Bagwell and Robert W. Staiger, Chapter 1, 3–108. Amsterdam:North-Holland.

Broda, Christian, Nuno Limão, and David E. Weinstein. 2008. “Optimal Tariffs and Market Power: The Evidence.” *American Economic Review*, 98(5): 2032–65.

Caliendo, Lorenzo, Robert Feenstra, John Romalis, and Alan Taylor. 2023. “A Second-best Argument for Low Optimal Tariffs.” *Journal of International Economics*, 145: 103824.

Dietzenbacher, Eric, Bart Los, Robert Stehrer, Marcel Timmer, and Gaaitzen de Vries. 2013. “The Construction of World Input-Output Tables in the WIOD Project.” *Economic Systems Research*, 25(1): 71–98.

Freund, Caroline, and Emanuel Ornelas. 2010. “Regional Trade Agreements.” *Annual Review of Economics*, 2: 139–166.

Galle, Simon, Andrés Rodríguez-Clare, and Moises Yi. 2023. “Slicing the Pie: Quantifying the Aggregate and Distributional Effects of Trade.” *The Review of Economic Studies*, 90(1): 311–375.

Gawande, Kishore, and Usree Bandyopadhyay. 2000. “Is Protection for Sale? Evidence on the Grossman-Helpman Theory of Endogenous Protection.” *Review of Economics and Statistics*, 82(1): 139–152.

Goldberg, Pinelopi K., and Giovanni Maggi. 1999. “Protection for Sale: An Empirical Investigation.” *American Economic Review*, 89(5): 1135–1155.

Grossman, Gene, and Esteban Rossi-Hansberg. 2008. “Trading Tasks: A Simple Theory of Offshoring.” *American Economic Review*, 98(5): 1978–1997.

Grossman, Gene M., and Elhanan Helpman. 1994. “Protection for Sale.” *American Economic Review*, 84(4): 833–850.

Grossman, Gene M., and Elhanan Helpman. 1995*a*. “The Politics of Free Trade Agreements.” *American Economic Review*, 85(4): 667–690.

Grossman, Gene M., and Elhanan Helpman. 1995*b*. “Trade Wars and Trade Talks.” *Journal of Political Economy*, 103(4): 675–708.

Helpman, Elhanan. 1997. “Politics and Trade Policy.” In *Advances in Economics and Econometrics: Theory and Applications*. Vol. 2, , ed. David M. Kreps and Kenneth F. Wallis, Chapter 2, 19–45. New York:Cambridge University Press.

Hoekman, Bernard. 2014. *Supply Chains, Mega-Regionals and Multilateralism A Road Map for the WTO.* London:CEPR Press.

Jensen, J. Bradford, Dennis P. Quinn, and Stephen Weymouth. 2015. "The Influence of Firm Global Supply Chains and Foreign Currency Undervaluations on US Trade Disputes." *International Organization*, 69(4): 913–947.

Johnson, Harry G. 1951-1952. "Optimum Welfare and Maximum Revenue Tariffs." *Review of Economic Studies*, 19(1): 28–35.

Johnson, Harry G. 1953-1954. "Optimum Tariffs and Retaliation." *Review of Economic Studies*, 21(2): 142–153.

King, Gary, and Langche Zeng. 2001. "Logistic Regression in Rare Events Data." *Political Analysis*, 9(2): 137–163.

Lagakos, David, and Michael E. Waugh. 2013. "Selection, Agriculture, and Cross-Country Productivity Differences." *American Economic Review*, 103(2): 948–980.

Los, Bart, Marcel P. Timmer, and Gaaitzen J. de Vries. 2015. "How Global are Global Value Chains? A New Approach to Measure International Fragmentation." *Journal of Regional Science*, 55(1): 66–92.

Ludema, Rodney, Anna Maria Mayda, Zhi Yu, and Miaojie Yu. 2021. "The Political Economy of Protection in GVCs: Evidence from Chinese Micro-data." *Journal of International Economics*, 131: 103479.

Ludema, Rodney D., and Anna Maria Mayda. 2013. "Do Terms-of-Trade Effects Matter for Trade Agreements? Theory and Evidence from WTO Countries." *Quarterly Journal of Economics*, 128(4): 1837–1893.

Nicita, Alessandro, Marcelo Olarreaga, and Peri Silva. 2018. "Cooperation in WTO's Tariff Waters?" *Journal of Political Economy*, 126: 1302–1338.

Ornelas, Emmanuel, and John L. Turner. 2008. "Trade Liberalization, Outsourcing, and the Hold-up Problem." *Journal of International Economics*, 74(1): 225–241.

Ornelas, Emmanuel, and John L. Turner. 2012. "Protection and International Sourcing." *The Economic Journal*, 122(559): 26–63.

Ossa, Ralph. 2014. "Trade Wars and Trade Talks with Data." *American Economic Review*, 104(12): 4104–4146.

Ossa, Ralph. 2016. "Quantitative Models of Commercial Policy." In *Handbook of Commercial Policy*. Vol. 1, , ed. Kyle Bagwell and Robert W. Staiger, Chapter 4, 207–259. North-Holland.

Prusa, Tomas. 2010. "Comment." In *China's Growing Role in World Trade*. , ed. R C Feenstra and S J Wei, 338–343. University of Chicago Press for the NBER.

Rauch, James E. 1999. "Networks Versus Markets in International Trade." *Journal of International Economics*, 48(1): 7–35.

Shapiro, Joseph S. 2021. "The Environmental Bias of Trade Policy." *The Quarterly Journal of Economics*, 136: 831–886.

Soderbery, Anson. 2018. "Trade Elasticities, Heterogeneity and Optimal Tariffs." *Journal of International Economics*, 114: 44–62.

Timmer, Marcel P., Eric Dietzenbacher, Bart Los, Robert Stehrer, and Gaaitzen de Vries. 2015. "An Illustrated User Guide to the World Input–Output Database: the Case of Global Automotive Production." *Review of International Economics*, 23: 575–605.

Trefler, Daniel. 1993. "Trade Liberalization and the Theory of Endogenous Protection: An Econometric Study of U.S. Import Policy." *Journal of Political Economy*, 101(1): 138–60.

WTO. 2014. *World Trade Report 2014: Trade and Development: Recent Trends and the Role of the WTO.* Geneva:World Trade Organization.