Intersectoral Distortions and the Welfare Gains from Trade*

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Abstract

How large are the welfare gains from trade when factors are misallocated due to domestic distortions? In this paper I provide a theoretical and a quantitative answer to this question by incorporating distortions to the allocation of labor across sectors into a Ricardian trade model. Applying the model to data for a diverse set of countries I find that (1) gains from trade for net exporters in sectors with low marginal product of labor are overstated in models that abstract from intersectoral distortions since in those countries trade tends to exacerbate the effect of domestic frictions; (2) the gains from implementing optimal tariffs are substantial in the presence of domestic frictions because trade policy can offset some of their negative effect; and (3), mitigating domestic frictions has a much larger potential payoff for countries when they are open to international trade.

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1 Introduction

How large are the welfare gains from international trade? This classic topic in the international trade literature has recently received renewed interest following the findings of Arkolakis et al. (2012). These authors show the similarity of gains from trade predicted by a range of workhorse international trade models. One feature that all those standard models have in common is that they abstract from distortions on domestic markets. Yet we have ample evidence that domestic distortions are prevalent. That domestic frictions affect the benefits of engaging in international trade has been long recognized. Using highly stylized models, theoretical literature some fifty years ago showed that a country might even lose from international trade if trade exacerbates the effects of domestic distortions.[1] The goal of this paper is to go beyond such qualitative predictions and quantify the effects of intersectoral distortions on the welfare gains from trade for a broad range of countries using a modern multi-country general equilibrium model of international trade.

My point of departure is a multisector version of a Ricardian model of Eaton and Kortum (2002). As in Caliendo and Parro (2015), my model uses homogeneous labor as the only primary factor of production, features input-output linkages across sectors, incorporates import tariffs and allows for aggregate trade to be unbalanced. This otherwise standard setup is modified by the presence of distortions to the allocation of labor across sectors. Their introduction is motivated by studies by Vollrath (2009) and Gollin et al. (2014) who document that the value marginal products of labor are not equalized across sectors, suggesting labor misallocation. I do not take a stand on what the underlying sources of intersectoral distortions are and simply model the distortions as wedges between the value marginal product of labor across sectors. In the model these wedges correspond to differences in labor costs faced by producers in different sectors.[2] I treat the labor wedges as fixed and not affected by the trade regime.

My theoretical contribution is to derive an intuitive relationship between the true size of the gains from trade and the gains from trade that would be calculated using a standard model that abstracts from intersectoral distortions. The standard measure of the gains from trade needs to be corrected by a distortions adjustment term that can be expressed in terms of wedges and easily observable trade and production data. The correction implies that the standard model overstates the gains for trade for countries that are net exporters in sectors in which the value marginal product of labor is low because of domestic distortions. The intuition for this result is simple. Opening to trade typically results in the reallocation of labor towards sectors in which a country becomes a net exporter. But if the value marginal product of workers in those sectors is low then such reallocation is inefficient. Consequently, the benefits of trade are not as large as would be predicted by a model abstracting from this allocative inefficiency.

To assess the quantitative importance of intersectoral distortions for the effects of trade I apply

[1] See, e.g., Hagen (1958).

[2] Hsieh and Klenow (2009) use a similar approach to model misallocation of factors across firms. In this paper misallocation happens across sectors.

the model to data on 61 countries and 16 sectors in 2006. Since the available evidence suggests that intersectoral labor distortions are especially large in poor countries I strive to include as many major developing countries as possible by combining sector-level data from a number of sources. I identify the intersectoral labor distortions from the differences in labor compensation per worker across sectors. Given the wedges, I need exactly the same data as a standard frictionless model in order to evaluate the gains from trade and conduct other counterfactual calculations.

The calculated intersectoral labor distortions imply substantial variation in the value marginal product of labor across sectors. Marginal products tend to be low in sectors such as textiles and, especially, agriculture, and high in sectors such as mining and chemicals. The largest distortions are often found in poor countries, with the magnitude of distortions generally decreasing with income. These patterns of intersectoral distortions are important for understanding the key quantitative results of this paper.

My main finding is that taking into account intersectoral labor distortions changes the magnitude of the gains from trade in an important way for a number of countries. For example, the true gains from trade for Ethiopia with its large trade surplus in low-productivity agriculture are 6.4 p.p. lower than 28.1% gains that a standard model would predict. To rephrase the intuition behind this result, since domestic distortions effectively depress labor costs in agriculture in Ethiopia they would result in production and employment in that sector above an efficient level in a closed economy. As trade further increases agricultural employment to generate the observed trade surplus, it tends to exacerbate the initial domestic distortions. Thus the benefits of trade for Ethiopia are not as large as the frictionless models would predict. More systematically, consider an ordering of countries by the ratio of the trade deficit in their low (below median) value marginal product sectors relative to GDP. Then for countries in the first quartile of this ratio (i.e. countries most specialized in exports in sectors with a low value marginal product of labor) the true gains from trade are 4.6 p.p. lower than in a standard calculation. On the other hand, for the highest quartile of countries the standard calculation would understate the true gains by 2.8 p.p. These adjustments are sizable relative to the absolute level of the gains from trade: the standard model overstates the gains by 28% for the first quartile and understates them by 21% for the fourth quartile, respectively.

Going beyond the issue of the gains from trade, I also study the implications of intersectoral distortions for trade policy. I find that unilaterally set optimal tariffs are quite dispersed across sectors, with high value marginal product of labor sectors protected by high tariffs. In a second-best world it might be optimal to introduce a distortion (tariff dispersion) to partially offset the effect of another distortion (labor wedges).[3] Because optimal tariffs bring the labor allocation closer to optimum, they have a first-order effect on welfare beyond the standard terms of trade improvement. Consequently, the welfare gains from unilaterally imposing optimal tariffs tend to be larger than in a frictionless model and can be substantial, especially for developing countries. For example, India

[3]However, the principle of targeting suggests that there are instruments more efficient than tariffs for correcting intersectoral labor distortions.

could gain as much as 9.9% from pursuing unilaterally optimal trade policy in my model whereas the gain predicted by the frictionless framework would be a modest 0.5%. However, my general equilibrium analysis shows that unilaterally optimal tariffs are a beggar-thy-neighbor policy, in that the large gains can come at the expense of hurting other (and often poor) countries.

I also look at the complementary issue of how trade openness affects the welfare cost of intersectoral distortions. Removing the calculated labor distortions would lead to an average welfare gain of 33.2% in the open economy, but the positive effect would be only about half as large in a hypothetical closed economy. The reason why distortions have a larger negative impact on welfare in an open economy is that there is a larger scope for misallocation in that case. When distortions depress labor costs in a sector, that sector expands beyond the efficient level. In autarky, the inefficient expansion is limited by the domestic demand for the sector's output. In contrast, when a country is open to trade the expansion can go further because distortions-driven low labor costs become a source of comparative advantage.

Related Literature

This paper is related to a few strands of the literature. It contributes to a voluminous body of research on the welfare gains from international trade by studying the impact of domestic distortions on those gains. Attempts to quantify the benefits of trade have for a long time been the domain of Computable General Equilibrium (CGE) models, in which trade arises due to the Armington assumption that goods are differentiated by country of origin.[4] Measuring the gains due to the classic Ricardian comparative advantage channel lacked a solid theoretical foundation until the seminal contribution of Eaton and Kortum (2002). In an influential theoretical article, Arkolakis et al. (2012) show that in the absence of domestic distortions the gains from trade in the Armington model are the same as in the Eaton and Kortum (2002) model and similar as in the most popular implementation of the Melitz (2003) model.[5] In this paper, I take one of those three workhorse quantitative trade models and demonstrate how the welfare gains from trade it predicts change, both analytically and quantitatively, when intersectoral allocation of labor is distorted due to domestic frictions.

The intersectoral labor distortions of this paper appear in the older theoretical trade literature as "wage differentials". Hagen (1958) demonstrates in a simple two-sector model that a country might even lose from trade if the wage paid by the import-competing sector is higher than the wage paid by the export sector. I show analytically how wage differentials shape the gains from trade in a multi-country multi-sector general equilibrium framework. Bhagwati and Ramaswami (1963) rank various policies intended to ameliorate the effects of distortionary wage differentials in terms of their efficiency. While trade policy is never the first-best instrument, it can nevertheless increase welfare.

[4] See Hertel (1999) for an overview of CGE trade modeling.

[5] See also Costinot and Rodríguez-Clare (2014) for an overview of results on the gains from trade in a world without domestic distortions.

Katz and Summers (1989a) discuss the empirical relevance of intersectoral wage differentials as a motive for strategic trade policy in the context of manufacturing trade in the United States. I calculate optimal tariffs for many countries and sectors and show that intersectoral labor distortions play a key role in their determination.[6] This result also contributes to the quantitative literature on optimal trade policy, which traditionally focuses on export supply elasticities as in Broda et al. (2008).[7]

Two papers closely related to my work are Xu (2012) and Tombe (2015). Both studies combine the Eaton and Kortum (2002) trade structure with some form of friction between agriculture and the rest of the economy. In the case of Xu (2012) the friction takes the form of home production in agriculture. My model is more similar to Tombe's, who uses a labor wedge between agriculture and nonagriculture that plays a role analogous to my intersectoral distortions. The substantial focus of the papers is different, however. Tombe and Xu show that their frictions, when combined with high trade costs in agriculture that they estimate, help to account for surprisingly low food imports by poor countries. Xu then emphasizes large potential gains for poor countries from increasing agricultural imports, while Tombe focuses on accounting for differences in agricultural and aggregate productivity across countries. In contrast, my main interest lies in measuring the welfare gains from observed volumes of trade and in understanding how they are affected by domestic intersectoral distortions.[8] I theoretically derive a sufficient statistic which shows that the impact of distortions on the gains from trade depends on the composition of trade (rather than the level of income directly). Moreover, unlike the other papers I quantitatively explore the implications of distortions for optimal trade policy. My framework also goes beyond "the food problem" by featuring distortions between many tradable and nontradable sectors.

The rest of this paper is structured as follows. In Section 2 I present the theoretical model. Section 3 describes how the model is mapped to the data. The key quantitative results of the paper are presented in Section 4. The final Section 5 offers closing remarks.

2 Theoretical Framework

In this section I present the model and derive analytical results that form the basis for my quantitative investigation of international trade in the presence of intersectoral distortions. The model features multiple sectors with input-output linkages, revenue-generating tariffs, and aggregate trade

[6] In Ossa (2014) tariff differences across sectors are driven by another mechanism - profit shifting occurring when markups charged by monopolistically competitive differ across sectors.

[7] To the best of my knowledge, this is the first paper to calculate optimal sectoral tariffs in a rich quantitative Ricardian model.

[8] There is a growing literature calculating the gains from trade reforms in the presence of frictional labor markets, e.g. Kambourov (2009), Artuc et al. (2010) and Dix-Carneiro (2014). These papers provide more detailed microfoundations for labor marker frictions at the expense of focusing on a single country treated as a small open economy. Frictions in this literature typically slow down the adjustment of labor markets to trade shocks and thus lower the gains from trade reform. In contrast, in my setting trade reform can mitigate the effect of intersectoral distortions so the gains from trade can be larger in a presence of distortions.

imbalances. Except for the presence of intersectoral distortions, the structure of the model is similar to Ricardian models in Costinot and Rodríguez-Clare (2014) and Caliendo and Parro (2015). Most of the exposition is therefore brief. Intersectoral distortions central to this paper are discussed in more detail in Section 2.2 and their implications for the welfare gains from trade are derived in Section 2.6.

2.1 Consumers and Production

There are N countries (indexed by i, j) and S sectors (indexed by s, k). Preferences of consumers are given by the Cobb-Douglas form

$$C_j = \prod_{s=1}^{S} C_{j,s}^{\beta_{j,s}},$$

where $\beta_{j,s} \geq 0$ are preference parameters satisfying $\sum_{s=1}^{S} \beta_{j,s} = 1$ and $C_{j,s}$ is consumption of the composite good s in country j.

Labor is the only primary factor of production. There are L_i identical workers in country i and each of them supplies one unit of labor inelastically.

In each sector there is a unit measure of intermediate goods indexed by $h \in [0, 1]$. Intermediates are produced using a Cobb-Douglas technology combining labor and the composite goods of each sector. Specifically, the cost of producing a unit of variety h in sector s and country i is $c_{i,s}/z_{i,s}(h)$, where $z_{i,s}(h)$ denotes the variety-sector-country-specific productivity and $c_{i,s}$ is the cost of an input bundle

$$c_{i,s} = w_{i,s}^{1-\alpha_{i,s}} \prod_{k=1}^{S} P_{i,k}^{\alpha_{i,ks}}, \tag{1}$$

where $\alpha_{i,ks} \geq 0$ are technology parameters such that $\alpha_{i,s} \equiv \sum_k \alpha_{i,ks} \in [0,\, 1]$, $P_{i,k}$ is the price of the composite good k in country i and $w_{i,s}$ is the wage in sector s in country i.

The nontraded composite good of industry s is costlessly assembled from all intermediates produced in that industry using the CES technology

$$Q_{i,s} = \left[\int_0^1 x_{i,s}(h)^{\frac{\sigma-1}{\sigma}} \, dh \right]^{\frac{\sigma}{\sigma-1}},$$

where σ is the elasticity of substitution across varieties and $x_{i,s}(h)$ is the quantity of variety h used in production in sector s in country i. The composite good of sector s is used both as an input for production of intermediates and to satisfy final demand.

The product market is perfectly competitive. Given prices of intermediates $p_{i,s}(h)$ prevailing in market i, the price index for the composite good is given by $P_{i,s} = \left[\int_0^1 p_{i,s}(h)^{1-\sigma} \, dh \right]^{\frac{1}{1-\sigma}}$.

2.2 Distortions

The fact that the wage $w_{i,s}$ appearing in (1) is sector-specific is a central feature of the model. Since labor is assumed to be homogeneous, differential wages in the model do not reflect heterogeneity in worker productivity.[9] Instead, wage differentials are meant to capture distortions to the intersectoral allocation of labor in a tractable way. Since $w_{i,s}$ is the wage faced by the firms, wage differentials represent the distortionary effect of any policies or institutions that have different impact on the labor costs faced by firms across sectors. Such policies can be interpreted as an implicit sector-specific labor tax $t^L_{i,s}$, so that $w_{i,s} = \left(1 + t^L_{i,s}\right) w_i$, where w_i is the take-home wage of workers. With labor mobile within countries, the take-home wage is equalized across sectors.[10]

What matters for the allocation of labor across sectors is the relative magnitude of distortions across sectors and not their absolute level.[11] Distortions will be therefore without loss of generality summarized by the wedge between the wage in sector s and the wage in sector 1, i.e. I will call the object

$$\xi_{i,s} \equiv \frac{w_{i,s}}{w_{i,1}} \tag{2}$$

the wedge in sector s. By construction the wedge in sector 1 is then equal to one, $\xi_{i,s} \equiv 1$.

The wage $w_{i,s}$ that is payed by firms in sector s equals the value marginal product of labor ($VMPL_{i,s}$) in that sector.[12] Thus intersectoral wage differentials in the model fundamentally capture differences in $VMPL$ across sectors. It is important to realize that the failure to equalize $VMPL$ implies the presence of distortion in the labor market rather than in some other markets (say, output markets). Moreover, $VMPL$ differences would imply the presence of labor distortions also in richer models. For example, in a model with capital and labor, $VMPL$ would be equalized across sectors in the absence of distortions affecting relative labor costs, regardless of whether capital allocation is itself distorted or not.[13] The flip side of this argument is that intersectoral differences in $VMPL$ do not capture distortions that might affect the economic efficiency through channels other than the labor market.

Theoretically, some such other distortions could even have the same general equilibrium implications as appropriately chosen labor wedges.[14] Thus in principle, labor wedges in the model could

[9] Empirical plausibility of this assumption is discussed in Section 3.2.

[10] It is also possible that wage differentials across sectors might reflect real mobility costs rather than distortions. While the model can in principle accommodate this possibility as well, welfare calculations in counterfactual exercises would require me to take a stand on the structure of such mobility costs. Modeling switching costs is beyond the scope of this paper so I attribute wage differentials to distortions only.

[11] This is because labor is supplied inealastically and the revenue from labor taxes is assumed to be redistributed lump-sum to workers.

[12] This follows from intermediate good producing firm's FOC with respect to labor input. Note that the $VMPL$ is equalized across all firms in a sector within a country.

[13] See Online Appendix B.

[14] For example, a mixture of sector-specific labor tax and output tax coupled with equivalent subsidy for intermediates would have the same macroeconomic implications as an appropriately chosen labor wedge. That labor wedge would not be equal to the relative labor costs actually faced by the firms, however.

be used to summarize a broader range of distortions in factor and output markets and not just differences in $VMPL$ across sectors. However, as discussed further in Section 3.2, my empirical measure of the labor wedge can identify only distortions that directly affect the relative labor costs across sectors. For this reason, I refer to labor wedges as labor distortions in this paper.

2.3 International Trade

Intermediate goods are tradable subject to two types of costs. First, there are standard iceberg transportation costs, i.e., delivering a unit of variety h in sector s from country i to country j requires shipping $d_{ij,s} \geq 1$ units of the good, with $d_{jj,s} = 1$. Second, there is an ad-valorem tariff $t_{ij,s}$ levied by country j on sector s goods imported from country i. With perfect competition, the price of variety h delivered to j from i is then

$$p_{ij,s}(h) = \frac{c_{i,s}\tau_{ij,s}}{z_{i,s}(h)},$$

where $\tau_{ij,s} = d_{ij,s}(1 + t_{ij,s})$ is the total bilateral trade cost. Every country will choose the cheapest source for each variety. The price actually paid in country j for a variety h in sector s is therefore

$$p_{j,s}(h) = \min_{i=1,..,N} \{p_{ij,s}(h)\}.$$

Country i draws productivity $z_{i,s}(h)$ in variety h from a distribution with cumulative distribution function $G_{i,s}$, with draws independent across countries, sectors, and varieties. Following Eaton and Kortum (2002)), the realizations are assumed to come from the Fréchet distribution with CDF $G_{i,s}(z) = e^{-T_{i,s}z^{-\theta_s}}$. The parameter $T_{i,s}$ is related to country i's average efficiency in sector s. The parameter θ_s is an inverse measure of the dispersion of productivity draws and is assumed to be constant across countries.

Let $E_{j,s}$ denote the total expenditure on varieties from sector s in country j and $X_{ij,s}$ the expenditure on a subset of varieties sourced from country i. Then the Eaton and Kortum (2002) structure delivers the following expressions for the share of expenditure in country j going to goods from country i:

$$\pi_{ij,s} = \frac{X_{ij,s}}{E_{j,s}} = \frac{T_{i,s}(c_{i,s}\tau_{ij,s})^{-\theta_s}}{\sum_m T_{m,s}(c_{m,s}\tau_{mj,s})^{-\theta_s}}. \tag{3}$$

The price index in the tradable sectors can be written as[15]

$$P_{j,s} = \Gamma_s \left[\sum_i T_{i,s}(c_{i,s}\tau_{ij,s})^{-\theta_s}\right]^{-\frac{1}{\theta_s}}. \tag{4}$$

[15] $\Gamma_s \equiv \Gamma\left(\frac{\theta_s+1-\sigma}{\theta_s}\right)$, where $\Gamma(\cdot)$ is a Gamma function.

2.4 Equilibrium

In this subsection I characterize the equilibrium of the world economy. Let $L_{i,s}$ denote employment in sector s in country i and let Y_i denote the income (GDP) of country i:

$$Y_i = w_{i,1} \sum_{s=1}^{S} \xi_{i,s} L_{i,s}. \tag{5}$$

In addition to the income from labor, the final demand (absorption) F_j also consists of exogenously fixed aggregate trade deficit D_j and net tariff revenue T_j , i.e. $F_j = Y_j + T_j + D_j$.

Total expenditure on sector s in country j comes from final demand and from intermediate consumption: $E_{j,s} = \beta_{j,s} F_j + \sum_{k=1}^{S} \alpha_{j,sk} R_{j,k}$, where $R_{j,k}$ denotes the gross output of sector k. Recognizing that gross output is equal to revenue from sales to all countries

$$R_{i,s} = \sum_{j=1}^{N} \frac{\pi_{ij,s}}{1 + t_{ij,s}} E_{j,s}, \tag{6}$$

and that tariff revenue is given by $T_j = \sum_s \sum_i \frac{t_{ij,s}}{1+t_{ij,s}} \pi_{ij,s} E_{j,s}$, the total expenditure on sector s can be expressed as

$$E_{j,s} = \beta_{j,s} \left(Y_j \left(1 + \delta_j\right) + \sum_k \sum_i \frac{t_{ij,k}}{1 + t_{ij,k}} \pi_{ij,k} E_{j,k} \right) + \sum_{k=1}^{S} \alpha_{j,sk} \sum_{i=1}^{N} \frac{\pi_{ji,k}}{1 + t_{ji,k}} E_{i,k}, \tag{7}$$

where $\delta_j \equiv D_j / Y_j$ denotes the ratio of aggregate trade deficit to income.

On the labor market side, since payments to labor are a fraction $(1 - \alpha_{i,s})$ of gross output of sector s, we can write the sectoral labor demand (using also (6)) as

$$L_{i,s} = \frac{(1 - \alpha_{i,s})}{w_{i,1} \xi_{i,s}} \sum_{j=1}^{N} \frac{\pi_{ij,s}}{1 + t_{ij,s}} E_{j,s}. \tag{8}$$

The labor market clearing condition requires that

$$\sum_s L_{i,s} = L_i. \tag{9}$$

Definition 1. Given technology and preference parameters, labor wedges $\{\xi_{i,s}\}$, labor endowments $\{L_i\}$, tariffs $\{t_{ij,s}\}$, and trade deficits $\{D_i\}$ satisfying $\sum_i D_i = 0$, the trade equilibrium can be summarized as a collection of sector 1 wages $\{w_{i,1}\}$, incomes $\{Y_i\}$, sector-level input bundle costs $\{c_{i,s}\}$, sector-level prices $\{P_{i,s}\}$, sector level expenditures $\{E_{i,s}\}$, sector-level labor allocations $\{L_{i,s}\}$, and sector-level bilateral trade shares $\{\pi_{ij,s}\}$ such that equations (1), (3), (4), (5), (7), (8), and (9) are satisfied. World GDP is chosen as the numeraire, so that $\sum_i Y_i = 1$.

2.5 Counterfactual Equilibrium

Evaluating the role of international trade and intersectoral distortions requires solving for counterfactual equilibria with varying magnitudes of trade and distortions. I adapt the methodology of Dekle et al. (2008), which relies on solving for an equilibrium in relative changes. The main advantage of this approach is that it avoids the need to specify hard-to-estimate parameters (such as technology levels $T_{i,s}$ and iceberg trade costs $d_{ij,s}$) that support the baseline equilibrium.

For any variable x in the original equilibrium let x' denote its counterfactual value and let $\hat{x} = x'/x$ denote the proportional change. In the counterfactual exercises I consider the impact on equilibrium outcomes of exogenous changes in wedges $\left\{\hat{\xi}_{i,s}\right\}$, trade deficits relative to GDP $\left\{\hat{\delta}_i\right\}$ and trade costs $\{\hat{\tau}_{ij,s}\}$. Changes in trade costs can in a general case come from changes in iceberg costs $\left\{\hat{d}_{ij,s}\right\}$ and changes in tariffs from $\{t_{ij,s}\}$ to $\left\{t'_{ij,s}\right\}$:

$$\hat{\tau}_{ij,s} = \hat{d}_{ij,s}\frac{\left(1+t'_{ij,s}\right)}{\left(1+t_{ij,s}\right)}.$$

Given these exogenous changes, an equilibrium in relative changes can be summarized by a system of equations analogous to the system in levels in the previous subsection. The relevant equations are listed in the Appendix.

A measure of country's welfare is real consumption $C_j = F_j/P_j$. Proportional change in welfare associated with moving to a counterfactual equilibrium is therefore[16]

$$\hat{C}_j = \frac{\hat{F}_j}{\hat{P}_j}.$$

The proportional change in final demand can be written more explicitly as

$$\hat{F}_j = \frac{Y'_j\left(1+\delta'_j\right) + \sum_k \sum_i \frac{t'_{ij,k}}{1+t'_{ij,k}}\pi'_{ij,k}E'_{j,k}}{Y_j\left(1+\delta_j+t_j\right)},$$

with $t_j \equiv T_j/Y_j$ measuring the tariff revenue to GDP ratio. The change in the price index can be written as

$$\hat{P}_j = \hat{w}_{j,1}\prod_s\prod_k\left[\hat{\xi}_{j,k}^{\left(1-\alpha_{j,k}\right)\tilde{\alpha}_{j,sk}}\hat{\pi}_{jj,k}^{\frac{\tilde{\alpha}_{j,sk}}{\theta_k}}\right]^{\beta_{j,s}},$$

where $\tilde{\alpha}_{j,sk}$ is the (s,k) entry of the matrix $\left(I - A'_j\right)^{-1}$, with $A_j \equiv \{\alpha_{j,ks}\}$ an $S \times S$ direct input requirement matrix.[17]

[16] Proportional change in real consumption in this case also corresponds to an equivalent variation measured as a fraction of initial expenditure.

[17] Except for the presence of wedges, formulas appearing in this subsection are standard and their derivation can be found in, e.g., Costinot and Rodríguez-Clare (2014).

2.6 Welfare Gains from Trade

The key question this paper aims to answer is how intersectoral distortions affect the welfare gains from trade. Below I illustrate this dependence through an intuitive closed-form relationship between the welfare gains calculated in a model with and without distortions. Furthermore, I show that even in the model with intersectoral distortions the gains from trade can be expressed entirely in terms of easily measured data.

Formally, I define the welfare gains from trade for county j as

$$GFT_j \equiv 1 - \hat{C_j^A},$$

where $\hat{C_j^A} = C_j^A / C_j^T$ measures the loss in real consumption (welfare) from moving from the trade equilibrium to autarky in country j. When the counterfactual scenario involves moving to autarky, expressions derived in the previous subsection take a more specific form

$$\hat{P_j^A} = \hat{w}_{j,1} \prod_s \prod_k \pi_{jj,k}^{\frac{\beta_{j,s}\tilde{\alpha}_{j,sk}}{\theta_k}},$$

$$\hat{F_j^A} = \frac{Y_j^A}{Y_j^T(1+t_j)} = \frac{\hat{w}_{j,1}}{1+t_j} \frac{\sum_s \xi_{j,s} L_{j,s}^A}{\sum_s \xi_{j,s} L_{j,s}^T},$$

where I use the fact that in autarky there is no tariff revenue ($t_j^A = 0$). Moreover, because interpretation of the gains from trade in a static model is problematic in the presence of transfers from the rest of the world, I follow the literature by assuming that trade is balanced ($\delta_j = \delta_j^A = 0$).
Noting that $\hat{C_j^A} = \hat{F_j^A} / \hat{P_j^A}$, the welfare gains from trade in the presence of intersectoral distortions can be expressed as

$$GFT_j = 1 - \Upsilon_j \frac{1}{1+t_j} \prod_s \prod_k \pi_{jj,k}^{\frac{\beta_{j,s}\tilde{\alpha}_{j,sk}}{\theta_k}}, \tag{10}$$

where

$$\Upsilon_j = \frac{\sum_s \xi_{j,s} L_{j,s}^A}{\sum_s \xi_{j,s} L_{j,s}^T}. \tag{11}$$

The term Υ_j is the key object of interest in this paper because it summarizes the effect of intersectoral distortions on the gains from trade. To see this, notice that the gains from trade in a standard model abstracting from intersectoral distortions would be given by expression (10) but without the Υ_j term.[18] This discussion can be formalized in the following proposition.

Proposition 1. *Suppose that trade is balanced in each country. Consider two models consistent with the same observed sectoral final demand shares* $\{\beta_{j,s}\}$*, trade intensities* $\{\pi_{jj,s}\}$*, and input-output coefficients* $\{\alpha_{j,sk}\}$*: one with intersectoral distortions summarized by wedges* $\{\xi_{j,s}\}$ *and one without*

[18] Stated differently, the standard model with no distortions assumes $\xi_{j,s}^{ND} = 1$ for all j and s so $\Upsilon_j^{ND} = 1$.

domestic frictions. Then the relationship between the welfare gains from trade GFT_j calculated in the model with intersectoral distortions, and gains from trade GFT_j^{ND} calculated in a model without distortions, is given by

$$GFT_j = 1 - \Upsilon_j \left(1 - GFT_j^{ND}\right). \tag{12}$$

Expression (12) has an intuitive interpretation. It implies that the standard model overstates the magnitude of the gains from trade ($GFT_j^{ND} > GFT$) when $\Upsilon_j > 1$. From (11), the distortions adjustment term Υ_j can be interpreted as a proportional change in an employment-weighted mean wedge. So we have $\Upsilon_j > 1$ when the mean wedge is larger in autarky than with trade, i.e. when opening to trade induces economic activity to shift to sectors with relatively low $VMPL$ (low $\xi_{i,s}$). Thus if trade causes labor to move to sectors where it is relatively unproductive then it is not as beneficial as would be predicted by a model abstracting from distortions. To state this observation differently, relatively low wages faced by producers in sector s would generally lead to an expansion of that sector beyond what would be socially optimal in autarky. $\Upsilon_j > 1$ means that opening to trade leads to even further expansion of employment in low wage sectors. Thus if trade tends to exacerbate the effect of domestic distortions then the gains from trade are lower than what a frictionless framework would predict. Symmetrically, if $\Upsilon_j < 1$ then trade tends to mitigate the effects of domestic intersectoral distortions so the gains from trade are higher than predicted by standard models.

As written in (11), Υ_j depends on the unobserved allocation of labor in autarky. However, using the structure of the model I can derive an expression for Υ_j only in terms of quantities observed in the trade equilibrium. While the algebraic details are relegated to the Appendix, the two key steps can be succinctly stated. First, Υ_j can be equivalently written as a value-added-weighted harmonic mean wedge in autarky equilibrium relative to trade equilibrium:

$$\Upsilon_j = \frac{\sum_s \frac{y_{j,s}^T}{\xi_{j,s}}}{\sum_s \frac{y_{j,s}^A}{\xi_{j,s}}}. \tag{13}$$

Second, the value added share of sector s in autarky $y_{j,s}^A$ can be explicitly derived in terms of primitives of technology and preferences. This leads to an expression

$$\Upsilon_j = \frac{\sum_s \frac{y_{j,s}^T}{\xi_{j,s}}}{\sum_s \sum_k \frac{(1-\alpha_{j,s}) a_{j,sk} \beta_{j,k}}{\xi_{j,s}}}. \tag{14}$$

Finally, plugging (14) into (10) we find that the gains from trade in a model with distortions can still be easily calculated. Given wedges $\xi_{j,s}$, the data requirements are the same as for a standard model without distortions. All that is needed is sectoral final expenditure shares $\{\beta_{j,s}\}$, trade intensities $\{\pi_{jj,s}\}$, value added shares $\left\{y_{j,s}^T\right\}$, as well as input-output coefficients $\{\alpha_{j,sk}\}$ and productivity dispersion parameters $\{\theta_s\}$. All these quantities can be computed from the data or estimated under fairly weak assumptions, as described in the next section.

3 Quantification

In this section I describe how the theoretical model is mapped to the data. I start with a brief description of the data. More details on construction of variables and data sources are presented in the Online Data Appendix.

3.1 Data

In order to calculate the gains from trade and evaluate other counterfactual exercises considered in this paper, data on production, employment, and international trade is required, all at a sectoral level. While such data is easily available for developed countries, comparable and reliable data at a sector level is not comprehensively compiled for developing countries. Those countries are especially interesting for the purpose of this paper, however, since in those countries we might expect the impact of the intersectoral distortions to be large.

To maximize the size of the sample while maintaining sufficient quality of the data, I source sectoral production and employment data from four databases (in order of preference): World Input Output Database (WIOD) (Timmer et al. (2015)), OECD STAN Database (OECD (2011)), GGDC 10-Sector Database (Timmer et al. (2014)), and APO Productivity Database (APO (2015)). Because GGDC and APO databases aggregate all manufacturing industries into one sector, data for countries relying on these sources is supplemented with information on manufacturing from UNIDO INDSTAT2 database (UNIDO (2015)). Overall, I construct a consistent dataset for $N = 61$ countries (including one constructed region Rest of the World) and $S = 16$ sectors. The sectors are listed in Table A.1 and include 11 tradable sectors: agriculture (sector 1), mining (sector 2), and 9 manufacturing sectors (3-11), as well as 5 services sectors (12-16) which are treated as nontradable.[19] The list of countries is presented in Table A.2. Sample countries represent all continents and a wide range of income. Table A.2 classifies countries into one of three income groups: developing, middle income, and developed, based on the country's real GDP per worker calculated using version 8.1 of the Penn World Table (Feenstra and Timmer (2015)). Developing countries (first tercile of the sample) start with the poorest Ethiopia (1703 US$/worker), middle income countries (second tercile) begin with Bulgaria (US$ 22496), and developed countries start with an income level of Israel (US$ 57962). This grouping is used to summarize results in Section 4.

Data on bilateral trade flows comes from the CEPII BACI database (Gaulier and Zignago (2010)). Trade data at the 6-digit HS rev.2 (2002) level is mapped to 4-digit ISIC rev.3 sectors

[19] Disaggregated bilateral data on international trade in services for a broad range of countries is very limited but the situation is likely to improve in the future as attempts to measure flows of services are on the rise. For the period under consideration in this paper trade in service represents about 20% of world trade.

using a concordance table from World Integrated Trade Solutions (WITS) from the World Bank, and then further aggregated to the 11 tradable sectors. Finally, data on effectively applied tariffs is taken from the UNCTAD Trade Analysis and Information System (TRAINS).

All data used in this paper is for the year 2006 unless mentioned otherwise in the detailed Online Data Appendix.

3.2 Production and Demand Parameters

I now explain how the data is used to calculate quantities required to evaluate the welfare gains from trade and to perform other counterfactual simulations.

The assembled dataset contains information on gross output $R_{j,s}$, value added $Y_{j,s}$, bilateral trade flows $M_{ij,s}$ (imports to j form i excluding tariffs), and ad valorem tariffs $t_{ij,s}$ for all countries, as well as input-output tables for the WIOD subsample. Starting with technological coefficients, the overall share of intermediate consumption in gross output of sector s is obtained from $\alpha_{j,s} = 1 - Y_{j,s}/R_{j,s}$. For countries available in WIOD, input-output coefficients $\{\alpha_{j,ks}\}$ are computed directly as shares of intermediate input from sector k in the total intermediate consumption of sector s, ensuring that the shares of total intermediate consumption sum to $\alpha_{j,s}$. For all other countries, input-output coefficients are imputed through their median values among WIOD countries, but rescaled so their sum is equal to $\alpha_{j,s}$.

Next, unobserved domestic sales of an industry are calculated as the difference between gross output and exports, $M_{jj,s} = R_{j,s} - \sum_{i \neq j} M_{ji,s}$. Combining trade flows and tariff data, the expenditure in country j on goods from i is $X_{ij,s} = (1 + t_{ij,s}) M_{ij,s}$. Expenditure on sector s is $E_{j,s} = \sum_i X_{ij,s}$, and the bilateral expenditure shares are $\pi_{ij,s} = X_{ij,s}/E_{j,s}$. Tariff revenue is $T_j = \sum_s \sum_i t_{ij,s} M_{ij,s}$. Sectoral trade deficits are defined as $D_{j,s} = \sum_i M_{ij,s} - \sum_i M_{ji,s}$, aggregate deficits as $D_j = \sum_s D_{j,s}$, where at the world level deficits sum to zero, $\sum_j D_j = 0$.

To obtain demand parameters, I construct the final demand as the difference between total expenditure on a sector and expenditure on intermediates from that sector, $F_{j,s} = E_{j,s} - \sum_k \alpha_{j,sk} R_{j,k}$. Then the final demand shares are calculated as $\beta_{j,s} = F_{j,s}/F_j$, where $F_j = \sum_s F_{j,s}$. Country's income is equal to its total value added, $Y_j = \sum_s Y_{j,s}$.

The remaining parameters required for my analysis are $\{\theta_s\}$ governing the dispersion of Fréchet productivity draws and wedges $\{\xi_{i,s}\}$. Since intersectoral distortions are the non-standard feature of the paper, they deserve a longer discussion separated into the next subsection. For productivity dispersion parameters, in my baseline specification I use $\theta_s = 4.14$, the preferred estimate of Simonovska and Waugh (2014). Imposing a common value of θ across sectors might appear like a strong restriction. In the model θ_s maps directly into (minus) the partial trade elasticity which might vary across types of goods. I use a common elasticity as the baseline scenario for two reasons. First, the main results of the paper do not depend on the value of the trade elasticity. My main focus is not so much on the level of the gains from trade (which as Ossa (2015) points out are sensitive to sectoral elasticities), but rather on how these gains are affected by intersectoral distortions. Inspection of the key term Υ_j in (14) shows that θ_s does not affect that calculation at all. Discussion in Section 4.4 shows that other key results of the paper are also not affected by introducing heterogeneity in θ_s. Second, while there appears to be a consensus in the literature that the aggregate trade elasticity is around 4-5 (Head and Mayer (2014)), we lack precise estimates of elasticities at a sectoral level. With this caveat in mind, in Section 4.4 I use sectoral elasticities based on central estimates of Caliendo and Parro (2015) to illustrate the robustness of my main results.Intersectoral Labor Distortions

Distortions to the allocation of labor across sectors take a prominent role in my analysis. In this section I describe how I calculate the wedges and summarize their patterns in my dataset.

In the model labor is the only factor of production. Consequently, payments to labor in a sector are equal to sectoral value added and hence labor compensation per worker measures the sectoral wage and the sectoral $VMPL$. The labor wedge in the model is thus equal to relative labor compensation per worker. In taking the model to the data in my baseline case I keep this simple mapping from labor compensation and employment to wedges by calculating the wedges as

$$\xi_{i,s} = \frac{\eta_s}{\eta_1} \frac{Y_{i,s}/L_{i,s}^D}{Y_{i,1}/L_{i,1}^D}, \tag{15}$$

where $Y_{i,s}$ is the measured sectoral value added, $L_{i,s}^D$ is measured sectoral employment level, and η_s is the share of labor compensation in value added in sector s. Taking the model literally we could set η_s to one in all sectors. However, differences in value added per worker in the data can reflect differences in factor intensities across sectors. Wedges calculated using expression (15) take this correction for factor intensities into account. In Online Appendix B I show that (15) identifies labor distortions in a generalized model allowing for multiple factors of production when technology is Cobb-Douglas with common factor shares across countries. Consistent with this interpretation, I measure η_s as the median share of labor compensation in value added in sector s in my sample of WIOD countries, for which we have data on factor compensation.[20] Summarizing this discussion, I take the differences in labor compensation per worker in the data as an evidence for the intersectoral distortions to the allocation of labor. Before discussing potential measurement concerns with this approach, I describe how the baseline wedges look like in my sample.

Table 1 summarizes the extent to which $VMPL$ differs across sectors. The first panel shows that some sectors tend to have systematically higher labor compensation than others. For each sector s it reports the geometric mean of $\xi_{i,s}$ calculated across countries. Agriculture is sector 1, i.e. the reference point for the calculation of wedges. The most striking feature is that average wedges in all non-reference sectors are greater than one. Even controlling for sector's labor intensity, agriculture is the sector in which workers generate the lowest value added on average. In fact, agriculture is

[20]Using a median share mitigates concerns about imputations in data on factor shares. Main results of the paper are robust to using wedges based on country-specific labor shares of value added instead.

the sector with the lowest wedge in more than 60% of the countries. Textile sector also generates relatively little value per worker. On the other hand, producers in mining and in FIRE services (sector 15) systematically face particularly high costs of labor.

The second panel of Table 1 summarizes the dispersion of wedges within countries. For each country I calculate a coefficient of variation of wedges (employment-weighted). The second panel then reports the average coefficient of variation calculated for each of the three income groups: developing, middle-income, and developed countries. Dispersion of wedges tends to decrease in income. This point is further illustrated in Figure 1, which plots the coefficient of variation of wedges against the real GDP per worker for all countries. The visible negative relationship is statistically significant.

The two patterns described aid an interpretation of subsequent results in the paper. The finding that my baseline measure of $VMPL$ is generally low in agriculture relative to other sectors is helpful for understanding the relationship between the sectoral composition of net exports and the gains from trade discussed in Section 4.1. The finding that the magnitude of distortions is generally larger in poorer countries helps to account for large gains from reducing distortions in those countries calculated in Section 4.3.

The choice of formula (15) to calculate the wedges is driven by the fact that it is conceptually consistent with both the model and measurement practices. As measured in my data, the labor compensation component of VA includes labor taxes but excludes output taxes. Thus if labor was truly homogenous then (15) would capture the relative labor costs and $VMPL$ across sectors. However, there is a potential concern that the wedges might be driven by differences in levels of human capital per worker across sectors, an issue abstracted from by my model with homogeneous labor. To gauge the importance of this concern, in Online Appendix B I calculate wedges based on labor compensation per hour worked within three skill groups for the subsample of countries with more detailed data from WIOD. Controlling for worker skills and hours worked, the dispersion of wedges within countries is still more than 2/3 as large as for my baseline case. Differences in value marginal product of labor across sectors are also calculated in more detailed cross-sectional studies. Vollrath (2009) and Gollin et al. (2014) document the prevalence of such implied inefficiencies in developing countries. The latter paper, in particular, concludes that large productivity gaps between agriculture and nonagriculture (wedges in my terminology) remain in their dataset after they take into account a number of measurement issues.[21]

The discussion so far addresses observable differences in worker characteristics across sectors. It is also conceivable that my wedges reflect systematic differences in unobserved worker attributes across sectors. Lagakos and Waugh (2013) develop a Roy (1951)-like model in which sorting of workers based on unobserved productivity can generate differences in average wages across sectors

[21] Controlling for hours work and quality of human capital in their dataset lowers the average size of the wedge by 40%. Their starting point has data of lower quality than I use in this paper, however.

despite the allocation of labor being efficient.[22] Young (2013) argues that such sorting is consistent with a pattern of two way rural-urban migration in developing countries. Thus the extent to which intersectoral wage differences represent distortions vs. sorting is an area of debate in the literature. Since this debate is difficult to settle with cross-sectional data,[23] the most compelling evidence comes from observing workers who switch sectors.[24] Given the high demands on data, results are still scarce for developing countries. Most closely related work is Beegle et al. (2011), who find that moving out of agriculture increases consumption by 40% for individuals in Tanzania. Evidence on switchers is more readily available for developed countries. Katz and Summers (1989b) summarize an early literature showing that changes in wages of US workers who switch sectors closely match the cross-sectional intersectoral wage differentials. More recently, using a matched employer-employee dataset Sorkin (2015) estimates that sector of employment accounts for half of the variation in firm-level wages in the US. Taken together, this body of evidence is difficult to reconcile with marginal workers being paid the same wages across sectors.

To summarize this discussion, while the evidence strongly points towards an existence of differences in the value marginal product of labor across sectors, the precise magnitude of these distortions can be disputed. By attributing the differences in labor compensation per worker entirely to distortions to labor allocation in my baseline scenario I likely somewhat overstate the magnitude of distortions. But one advantage of my methodology is that it can be implemented for any values of wedges. While presenting the findings of key counterfactuals I thus discuss their sensitivity to alternative assumptions about the magnitude of distortions.

4 Results

In this section I provide a quantitative answer to the core question of the paper: how do domestic distortions affect the welfare gains from trade? In addition, I explore the implications of intersectoral labor distortions for trade policy. Finally, I illustrate how openness to international trade magnifies the welfare losses from distortions.

In the data trade is not balanced at a country level. Since interpreting the welfare gains from trade in a static model is problematic in the presence of aggregate deficits, I follow the literature by first eliminating aggregate imbalances. The baseline equilibrium that is a starting point for subsequent calculations is therefore not the raw observed data but the counterfactual equilibrium

[22] Adao (2015) and Galle et al. (2015) are among the recent papers that embed a Roy framework in trade models. These papers do not feature intersectoral labor distortions.

[23] Heckman and Honore (1990) demonstrate that without making strong functional form assumptions it is impossible to quantify the importance of sorting in a Roy model using only cross-sectional data.

[24] If intersectoral wage differentials capture only differences in average human capital by sector then we should not see large changes in wages for workers switching sectors. Even if skills are multi-dimensional as in a Roy model, the marginal workers (switchers) should be close to being indifferent to working in two sectors and thus we should not see large changes in their wages.

that eliminates aggregate deficits by setting $\delta'_j = 0$ in all countries.[25]

4.1 Gains From Trade

In this subsection I demonstrate the quantitative importance of intersectoral distortions for the magnitude of the welfare gains from trade. The first column of Table 2 lists the baseline gains from trade GFT, expressed in percentage terms, calculated using my model for all countries present in the sample.[26] For comparison, the second column shows the corresponding gains from trade GFT^{ND} that would be obtained from the same data in a standard model that abstracts from intersectoral distortions. The distortions adjustment term Υ linking the two sets of numbers is reported in column 4. For ease of interpretation column 3 also directly reports the difference between the true gains GFT and the gains GFT^{ND} from a standard model.[27]

Table 2 shows that the impact of distortions on the gains from trade is very heterogeneous across countries. In particular, it need not be the case that gains from trade are lower in the presence of distortions. In a second best world with frictions any outcome is possible and, in fact, the sample is equally split between countries for which the gains from trade are higher and for which the gains from trade are lower in the model with domestic distortions.[28]

The contribution of this paper is to derive a sufficient statistic Υ that provides a clear intuition for when the gains from trade are reduced by distortions and makes it easy to calculate the necessary adjustment relative to the frictionless case. Recall from Section 2.6 expression (13) and its interpretation: the standard model overstates the gains from trade when $\Upsilon > 1$, which happens when opening to trade causes economic activity to shift to sectors with relatively low $VMPL$. The formula (14) shows how the effects of this hypothetical reallocation can be expressed in terms of data observed in the trade equilibrium. This formula (used to calculate Υ in column 4 of Table 2) is rather complicated, however, as it captures the full richness of the input-output structure of the model. But there is a remarkably simple rule of a thumb to determine the magnitude of Υ.

All that is needed to accurately predict whether Υ_j is greater or less than one is to calculate the sign of $\sum_s \delta_{j,s}/\xi_{j,s}$, where $\delta_{j,s} = D_{j,s}/Y_j$ is a sectoral trade deficit relative to GDP. If the sum is negative, then a country tends to be a net exporter ($\delta_{j,s} < 0$) in sectors with low $VMPL$ and a net importer ($\delta_{j,s} > 0$) in sectors with high $VMPL$. In such a country opening to trade results in resources shifting on net to sectors with low $VMPL$ (in order to generate net exports) and hence

[25] Trade need not to be balanced sector-by-sector, however. Sectoral trade deficits adjust endogenously to be consistent with balanced aggregate trade. Eliminating aggregate imbalances has little effect on the average efficiency of labor allocation and thus on the main results of the paper.

[26] Percentage gains from trade are measured as $GFT \equiv 100\left(1 - C^A/C^T\right)$, where C^A/C^T is welfare (real consumption) in autarky relative to welfare with trade.

[27] With gains from trade expressed in percentage terms, the relationship between $\Delta GFT \equiv GFT - GFT^{ND}$ and Υ is given by $\Delta GFT = (1 - \Upsilon)\left(100 - GFT^{ND}\right)$.

[28] The effect of distortions on global gains from trade is theoretically ambiguous. In my sample, the gains from trade in a distorted model are 0.37 p.p. lower for a simple mean and 0.78 p.p. higher for a population-weighted mean across countries.

the gains from trade are lower than the standard model would predict. The sign of $\sum_s \delta_{j,s}/\xi_{j,s}$ correctly predicts the bias of a standard model in 59 out of 61 countries (and when it fails the Υ's are very close to 1). It is successful because it would predict the pattern perfectly in a model without linkages across sectors, and as discussed in Section 4.4 input-output linkages have very little effect on Υ.[29]

The intuitive relationship between sectoral trade deficits, wedges, and Υ justifies construction of a simple metric that can capture the magnitude of Υ. The metric is given by the ratio of trade deficit in low-$VMPL$ sectors relative to GDP. Specifically, I calculate $\delta_{j,LOW}$ by summing trade deficits in sectors with wedges below the median wedge in tradable sectors in country j, and expressing the deficit relative to GDP.[30] This metric can be interpreted as a simple rule of a thumb: the more a country exports (on net, relative to the size of its economy) in low-$VMPL$ sectors, the more its gains from trade are overstated by the standard model ignoring intersectoral distortions. This relationship is illustrated in Figure 2, which divides countries by quartile of $\delta_{j,LOW}$ and for each quartile plots the average difference $GFT - GFT^{ND}$. There is a strong negative relationship between $\delta_{j,LOW}$ and Υ_j. For countries in the first quartile of $\delta_{j,LOW}$ (i.e. largest net exporters in sectors with low $VMPL$) the GFT are on average 4.6 p.p. lower than GFT^{ND}, while for the highest quartile they are 2.8 p.p. higher. Expressed in relative terms, the standard model overpredicts the gains from trade for the first quartile of $\delta_{j,LOW}$ by 28% on average, while it underpredicts the gains for the fourth quartile by 21% on average. These large differences are the key quantitative finding of this paper. They illustrate the empirical importance of an observation that in a second-best world with domestic intersectoral distortions the gains from trade depend not only on how much you trade; what you export matters as well.[31]

Further inspection of results in Table 2 reveals another interesting pattern. Countries for which the frictionless model overstates the gains from trade the most tend to be poor. There is indeed a statistically significant negative relationship between Υ and the level of development measured by log real GDP per worker. For the group of developing countries the baseline GFT are on average 2.6 p.p. lower than in a frictionless model. In contrast, for developed countries the GFT are on average 1.0 p.p. higher in a model with distortions. The discrepancy is smallest for middle income countries, with GFT on average 0.6 p.p. higher than GFT^{ND}. Of course, low income levels are not a direct cause of high Υ. What drives the correlation is the fact that poor countries tend to be net exporters in sectors with low $VMPL$, while richer countries tend to be net exporters in high $VMPL$ sectors.[32]

[29] If trade is balanced and there are no input-output linkages (IO matrix is diagonal), then final demand in a sector is equal to the sum of value added and trade deficit in that sector. Assuming also tariff revenue is zero, we have $y^T_{j,s} = \beta_{j,s} - \delta_{j,s}$ and $y^A_{j,s} = \beta_s$. Plugging these in (13) we find that $\Upsilon_j > 1$ if $\sum_s \delta_{j,s}/\xi_{j,s} < 0$.

[30] Formally, $\delta_{j,LOW} = \sum_{s \in LOW_j} \delta_{j,s}$, where $LOW_j = \left\{ s : \quad s \leq 11 \wedge \xi_{j,s} < \tilde{\xi}_j \right\}$ and $\tilde{\xi}_j$ denotes the median wedge across tradable sectors (1 to 11) in country j.

[31] In a model with distortions a country might even lose from opening to trade. This does not happen in my sample with the baseline measure of distortions.

[32] In a dynamic context, McMillan and Rodrik (2011) argue that globalization might have reduced aggregate pro-

Agriculture plays a particularly important role in accounting for this pattern. Recall from Section 3.2 that agriculture is the lowest $VMPL$ sector in the majority of countries (and it is below the median among tradable sectors in 85% of countries). The sign of trade balance in agriculture alone can predict whether Υ is greater or smaller than one in 2/3 of cases.[33] Countries that are in the first quartile of agricultural net deficit ($\delta_{j,1}$) have their GFT overestimated by the standard model by 3.2 p.p. on average. The majority of these countries are poor. More broadly, 80% of developing countries in my sample are net exporters of agricultural goods. This relative specialization in agricultural exports coupled with low $VMPL$ systematically observed in agriculture goes a long way towards explaining why the gains from trade for developing countries are reduced in the model with intersectoral distortions.[34]

The numbers reported above correspond to my baseline specification which attributes differences in labor compensation per worker across sectors entirely to intersectoral distortions. I now explore the sensitivity of results on the size of the gains from trade to alternative measures of distortions. In the first sensitivity check I assume that true distortions (with respect to agriculture) are only half as large as calculated in the baseline case. The baseline wedge $\xi_{j,s}$ is thus replaced with an equally weighted average of $\xi_{j,s}$ and unity (no distortion) by setting $\xi'_{j,s} = 0.5\xi_{j,s} + 0.5$.[35] This reduction in distortions is somewhat larger than the 40% reduction in agricultural productivity gap that Gollin et al. (2014) find justifiable due to differences in human capital quality across sectors, as discussed in Section 3.2. Figure 3 plots the difference between the gains from trade with alternative wedges and the frictionless case, in analogy to Figure 2 for baseline wedges. As can be seen in the first panel of Figure 3, the sectoral composition of net exports still strongly affects the magnitude of Υ. With distortions half as large as in the baseline case, the model completely abstracting from intersectoral distortions would overpredict the gains from trade for the countries in the first quartile of trade deficit in low $VMPL$ sectors to GDP ratio by 3.3 p.p. on average, while underpredicting the gains for the highest quartile by 2.1 p.p. These effects are 75% as large as for the baseline wedges.

Figure 4 illustrates the sensitivity of Υ to a broader range of distortions. It plots Υ for a few countries as a function of $\chi \in [0, 1]$, with wedges set as $\xi'_{j,s} = (1-\chi)\,\xi_{j,s} + \chi$. Thus the plot spans the cases between baseline wedges ($\chi = 0$) and a frictionless world ($\chi = 1$). The plots tend to be steep in the neighborhood of $\chi = 1$, indicating that even moderate amount of distortions can matter quantitatively for the magnitude of the gains from trade.

The final exercise takes a different perspective to reducing the overall level of distortions. The

ductivity growth in developing Latin American and African countries by directing labor to low-productivity sectors.

[33]Trade balance in agriculture also explains more of variation in Υ than trade balance in any other sector.

[34]This does not mean that all agricultural exports are bad for developing countries. These countries can be very productive in producing certain goods - and in the Eaton and Kortum (2002) structure are guaranteed to be so. But when wages faced by producers in agriculture are lower than in other sectors the country will produce and export a broader range of agricultural goods than is efficient.

[35]This exercise preserves the ranking of sectors within a country in terms of $VMPL$. It also reduces distortions between any pair of sectors s and k in that $\xi'_{j,s}/\xi'_{j,k}$ is closer to one than $\xi_{j,s}/\xi_{j,k}$ but a rate of decline differs across sector pairs.

exercise eliminates differences in average wedges across sectors, while preserving the ranking of wedges within a sector across countries. Specifically, I calculate the level of wedges as $\xi'_{j,s} = \xi_{j,s}/\overline{\xi}_s$, where $\overline{\xi}_s$ is the geometric mean of $\xi_{j,s}$ across countries. Thus distortions are only identified from deviation of the baseline wedge from the geometric mean across countries. By assuming that $VMPL$ is on average the same in all sectors, this rather extreme calculation alleviates a concern that, e.g., labor compensation per worker in textiles is 40% higher on average than in agriculture (c.f. Table 1) because textile workers are 40% more productive (perhaps due to unobserved characteristics). But it still allows countries with particularly high labor costs in textiles (compared to other sectors) to have a cost disadvantage in textiles by preserving the ratio of wedges across countries, i.e. $\xi'_{j,s}/\xi'_{i,s} = \xi_{j,s}/\xi_{i,s}$. Under this scenario of distortions GFT are on average 1.8 p.p. higher than in a frictionless model (rather than 0.4 p.p. lower as is the case for baseline wedges).[36] This upward shift in the mean GFT can be seen in the second panel of Figure 3. But apart from the average level difference, the monotonic relationship with net deficits in low $VMPL$ sectors is similarly strong as in the baseline case. In particular, the difference between the 90th and 10th percentiles of ΔGFT is 6.0 p.p. for this scenario compared to 6.6 p.p. for the baseline case.

The robustness exercises presented above demonstrate that the mechanism emphasized in this paper remains quantitatively important for a plausible range of distortions. Even using much more conservative measures of distortions than in my baseline specification, distortions can add or subtract a few percentage points from the gains from trade depending on whether a country specializes in exporting in its high or low $VMPL$ sectors. These are large numbers relative to the overall level of the gains from trade obtained in the workhorse quantitative trade models.

4.2 Trade Policy

Moving away from the somewhat abstract comparisons with autarky and into a more policy-relevant area, I now focus on the interaction between intersectoral distortions and trade policy. The counterfactual calculations of this subsection show that in a second-best world with domestic distortions the effects of trade policy can be very potent.

As a natural starting point I first consider a classic question of optimal tariffs. Specifically, starting in the baseline equilibrium I find a vector of import tariffs $\left\{t^*_{j,s}\right\}$ (applied uniformly across trading partners) for 11 tradable sectors that maximizes country j's welfare.[37] These optimal tariffs are set unilaterally, keeping the tariffs of other countries at the baseline level observed in the data. Table 3 reports the key statistics from this exercise for each country. The first two columns show that there is a substantial variation in optimal tariffs across sectors within a country, as well as in

[36] The change in mean GFT is largely driven by a few developing countries that simultaneously have a large surplus in agriculture and agricultural $VMPL$ in line with other sectors in the baseline case. Under the alternative wedges $VMPL$ in agriculture becomes high relative to other sectors so large agricultural trade surplus translates to large benefits from trade.

[37] To solve this optimization problem computationally efficiently, it is set up as a constrained optimization problem with nonlinear (equilibrium) constraints, similarly as in Ossa (2014).

average tariffs across countries. Crucially, there is a systematic sectoral pattern to optimal tariffs. As can be seen in the first panel of Table 4, optimal tariffs are on average lowest in sectors such as agriculture, food, or textiles. Recall from Table 1 that these are sectors with the lowest $VMPL$. Similarly, optimal wedges tend to be highest in high-$VMPL$ sectors such as mining or chemicals and fuels. Figure 5 illustrates the positive relationship between optimal tariffs and $VMPL$ more clearly, by showing that sectors ranked higher within a country according to their wedge have higher optimal tariffs on average. The relationship between optimal tariffs and $VMPL$ is also demonstrated more systematically in the second panel of Table 4. Columns 1 and 3 show that within countries there is a strong, positive, statistically significant correlation between optimal tariffs and wedges.

To understand this result, it is instructive to compare it with optimal tariffs calculated in the absence of intersectoral distortions. In that case it would be unilaterally optimal for countries to impose a tariff that is essentially uniform across sectors. The rationale for optimal tariff in a frictionless model is a classic terms of trade argument. Alvarez and Lucas (2007) show that in a one-sector Eaton and Kortum model even a small country has market power in some goods because of unbounded productivity draws and its optimal tariff is therefore positive. But beyond the terms of trade manipulation motive, there is no reason to distort consumption and production via differential tariffs. Costinot et al. (2015) formally show that in a two-country Ricardian model optimal tariffs are uniform across goods.[38][39] In contrast, in the presence of intersectoral distortions tariffs also have first-order effects on welfare through factor allocation. If a tariff on a high $VMPL$ sector causes a worker to move to that sector from a low $VMPL$ sector, then this move will raise national income by the difference in $VMPL$ in the two sectors. This logic explains the positive correlation between wedges and optimal tariffs in the model with intersectoral distortions.[40] In fact, the factor-shifting motive can be sufficiently strong to make some optimal tariffs negative. This tends to happen for agriculture - since it is often the lowest $VMPL$ sector by a substantial margin, more than 2/3 of the countries would actually find it optimal to subsidize agricultural imports to induce workers to move to other sectors.

Because of the first-order effects of tariffs, the welfare gains from optimal trade policy can be substantial, as documented in column 3 of Table 3. The potential welfare gains from optimal tariffs are 3.2% on average, but there is a lot of heterogeneity across countries. The largest gains occur for countries with high dispersion of wedges and a high fraction of workforce in low $VMPL$ sectors.

[38] Perhaps because of a more complex production structure and presence of multiple countries optimal tariffs in my numerical calculations are not exactly uniform, but very close. The standard deviation of tariffs within a country is just 0.16% on average (when the average tariff is 24.8%) and the additional welfare gain from allowing for tariff heterogeneity compared to optimal uniform tariff is just 0.0001% on average. For these reason I focus discussion on optimal uniform tariffs.

[39] When the set of policy instruments also includes export taxes, Costinot et al. (2015) show that export taxes optimally vary across goods according to comparative advantage while import tariffs remain uniform. In this paper I restrict my attention to import tariffs as these are the only trade policy instruments consistently measured in the data.

[40] Section 4.4 shows that this positive correlation is robust to allowing for sectoral heterogeneity in θ_s, which only has a small impact on variation in optimal tariffs.

These tend to be developing countries - the average welfare gain for that group is 4.8% and some large developing countries (China, India, Indonesia and Thailand) gain over 8%. For comparison, column 4 of Table 3 reports the gains from optimal uniform tariffs in a frictionless model. When there are only the classic terms of trade to be exploited, the benefits of optimal trade policy are much smaller: the welfare gains are only 1.3% on average and in no case larger than 3.7%.

To get another perspective on the unilaterally optimal tariffs, it is worthwhile to compare them to the tariffs actually observed in my data. As the first panel of Table 4 shows, observed tariffs are for the most part much smaller than optimal tariffs in my model with baseline wedges. The exception is agriculture, which faces the highest tariff in the data while having the lowest (and in most cases negative) optimal tariff. More broadly, observed tariffs tend to be, if anything, negatively correlated with wedges, as can be seen in columns 2 and 4 in the second panel of Table 4. It appears that governments might be protecting industries where the workers are relatively unproductive - a policy that might have a political appeal but is welfare-reducing when seen through the lens of my model.

Perhaps another reason why the optimal policy is not implemented is that it would have a negative effect on the welfare of other countries. The global general equilibrium framework of this paper allows me to quantify international spillovers of unilateral trade policies, showing them to be nontrivial. As an example, consider a case of India imposing its unilaterally optimal tariffs on other countries. The benefit to India is large at 9.9% increase in welfare. But the policy results in a loss for almost all (55 out of 60) other countries. These losses are not exactly trivial: 0.3% of welfare on average and 0.6% for other developing countries, with losses exceeding 1% for 8 countries. This example illustrates that unilaterally optimal trade policy has a beggar-thy-neighbor flavor in that the benefits come at the expense of other countries. The large gain for India arises from its ability to use trade policy to reorient the economy towards sectors with higher $VMPL$. In particular, the share of agriculture in value added decreases by 5.9 p.p. On the flip side, countries that lose the most pick up production in low $VMPL$ sectors India is leaving. Some of the most badly affected countries are India's poor neighbors. The welfare effects of India's policy on neighboring countries can be seen in Figure 6. For example, Pakistan loses 1.2%, to a large extent driven by an expansion of agriculture measured as 1.5 p.p. increase in agricultural value added share. These large movements occur only in the model with distortions. Without distortions India would gain only 0.5% due to the standard terms of trade improvement. The losses for its trading partners would also be correspondingly smaller, e.g., Pakistan would lose only 0.02%.

Unilaterally optimal tariffs predicted by the model tend to be quite large and their imposition can have substantial negative effects on other countries. They are therefore unlikely to be politically viable. Now I consider a perhaps more relevant scenario in which developed and middle-income countries remove tariffs in agriculture levied against developing countries. Agricultural protectionism is traditionally a contentious topic in trade policy negotiations, with improved market access for developing-country agricultural products currently serving as one of the stumbling blocks in the Doha Round. There are two lessons from the hypothetical elimination of tariffs on developing-country agricultural products. First, given the pattern of distortions a reform that encourages developing countries to increase exports in agriculture can actually hurt them. Indeed, 80% of developing countries would suffer from this policy change, with developing countries losing 0.6% in welfare terms on average.[41] Distortions are important for this result - in their absence all developing countries but one would gain (0.3% on average). Second, even in a world with distortion the welfare effects of this policy experiment are modest for most countries, exceeding 1% (in absolute value) for just 5 countries. This reflects relatively modest magnitude of measured tariffs: the average tariff in agriculture among developed and middle-income countries is 5.6%. Of course, there are substantial non-tariff barriers to trade in agriculture. But the logic of the model with distortions would apply to these barriers as well, warning that reducing these barriers can be actually detrimental to poor countries.

The main message of this subsection is thus that the presence of intersectoral distortions affects the benefits of pursuing trade policies in a quantitatively important way. In particular, developing countries might have strong incentives to shelter their high $VMPL$ sectors and to allow greater agricultural imports. These results should not be treated as direct policy recommendations, however, since they are conditioned on a fixed size of labor wedges. To the extent that the distortions themselves are partially explained by domestic policy it is likely that reforming those domestic policies should be preferred to taking the roundabout way of undoing the effects of distortions via trade policy. Even if reducing sectoral wage differentials directly is not feasible, there might still be other policy instruments (such as production taxes and subsidies) available that are preferable to tariffs.[42]

4.3 Intersectoral Labor Distortions

I now turn to a set of counterfactuals looking at the interactions between intersectoral labor distortions and international trade from a different perspective. Instead of asking how the presence of distortions affects the benefits from trade, we can also study a complementary issue of how international trade affects the benefits of reducing domestic distortions. The answer that emerges from the analysis below is that trade tends to magnify the impact of distortions.

The first counterfactual involves completely removing the wedges simultaneously in all countries. Column 1 of Table 5 shows just how large the welfare costs of distortions are. If hypothetical institutional and policy reforms succeeded in eliminating intersectoral wedges, then the welfare would increase by 33.2% on average across countries. The benefits tend to decline with country's income: whereas welfare of households in the developing countries rises on average by an impressive 60.0%, the benefits for middle-income and developed countries are 25.9% and 12.3%, respectively.

[41] Results broken down by country are reported in Table E.1 in the Online Appendix E.

[42] The theoretical validity of that point in a simpler model was shown by Bhagwati and Ramaswami (1963).

The ranking of gains should not be surprising in light of the pattern of declining magnitude of distortions documented in Section 3.2.

To illustrate the importance international trade plays in enabling large gains, the next exercise considers the same elimination of labor wedges but undertaken in a closed economy.[43] Column 2 of Table 5 shows that the gains in autarky are systematically lower than in an open economy - the average gain in autarky is 18.2%, or just over half as large as in the open economy baseline.

To understand why the benefits from reducing wedges are smaller in autarky, observe that low wage in a sector translates to inefficiently low price of that sector's output. Consequently, demand for output (for both final and intermediate consumption) of low $VMPL$ sectors is inefficiently high, leading to inefficiently high employment. In a closed economy there is a clear limit to this misallocation of labor because domestic production needs to match domestic demand that is determined by preferences and technology. When both preferences and technology have a Cobb-Douglas structure as in this paper, the sectoral value added shares are in fact pinned down by preference parameters and input-output matrix coefficients. Wedges thus affect labor allocation but not nominal output shares.[44] In contrast, in an open economy the low $VMPL$ sectors can expand even further because low sectoral wages become a source of comparative advantage. This magnification manifests itself in higher value added shares of low $VMPL$ sectors in the baseline equilibrium than in the counterfactual trade equilibrium without wedges. Because there is greater scope for misallocation in an open economy, removing distortions has correspondingly larger positive welfare effects than in autarky.[45]

The next counterfactual illustrates the general equilibrium effects of reducing distortions in one country on other countries. Specifically, consider an experiment in which China reduces the wedges between agriculture and other sectors by half, keeping the relative wedges across other sectors constant (i.e. setting $\xi'_{CHN,s} = \frac{1}{2}\xi_{CHN,s}$). This counterfactual can be thought of as capturing the effects of reducing distortionary policies keeping Chinese workers in rural areas (e.g, relaxing the *hukou* household registration system). The gain to China from this reduction in distortions alone is 20.4%. However, while China gains, most other countries lose, as is reported by column 3 of Table 5. The effect on welfare of developed countries is rather trivial, but poorer countries can feel a substantial burden of the Chinese reform, with six countries experiencing losses in excess of 1%. On average, developing countries other than China lose 0.6%. The large gain for China comes mainly from a reallocation of activity from agriculture towards sectors with higher $VMPL$, with the share of agriculture in value added decreasing by 2.9 p.p. in China. Symmetrically, countries suffering the

[43] Starting in the baseline equilibrium, I first close a country to international trade holding wedges constant, and then eliminate the wedges.

[44] The welfare gain from eliminating distortions in a closed economy can be written explicitly as $\hat{C}_j = \left[\sum_s \sum_k \xi_{j,s}^{-1}\left(1-\alpha_{j,s}\right) a_{j,sk}\beta_{j,k}\right] \prod_s \prod_k \xi_{j,k}^{\beta_{j,s}\tilde{\alpha}_{j,sk}\left(1-\alpha_{j,k}\right)}$.

[45] In a similar spirit, Tombe (2015) finds that labor distortions between agriculture and non-agriculture have larger consequences for welfare and productivity in an open economy. The magnification effect of trade is absent in Jones (2011) because in that model goods subject to distortions are not exported directly, so distortions do not become a source of comparative advantage.

most are those poor countries which expand production in their relatively unproductive agriculture. For example, the value added share of agriculture in Indonesia increases by 0.7 p.p., which largely explains why Indonesia suffers a 1.5% welfare loss.

To illustrate the global interdependence of policies further, consider now a situation in which not just China, but all countries simultaneously halve the distortions between agriculture and other sectors. In this scenario the benefits to China at 15.2% would be lower than in the unilateral reform case. But this time almost all countries would benefit, with an average gain among developing countries of 13.4% (Indonesia would gain 13.3%). Contrasting the two scenarios illustrates an international complementarity of domestic policies: reducing distortions becomes relatively more important if other countries reduce their own distortions because foreign reforms can shift activity in low $VMPL$ sectors to a laggard country.

An interesting question concerns the optimal size of distortions. Implicit in the discussion in this paper is the notion that equalizing wages faced by producers across sectors is optimal. Strictly speaking, it is only true in the closed economy where there is no reason to distort the allocation of labor. The trade equilibrium is in the realm of second-best world, however, due to trade costs and distortions in other countries. Thus if the size of domestic wedges is partially determined by policy (recall the tax interpretation of wedges) then a country might actually be better off with some amount of distortions. The calculations for a few countries suggest that it might indeed be optimal to distort domestic labor allocation, however the magnitude of optimal distortions is small relative to the baseline wedges and the welfare benefit of such distortionary policy over eliminating wedges is tiny.[46]

4.4 Discussion

In this subsection I first illustrate that my main results are robust to relaxing the assumption of common trade elasticity across sectors. Then I clarify the role input-output linkages play in my calculations.

Trade Elasticity

My baseline analysis imposes the same value of productivity dispersion parameter θ in all sectors, implying a common trade elasticity. While this assumption is arguably strong, it has little effect on the results of main interest in this paper. To substantiate this claim, in Online Appendix C I allow for sectoral heterogeneity in dispersion parameters. The values of $\{\theta_s\}$ I use (reported in column 1 of the first panel of Table C.1) are based on Caliendo and Parro (2015) adapted for my sectoral aggregation.

[46]For the 8 countries for which I have done the calculation the average gain from setting optimal wedges (26.4%) is only marginally higher than the average gain from removing wedges (26.3%).

Regarding the results on the gains from trade, Section 3.2 mentions a point made forcefully by Ossa (2015) that the gains from trade in multi-sector models can be very sensitive to the values of sectoral trade elasticities.[47] However, while the choice of $\{\theta_s\}$ affects the level of the gains from trade, it does so in a proportional way in a model with distortions and in a model without distortions. Trade elasticities do not enter at all the key Υ term (c.f. equation in (14)) summarizing how intersectoral distortions affect the gains from trade. That term depends only on the fixed wedges, observed value added shares in the trade equilibrium, and on counterfactual value added shares in autarky. But as explained in the previous subsection, the autarky shares depend only on preference and input-output parameters, and in particular, are independent of $\{\theta_s\}$.

Another concern is how the heterogeneity in $\{\theta_s\}$ affects the results on optimal tariffs. Here the first key finding is that in a model with distortions optimal tariffs are quite dispersed and positively correlated with wedges, whereas in a frictionless model optimal tariffs are approximately uniform. However, since Alvarez and Lucas (2007) show that in a one-sector Eaton and Kortum (2002) model the optimal tariff for a small country is given by $1/\theta$, one could expect that in a multi-sector model large differences in θ_s across sectors alone would imply large differences in optimal tariffs. This is not the case. In the absence of distortions a uniform tariff is still approximately optimal. Comparing columns 6 and 8 in the second panel of Table C.1 we can see that the 0.96% average welfare gain from imposing an optimal uniform tariff is only 0.03% lower than the average gain from optimally choosing all 11 sector-specific tariffs. The dispersion of these unconstrained tariffs within countries is relatively low in the absence of intersectoral distortions: the average standard deviation of tariffs is just 2.5% when the average optimal tariff is 19.0% (see columns 4 and 5).

Sectoral trade elasticities do matter for optimal trade policy, but to the extent that they affect a country's average trade elasticity. A country specializing in exports in industries with low foreign import demand elasticity should optimally set high tariffs, but conditional on a high average tariff it should not distort domestic production and consumption by introducing an excessive dispersion in tariffs. This point is illustrated in Figure C.1, which plots the range of unconstrained optimal sectoral tariffs as well as the optimal uniform tariff against an inverse measure of country's average trade elasticity.[48]

In contrast to the narrow range of tariffs in a frictionless model, in the presence of distortions optimal tariffs are much more dispersed, as reported in column 2 in the second panel of Table C.1.

[47] To give an example in the context of this paper, the average gains from trade in my baseline case at 17.3% are similar to the 20.2% average gains from trade with $\{\theta_s\}$ given in Table C.1A. But changing a single elasticity - replacing $\theta_{10} = 1.01$ in Transport Equipment (based on Caliendo and Parro Auto sector) to $\theta_{10} = 0.37$ (based on Caliendo and Parro Other Transport sector) - would increase the average gains from trade by more than 50% to 32.6%.

[48] The horizontal axis shows an inverse of $\overline{\theta\pi^*_{jj}}$, where $\overline{\theta\pi^*_{jj}}$ is an average of $\theta_s\pi^*_{jj,s}$ weighted by sector's s share in exports of country j and $\pi^*_{jj,s}$ is the share of expenditure in countries other than j on sector s goods coming from countries other than j. For most observations $\pi^*_{jj,s}$ is very close to one but it helps to account for why larger countries charge higher tariffs - see Helpman and Krugman (1989) for a formal argument in a related context. Figure C.1 shows that $1/\left(\overline{\theta\pi^*_{jj}}\right)$ provides a good approximation to the optimal uniform tariff.

Comparing the two scenarios shows that the dispersion of optimal tariffs is driven by wedges and not the dispersion in θ_s itself. Moreover, the optimal tariffs are strongly positively correlated with wedges within countries, just as in the baseline common-θ case, as confirmed by the third panel of Table C.1. Finally, allowing for heterogeneity in sectoral trade elasticities actually magnifies the difference between the welfare gains from setting unilaterally optimal tariffs in the model with and without distortions.[49] In summary, heterogeneity in θ_s does not alter the key take away points from my trade policy analysis.

Intersectoral Linkages

Discussion throughout this paper is often focused on a relationship between the $VMPL$ in a sector and outcomes (optimal tariffs, trade deficits, etc) in the same sector. This is a simplification in the presence of intersectoral input-output linkages because, e.g, an optimal tariff in a sector in general depends on all wedges. But as I now argue, not much is lost in understanding the mechanisms of the model by not highlighting the linkages explicitly.

In order to illustrate the role of intermediate linkages, in Online Appendix D I repeat the key calculations in a model without input-output linkages.[50] Starting with the results on the gains form trade, their average level is a little higher (23.7% vs. 17.3% in the baseline) when a simpler input-output structure is employed. But more importantly in the context of this paper, the linkages actually have very little effect on how the level of the gains is affected by distortions. Figure D.1 plots the distortions adjustment term Υ calculated in a model without linkages against its baseline value. The two values are extremely similar.

Table D.1 summarizes the optimal tariffs calculations. Comparing the numbers with those reported in Table 3, we can see that the magnitude and dispersion of tariffs tends to be larger in a model without linkages. Some tariffs are essentially prohibitive, whereas with linkages it is preferable to dampen the tariffs on high $VMPL$ sectors when they are used as inputs to other high $VMPL$ sectors. Welfare gains from imposing optimal unilateral tariffs tend to be correspondingly larger in the model without linkages, by about 30% on average. However, the crucial positive correlation between wedges and optimal tariffs has similar strength as in the baseline case, as seen by comparing the second panels of Table D.1 and 4.

Finally, Table D.2 reports the effects of removing intersectoral distortions. The numbers for both an open and closed economy counterfactuals are very similar to the baseline numbers reported in Table 5.

[49] Compare the difference between columns 3 and 6 in Table C.1B to the difference between columns 3 and 4 in Table 3. The magnification is largely due to higher gains in the model with distortions in the heterogeneous θ_s case, in turn driven by very large gains for 4 large developing countries: Thailand, China, Indonesia and India all have gains in excess of 20%.

[50] To focus on the linkages themselves rather than the standard magnification effects associated with use of intermediates, the model in Online Appendix D sets the input-output matrix to diagonal while preserving the same ratio of value added to gross output as in the baseline model. The magnifying role of intermediates is discussed in, e.g., Costinot and Rodríguez-Clare (2014) for the gains from trade and in Jones (2011) for distortions.

In summary, while taking into account the input-output structure of the economy moderates the sharpest edges of the framework (like prohibitive tariffs), it is not critical for getting a first-order understanding of how intersectoral distortions interact with international trade.

5 Conclusions

The primary goal of this paper is to quantify the impact of domestic distortions on the welfare gains from international trade. To address this issue, I build a model of trade in which wedges between labor costs faced by producers in different sectors distort the intersectoral allocation of labor. I then use the model to evaluate the welfare gains from trade for a diverse set of countries.

My main result is that domestic intersectoral distortions affect the welfare gains from trade in a quantitatively important way. To isolate the effect of domestic frictions, I derive a theoretical relationship between the gains from trade that models with and without distortions would predict given the same data. Standard models that abstract from intersectoral distortions would overstate the benefits of trade for countries that are net exporters in sectors in which distortions depress the value marginal product of labor. Intuitively, in such countries international trade magnifies the misallocation of labor caused by domestic distortions. For example, the gains from trade in my model are 6.4 p.p. lower than in a frictionless framework for Ethiopia specializing in exports in low-value agriculture. Conversely, the workhorse trade model would understate the gains for net exporters of high-value goods, e.g., by 2.0 p.p. in case of Ireland specialized in machinery and chemicals and fuels.

Beyond improving the measurement of the gains from trade, my results show two additional benefits of incorporating intersectoral distortions into a trade model. First, it generates new insights on trade policy. I find that optimal tariffs should vary substantially across sectors in order to offset the effects of distortions. Second, my results suggest that taking into account openness to trade is important for assessing the welfare costs of domestic distortions. I find that a hypothetical reduction in distortions generates much larger welfare gains when international trade can decouple domestic consumption and production patterns.

To provide quantitative evidence on domestic distortions and the gains from trade, the model inevitably makes a number of assumptions which could be relaxed in further work. In particular, in this paper I treat intersectoral distortions as fixed and independent of the trade regime. In future research it would be interesting to distinguish between different types of distortions and relate them to actual policies and institutions. This would open up an interesting possibility that the magnitudes of domestic frictions and international trade flows are jointly determined. Perhaps one of the main benefits of international trade is that it tends to discipline the occurrence of domestic distortions.

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Table 1: Wedges

(A) Mean Wedge by Sector

Sector	Mean Wedge
Agriculture	1
Mining	4.84
Food	2.37
Textiles	1.40
Wood and Paper	2.12
Chemicals and Fuels	3.14
Minerals	2.38
Metals	2.79
Machinery	2.47
Transport Equipment	2.95
Other Manuf.	1.63
Utilities and Const.	2.29
Trade and Hospitality	1.82
Transport Services	2.77
FIRE	3.40
Social and Personal	2.20

(B) Dispersion of Wedges within Countries

Country Group	Coeff. of Var. of Wedges
Developing	1.00
Middle-income	0.51
Developed	0.37

Notes: Panel A: Geometric mean of wedge b/w the row sector and Agriculture, calculated across countries in the dataset. Panel B: Coefficient of variation of wedges across sectors within country, averaged within each country income group.

Table 2: Welfare Gains from Trade

Country	(1) GFT	(2) GFT^{ND}	(3) ΔGFT	(4) Υ	Country	(1) GFT	(2) GFT^{ND}	(3) ΔGFT	(4) Υ
Australia	9.02	6.56	2.47	0.974	Malaysia	28.86	27.38	1.48	0.980
Austria	21.45	20.96	0.49	0.994	Mexico	11.28	9.22	2.06	0.977
Bangladesh	12.24	14.85	-2.61	1.031	Morocco	20.71	24.69	-3.99	1.053
Belgium	33.17	33.65	-0.48	1.007	Nepal	7.27	8.16	-0.89	1.010
Brazil	1.19	3.99	-2.81	1.029	Netherlands	34.64	35.43	-0.79	1.012
Bulgaria	24.51	27.68	-3.18	1.044	New Zealand	10.57	10.04	0.53	0.994
Canada	13.45	12.00	1.45	0.984	Norway	21.34	12.08	9.27	0.895
Chile	34.66	24.14	10.52	0.861	Pakistan	4.50	8.66	-4.16	1.046
China	9.31	8.59	0.73	0.992	Peru	9.10	8.44	0.66	0.993
Colombia	9.65	9.52	0.12	0.999	Philippines	12.96	13.64	-0.68	1.008
Costa Rica	35.13	33.56	1.57	0.976	Poland	13.09	13.63	-0.54	1.006
Czech Republic	22.87	22.48	0.39	0.995	Portugal	14.68	14.73	-0.05	1.001
Denmark	23.74	22.36	1.39	0.982	Rest of World	28.98	17.68	11.30	0.863
Egypt	14.96	12.16	2.80	0.968	Romania	15.25	16.70	-1.44	1.017
Estonia	56.92	58.16	-1.25	1.030	Russia	14.02	6.92	7.10	0.924
Ethiopia	21.71	28.12	-6.41	1.089	Slovakia	38.93	37.73	1.19	0.981
Finland	15.03	13.25	1.78	0.980	Slovenia	28.37	27.32	1.05	0.986
France	8.93	8.68	0.25	0.997	South Africa	10.75	11.02	-0.27	1.003
Germany	13.36	12.02	1.34	0.985	Spain	9.10	8.97	0.13	0.999
Ghana	25.58	23.17	2.42	0.969	Sri Lanka	15.24	17.75	-2.51	1.031
Greece	5.11	7.40	-2.29	1.025	Sweden	12.97	12.93	0.04	1.000
Hungary	29.55	27.94	1.61	0.978	Switzerland	22.79	21.29	1.50	0.981
India	2.11	6.53	-4.42	1.047	Taiwan	16.04	17.90	-1.86	1.023
Indonesia	9.07	10.19	-1.12	1.013	Tanzania	16.00	24.15	-8.15	1.107
Ireland	19.63	17.61	2.01	0.976	Thailand	14.22	21.65	-7.44	1.095
Israel	15.59	15.83	-0.24	1.003	Turkey	6.91	8.36	-1.45	1.016
Italy	7.61	7.86	-0.25	1.003	United Kingdom	8.22	7.94	0.28	0.997
Japan	6.36	4.71	1.65	0.983	United States	2.79	2.96	-0.17	1.002
Korea	15.22	14.42	0.80	0.991	Viet Nam	19.89	26.21	-6.32	1.086
Latvia	29.80	31.26	-1.46	1.021	Developing	14.16	16.80	-2.63	1.035
Lithuania	28.35	30.35	-2.00	1.029	Middle-income	21.98	21.34	0.64	0.993
Malawi	7.62	31.02	-23.40	1.339	Developed	15.76	14.75	1.01	0.989
					Mean	17.25	17.62	-0.37	1.006
					Std. Dev.	10.57	10.45	4.62	0.062

Notes: GFT are welfare gains from trade expressed in percentage terms, $GFT \equiv 100\left(1 - C^A/C^T\right)$, where C^A/C^T is welfare (real consumption) in autarky relative to welfare with trade. GFT^{ND} are welfare gains from trade calculated in a model without distortions and Υ is the distortion adjustment term. $\Delta GFT = GFT - GFT^{ND} = (1-\Upsilon)\left(100 - GFT^{ND}\right)$. Bottom-right panel: means for each country income group as well as overall mean and standard deviation.

Table 3: Optimal Tariffs

Country	(1) Mean	(2) SD	(3) Gains	(4) GainsND	Country	(1) Mean	(2) SD	(3) Gains	(4) GainsND
Australia	3.1	20.0	0.49	0.61	Malaysia	21.1	24.5	3.05	2.39
Austria	16.1	16.5	1.81	1.51	Mexico	31.5	62.8	4.93	0.95
Bangladesh	65.6	80.7	5.50	3.73	Morocco	38.9	21.3	2.95	0.53
Belgium	22.4	5.0	2.37	2.74	Nepal	26.3	28.6	1.27	0.13
Brazil	40.6	42.3	2.89	0.30	Netherlands	27.0	42.1	2.73	1.93
Bulgaria	23.8	16.2	4.09	2.86	New Zealand	29.2	15.2	1.09	0.75
Canada	15.9	24.8	1.02	1.10	Norway	-2.7	50.6	1.95	0.91
Chile	14.1	29.8	2.03	0.86	Pakistan	46.9	41.0	2.30	0.35
China	14.5	33.6	11.32	1.09	Peru	17.2	36.0	5.76	0.55
Colombia	22.8	21.9	1.48	0.31	Philippines	11.6	19.3	2.71	1.43
Costa Rica	40.2	20.1	3.35	1.04	Poland	21.0	17.9	2.74	1.39
Czech Republic	24.5	4.0	3.08	2.82	Portugal	23.9	17.4	2.65	1.43
Denmark	36.2	64.3	1.07	1.08	Rest of World	9.5	48.6	5.87	1.22
Egypt	9.6	25.8	1.72	0.47	Romania	29.8	25.2	4.02	1.37
Estonia	29.0	11.8	3.68	2.96	Russia	0.5	35.3	6.46	0.75
Ethiopia	36.5	18.7	1.20	0.26	Slovakia	24.9	8.3	3.41	3.08
Finland	11.4	10.1	0.91	1.36	Slovenia	18.7	15.2	3.03	2.21
France	22.5	5.0	0.94	0.96	South Africa	20.0	26.7	3.60	0.94
Germany	16.9	9.5	0.99	1.32	Spain	21.9	7.0	1.07	1.04
Ghana	41.3	21.0	2.34	0.38	Sri Lanka	43.4	26.3	3.80	0.61
Greece	34.6	21.5	2.42	0.79	Sweden	15.8	8.8	0.73	1.22
Hungary	18.7	12.8	2.48	2.83	Switzerland	8.9	10.7	0.89	1.87
India	38.0	50.6	9.94	0.47	Taiwan	16.0	15.6	2.74	1.98
Indonesia	24.8	59.5	8.56	0.65	Tanzania	66.7	52.7	1.90	0.40
Ireland	10.2	15.6	1.57	1.51	Thailand	28.8	35.2	8.25	1.72
Israel	14.7	8.5	0.79	1.16	Turkey	25.9	21.8	3.23	0.97
Italy	23.4	9.8	1.10	0.94	United Kingdom	24.9	33.1	0.87	0.79
Japan	9.3	18.9	1.15	0.56	United States	19.3	15.8	0.58	0.54
Korea	14.1	9.9	5.39	2.74	Viet Nam	32.9	32.1	4.46	1.01
Latvia	32.0	12.8	3.47	1.79	Developing	39.2	38.4	4.79	0.82
Lithuania	21.6	15.8	2.25	1.76	Middle-income	22.9	20.2	3.35	1.78
Malawi	167.5	90.8	13.09	0.57	Developed	16.7	19.6	1.29	1.26
					Mean	26.5	26.3	3.17	1.28
					Std. Dev.			2.62	0.84

Notes: Mean and SD: Mean and standard deviation of unilaterally optimal tariffs across tradable sectors for each row country. Optimal tariffs are common across trading partners, can be negative (import subsidies), and are expressed in ad valorem percentage terms. Gains: welfare gains [in %] from unilaterally setting optimal tariffs. GainsND: welfare gains [in %] from unilaterally setting optimal uniform (across sectors and trading partners) tariffs in a model without distortions. Bottom-right panel: means for each country income group as well as overall mean and standard deviation.

Table 4: Optimal and Observed Tariffs

(A) Mean Tariff by Sector

Sector	(1) Mean Optimal Tariff	(2) Mean Observed Tariff
Agriculture	-12.3	7.0
Mining	62.6	1.1
Food	14.2	8.9
Textiles	17.4	9.7
Wood and Paper	22.9	3.6
Chemicals and Fuels	42.8	3.6
Minerals	32.4	11.7
Metals	34.6	3.4
Machinery	26.1	3.1
Transport Equipment	34.2	8.0
Other Manuf.	16.5	6.2

(B) Tariffs vs. Wedges

Dependent variable:	(1) Opt. Tariff $\ln\left(1+t^*_{j,s}\right)$	(2) Obs. Tariff $\ln\left(1+t_{j,s}\right)$	(3) Opt. Tariff $\ln\left(1+t^*_{j,s}\right)$	(4) Obs. Tariff $\ln\left(1+t_{j,s}\right)$
$\ln \xi_{j,s}$	0.283***	-0.018***	0.253***	-0.009*
	(0.013)	(0.004)	(0.013)	(0.005)
Country FE	Yes	Yes	Yes	Yes
Sector FE			Yes	Yes
Observations	671	671	671	671

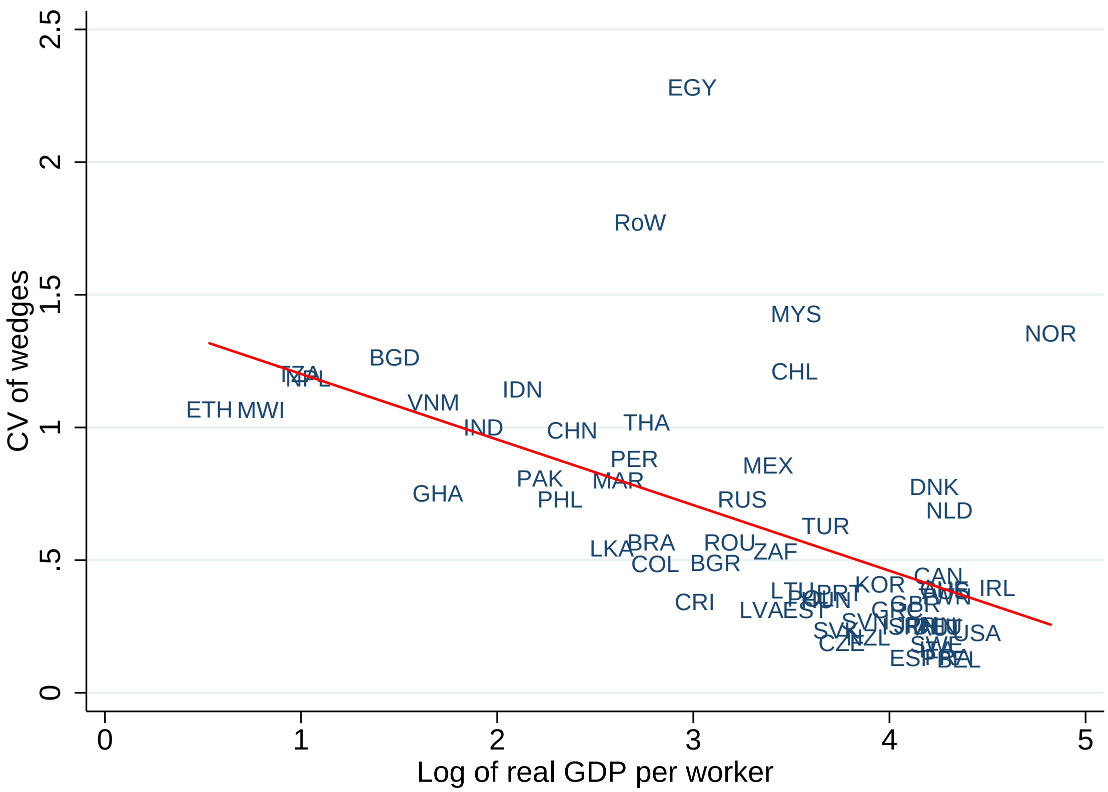
Notes: Panel A: Mean tariff across countries expressed in ad valorem percentage terms for each row sector. Unilaterally optimal tariffs (column 1) and observed tariffs (column 2) are uniform across trading partners. Panel B: Regression of the logarithm of (1+tariff) on the logarithm of wedges, with unilaterally optimal (columns 1 and 3) or observed (coulumns 2 and 4) tariff expressed in ad valorem terms. Robust standard errors in parentheses. Significance levels: * p<0.10, ** p<0.05, *** p<0.01.

Table 5: Removing Intersectoral Labor Distortions

Country	(1) Gains	(2) Gains^{CE}	(3) Gains^{CHN}	Country	(1) Gains	(2) Gains^{CE}	(3) Gains^{CHN}
Australia	10.4	5.2	0.0	Malaysia	51.4	35.5	0.1
Austria	8.8	3.8	-0.1	Mexico	28.2	23.4	0.0
Bangladesh	133.3	38.9	-0.2	Morocco	45.1	27.0	0.0
Belgium	26.7	0.9	0.0	Nepal	73.2	56.3	-0.1
Brazil	20.5	14.0	-1.1	Netherlands	26.3	15.1	0.2
Bulgaria	32.6	11.9	-0.1	New Zealand	17.4	2.8	0.3
Canada	10.8	7.2	0.0	Norway	11.6	14.1	0.1
Chile	66.0	45.4	-0.2	Pakistan	39.9	29.8	0.0
China	69.5	44.4	20.4	Peru	40.4	30.6	-0.1
Colombia	18.5	11.7	0.0	Philippines	35.7	24.3	-0.7
Costa Rica	33.4	7.4	0.1	Poland	15.4	6.9	0.0
Czech Republic	14.6	1.6	0.0	Portugal	21.8	8.0	-0.1
Denmark	19.1	6.0	-0.1	Rest of World	55.3	36.9	-1.0
Egypt	64.6	54.5	0.0	Romania	31.9	16.1	-0.1
Estonia	33.6	5.2	0.1	Russia	15.5	20.0	-1.3
Ethiopia	69.8	41.0	0.7	Slovakia	14.8	2.9	0.0
Finland	11.1	2.5	-0.2	Slovenia	11.3	4.6	-0.1
France	6.6	1.0	0.0	South Africa	29.5	13.7	-0.4
Germany	7.4	2.9	0.0	Spain	9.7	1.0	0.0
Ghana	58.1	26.0	0.3	Sri Lanka	43.2	16.0	-0.3
Greece	18.3	4.9	-0.1	Sweden	5.8	1.6	0.0
Hungary	17.7	7.4	0.1	Switzerland	8.2	6.6	-0.1
India	79.2	48.3	-1.0	Taiwan	24.3	9.7	0.1
Indonesia	52.6	45.4	-1.5	Tanzania	91.4	57.7	-0.9
Ireland	12.4	6.9	0.0	Thailand	78.1	50.0	-3.3
Israel	14.0	3.8	0.0	Turkey	32.3	18.5	0.0
Italy	8.8	1.5	0.0	United Kingdom	6.0	4.4	0.0
Japan	8.7	3.6	-0.1	United States	8.8	2.9	0.0
Korea	24.5	8.7	-0.3	Viet Nam	59.5	46.1	-2.8
Latvia	21.5	5.6	0.0	Developing	59.9	36.2	-0.6*
Lithuania	20.4	6.8	-0.1	Middle-income	25.9	12.5	-0.1
Malawi	97.6	53.2	0.0	Developed	12.3	5.0	0.0
				Mean	33.2	18.2	0.1
				Std. Dev.	27.0	17.6	2.7

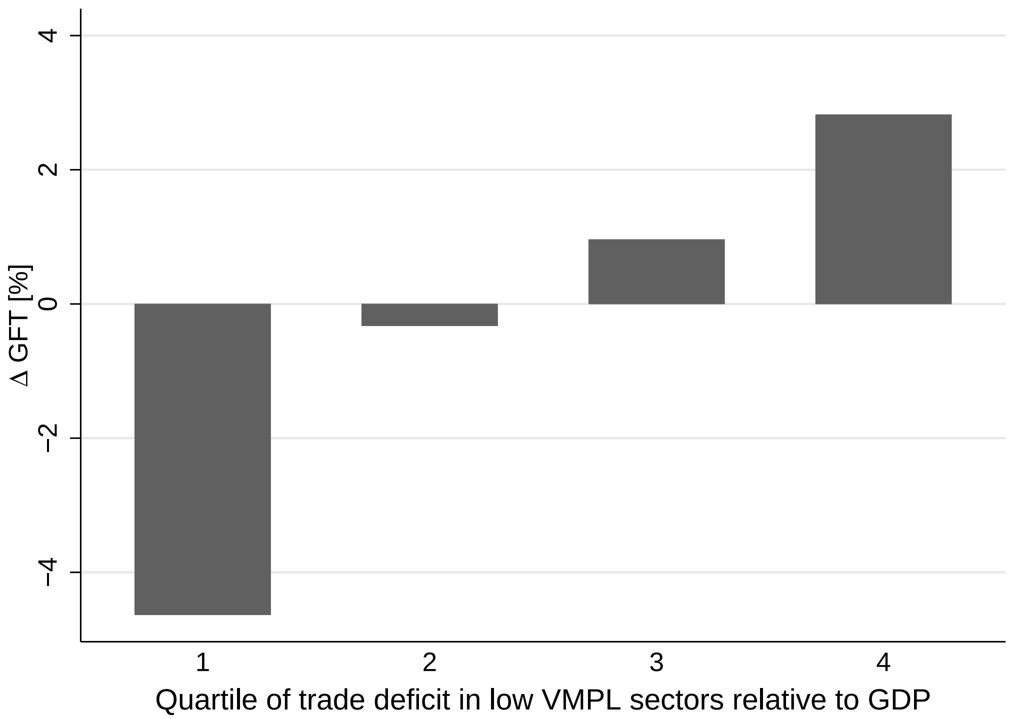
Notes: Gains: welfare gains [in %] from removing intersectoral distortions simultaneously in all countries. Gains^{CE}: welfare gains [in %] from removing distortions in a closed economy. Gains^{CHN}: welfare gains [in %] in a counterfactual with China reducing wedges between agriculture and other sectors by half. Bottom-right panel: means for each country income group as well as overall mean and standard deviation.*Developing countries excluding China.

Figure 1: Dispersion of Wedges



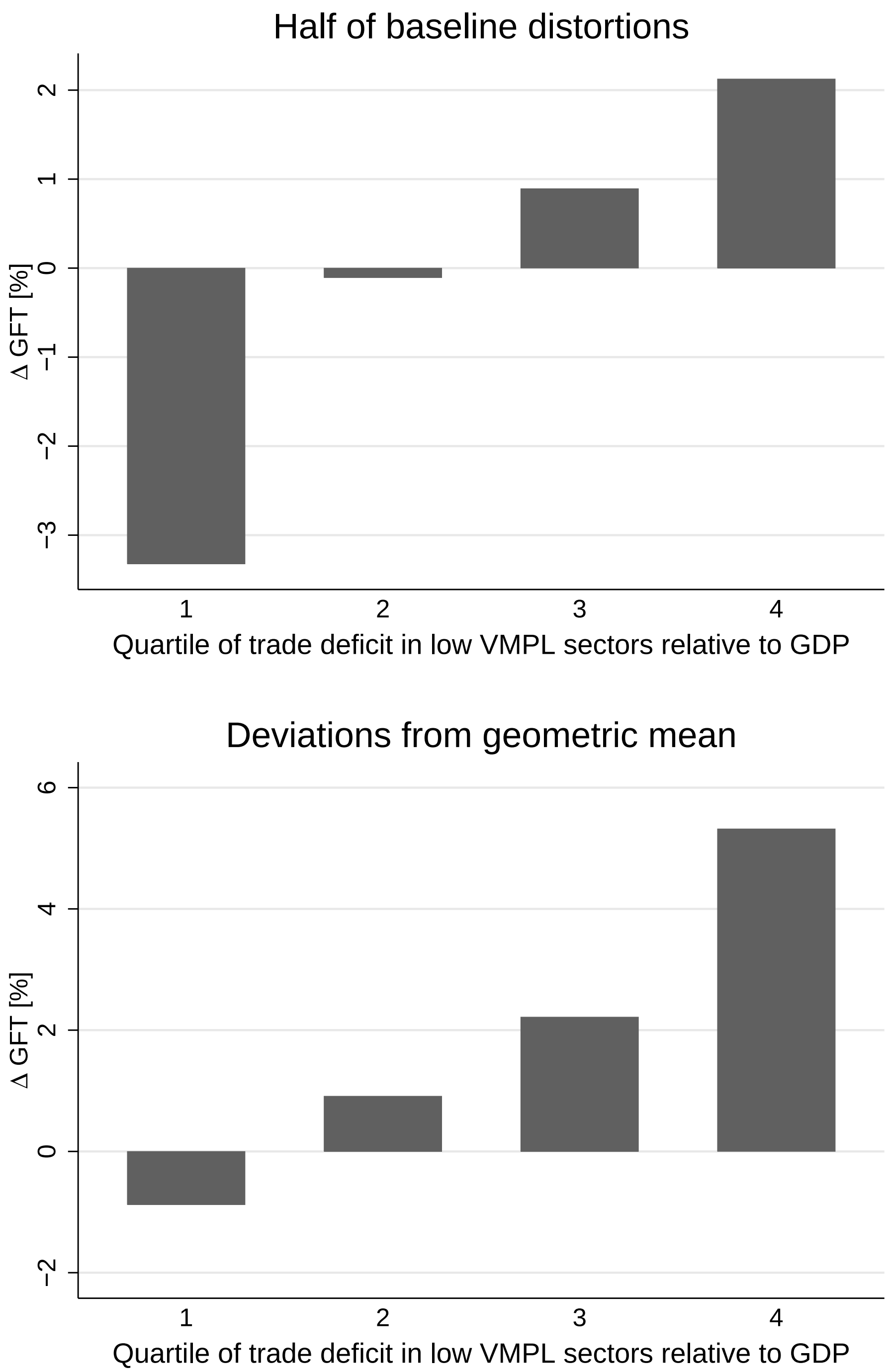
Notes: Red solid lines present the best linear fit between the coefficient of variation of wedges (employment-weighted) within a country and the logarithm of country's real income (real GDP per worker).

Figure 2: Comparison of Welfare Gains from Trade



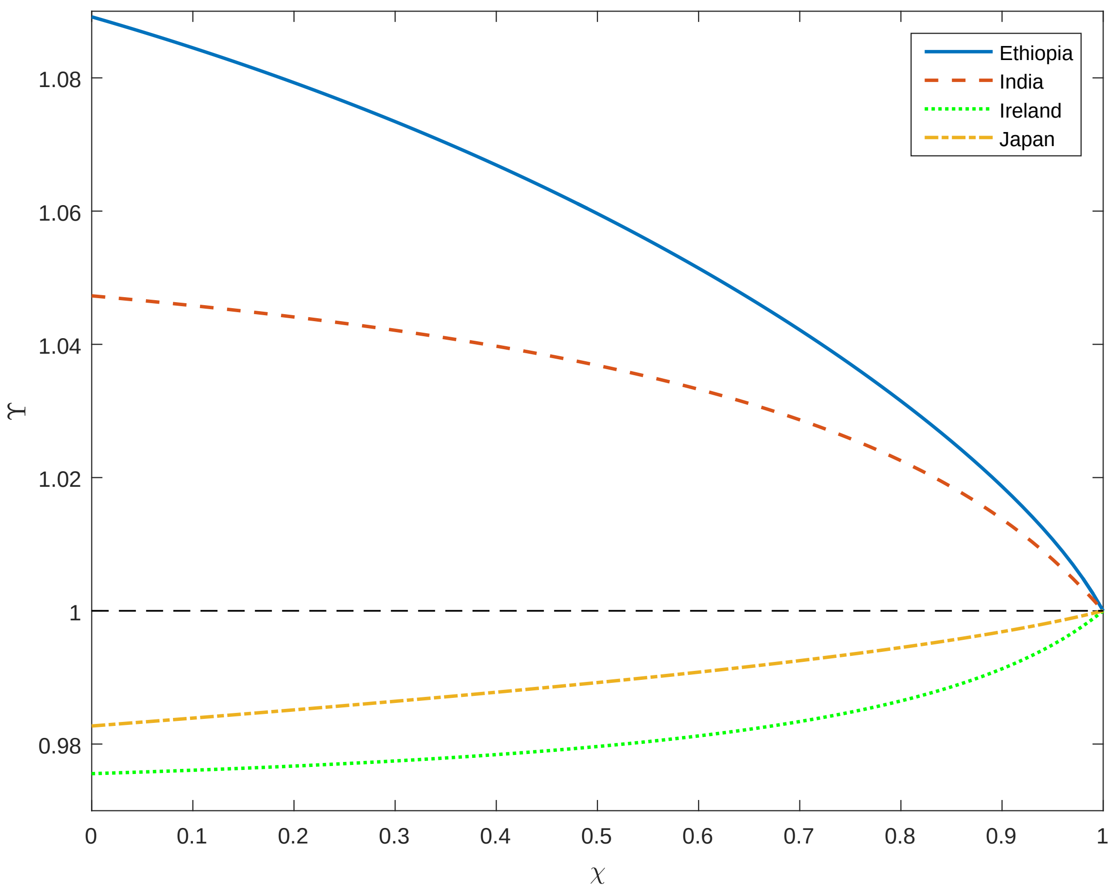
Notes: $\Delta GFT = GFT - GFT^{ND}$ is the difference between welfare gains from trade in a model with intersectoral distortions and in a model ignoring distortions.

Figure 3: Comparison of Welfare Gains from Trade for Alternative Measures of Wedges



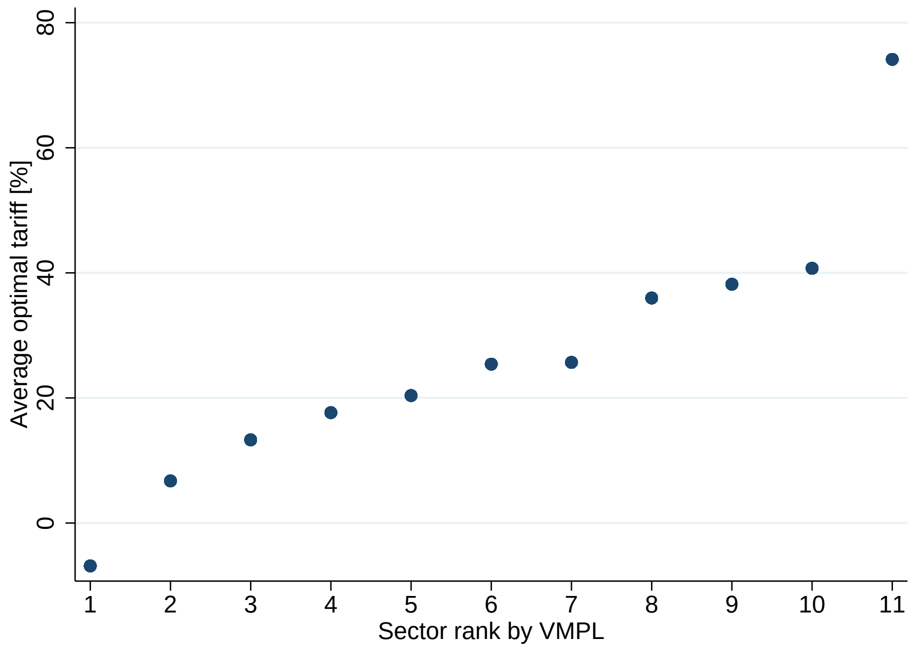
Notes: $\Delta GFT = GFT - GFT^{ND}$ is the difference between welfare gains from trade in a model with various measures of intersectoral distortions and in a model ignoring distortions.

Figure 4: Υ and Magnitude of Distortions



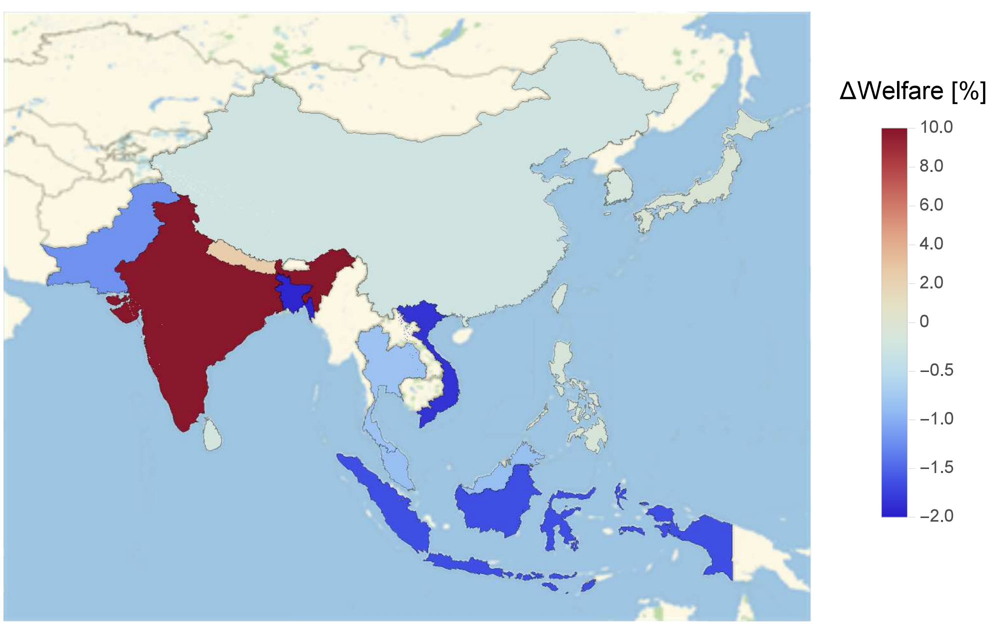
Notes: Υ as a function of χ, with wedges set as $\xi'_{j,s} = (1-\chi)\,\xi_{j,s} + \chi$ and $\xi_{j,s}$ representing the baseline wedges.

Figure 5: Optimal Tariffs



Notes: Figure constructed by ranking tradable sectors 1-11 by increasing $VMPL$ in each country and then taking the average (across countries) of optimal tariffs for each of the sector ranks.

Figure 6: Welfare Effects of India Imposing Unilaterally Optimal Tariffs



Notes: Percentage change in welfare in South and East Asian countries as a consequence of India imposing unilaterally optimal tariffs.

Appendix

Sample Coverage

The sample used in this paper covers 16 sectors listed in Table A.1 for 60 countries listed in Table A.2 (plus a constructed Rest of the World) for the year 2006.

Table A.1: Sectors

No.	Sector	Sector Description	ISIC Rev. 3
1	Agriculture	Agriculture, hunting forestry and fishing	A to B
2	Mining	Mining and quarrying	C
3	Food	Food products, beverages and tobacco	D: 15-16
4	Textiles	Textiles, textile products, leather and footwear	D: 17-19
5	Wood and Paper	Wood and paper products, printing and publishing	D: 20-22
6	Chemicals and Fuels	Chemical, rubber, plastics and fuel products	D: 23-25
7	Minerals	Other non-metallic mineral products	D: 26
8	Metals	Basic metals and fabricated metal products	D: 27-28
9	Machinery	Machinery and equipment	D: 29-33
10	Transport Equipment	Transport equipment	D: 34-35
11	Other Manuf.	Manufacturing n.e.c.; Recycling	D: 36-37
12	Utilities and Const.	Utilities and construction	E to F
13	Trade and Hospitality	Wholesale and retail trade, hotels and restaurants	G to H
14	Transport Services	Transport, storage and communications	I
15	FIRE	Finance, insurance, real estate and business activities	J to K
16	Social and Personal	Community, social and personal services	L to P

Supplemental Model Derivations

Equilibrium in Relative Changes

An equilibrium in relative changes satisfies the following system of equations (analogous to the system in levels in Section 2.4):

$$\hat{c}_{i,s} = \left(\hat{w}_{i,1}\hat{\xi}_{i,s}\right)^{1-\alpha_{i,s}} \prod_{k=1}^{S} \hat{P}_{i,k}^{\alpha_{i,ks}},$$

$$\hat{P}_{j,s} = \left[\sum_i \pi_{ij,s}\left(\hat{c}_{i,s}\hat{\tau}_{ij,s}\right)^{-\theta_s}\right]^{-\frac{1}{\theta_s}},$$

$$\hat{\pi}_{ij,s} = \frac{\left(\hat{c}_{i,s}\hat{\tau}_{ij,s}\right)^{-\theta_s}}{\sum_m \pi_{mj,s}\left(\hat{c}_{m,s}\hat{\tau}_{mj,s}\right)^{-\theta_s}},$$

$$\hat{E}_{j,s}E_{j,s} = \beta_{j,s}\left(\hat{Y}_j Y_j\left(1+\hat{\delta}_j\delta_j\right) + \sum_k\sum_i \frac{t'_{ij,k}}{1+t'_{ij,k}}\hat{\pi}_{ij,k}\pi_{ij,k}\hat{E}_{j,k}E_{j,k}\right) + \sum_{k=1}^{S}\alpha_{j,sk}\sum_{i=1}^{N}\frac{1}{1+t'_{ji,k}}\hat{\pi}_{ji,k}\pi_{ji,k}\hat{E}_{i,k}E'_{i,k},$$

Table A.2: Countries

Country	Code	Group	Country	Code	Group	Country	Code	Group
Australia	AUS	3	Greece	GRC	2	Peru	PER	1
Austria	AUT	3	Hungary	HUN	2	Philippines	PHL	1
Bangladesh	BGD	1	India	IND	1	Poland	POL	2
Belgium	BEL	3	Indonesia	IDN	1	Portugal	PRT	2
Brazil	BRA	1	Ireland	IRL	3	Romania	ROU	2
Bulgaria	BGR	2	Israel	ISR	3	Russia	RUS	2
Canada	CAN	3	Italy	ITA	3	Slovakia	SVK	2
Chile	CHL	2	Japan	JPN	3	Slovenia	SVN	2
China	CHN	1	Korea	KOR	2	South Africa	ZAF	2
Colombia	COL	1	Latvia	LVA	2	Spain	ESP	3
Costa Rica	CRI	1	Lithuania	LTU	2	Sri Lanka	LKA	1
Czech Republic	CZE	2	Malawi	MWI	1	Sweden	SWE	3
Denmark	DNK	3	Malaysia	MYS	2	Switzerland	CHE	3
Egypt	EGY	1	Mexico	MEX	2	Taiwan	TWN	3
Estonia	EST	2	Morocco	MAR	1	Tanzania	TZA	1
Ethiopia	ETH	1	Nepal	NPL	1	Thailand	THA	1
Finland	FIN	3	Netherlands	NLD	3	Turkey	TUR	2
France	FRA	3	New Zealand	NZL	2	United Kingdom	GBR	3
Germany	DEU	3	Norway	NOR	3	United States	USA	3
Ghana	GHA	1	Pakistan	PAK	1	Viet Nam	VNM	1

Notes: Group: Tercile of real GDP per worker within the sample.

$$\hat{L}_{i,s}L_{i,s} = \frac{(1-\alpha_{i,s})}{\hat{w}_{i,1}w_{i,1}\hat{\xi}_{i,s}\xi_{i,s}} \sum_{j=1}^{N} \frac{\hat{\pi}_{ij,s}\pi_{ij,s}}{1+t'_{ij,s}} \hat{E}_{j,s}E_{j,s},$$

$$\sum_{s} \hat{L}_{i,s}L_{i,s} = L_i,$$

$$\hat{Y}_i Y_i = \sum_{s=1}^{S} \hat{w}_{i,1}w_{i,1}\hat{\xi}_{i,s}\xi_{i,s}\hat{L}_{i,s}L_{i,s}.$$

The choice of world GDP as numeraire imposes as a normalization that $\sum_i \hat{Y}_i Y_i = 1$.

Derivation of the Closed Form Formula for Υ

Let $l_{j,s}$ and $y_{j,s}$ be the employment and value added share of sector s in country j. When labor is the only primary factor of production, for given wedges $\{\xi_{j,s}\}$ the two shares are linked as:

$$l_{j,s} = \frac{\frac{y_{j,s}}{\xi_{j,s}}}{\sum_k \frac{y_{j,k}}{\xi_{j,k}}}.$$

Using this relationship we can express Υ as

$$\Upsilon_j = \frac{\sum_s \xi_{j,s} l_{j,s}^A}{\sum_s \xi_{j,s} l_{j,s}^T} = \frac{\sum_s \frac{y_{j,s}^T}{\xi_{j,s}}}{\sum_s \frac{y_{j,s}^A}{\xi_{j,s}}}.$$

This means that Υ can be interpreted as a value-added-weighted harmonic mean wedge in autarky equilibrium relative to trade equilibrium.

While the value added shares in the trade equilibrium $y_{j,s}^T$ can be directly observed, the value added shares in autarky are not. The next step is therefore to find the counterfactual $y_{j,s}^A$ using the structure of the model. Using (7) and noting that in a closed economy $R_{j,s} = E_{j,s}$, we can write the sectoral expenditures as

$$E_{j,s}^A = \beta_{j,s} \sum_{k=1}^{S} Y_{j,k}^A + \sum_{k=1}^{S} \alpha_{j,sk} E_{j,k}^A.$$

This expression can be rewritten as

$$\frac{Y_{j,s}^A}{1-\alpha_{j,s}} = \beta_{j,s} \sum_k Y_{j,k}^S + \sum_k \alpha_{j,sk} \frac{Y_{j,k}^A}{1-\alpha_{j,k}}.$$

Dividing sides by Y_j^A to get value added shares $y_{j,s}^A$ and noting that the shares sum to one gives

$$\frac{y_{j,s}^A}{1-\alpha_{j,s}} = \beta_{j,s} + \sum_k \alpha_{j,sk} \frac{y_{j,k}^A}{1-\alpha_{j,k}},$$

which can be expressed in matrix form as

$$(I - A)\, \tilde{\mathbf{y}}_{\mathbf{j}}^A = \beta_{\mathbf{j}},$$

where $A \equiv \{\alpha_{j,ks}\}$ is the direct input requirement matrix and where $\tilde{y}_{j,s}^A \equiv y_{j,s}^A / (1 - \alpha_{j,s})$. This linear system can be inverted to give

$$\tilde{\mathbf{y}}_j^A = (I - A)^{-1} \beta_j,$$

or

$$y_{j,s}^A = (1 - \alpha_{j,s}) \sum_k a_{j,sk} \beta_{j,k},$$

where $a_{j,sk}$ is the (s,k) entry of the Leontief inverse matrix $(I - A_j)^{-1}$. Plugging this expression in (13) we obtain (14), which is the desired result.

Online Appendix

A Data Appendix

In this Appendix I document the sources of the data and outline the construction of variables used in my quantitative analysis. Unless noted otherwise all data is for the year 2006.

The dataset collects information for 16 sectors for a sample of 60 countries plus a constructed Rest of the World. The 16 sectors based on an aggregation of 2-dig ISIC Rev. 3 industries are listed in Table A.1. The countries are listed in Table A.2.

Table A.1: Sectors

No.	Sector	Sector Description	ISIC Rev. 3
1	Agriculture	Agriculture, hunting forestry and fishing	A to B
2	Mining	Mining and quarrying	C
3	Food	Food products, beverages and tobacco	D: 15-16
4	Textiles	Textiles, textile products, leather and footwear	D: 17-19
5	Wood and Paper	Wood and paper products, printing and publishing	D: 20-22
6	Chemicals and Fuels	Chemical, rubber, plastics and fuel products	D: 23-25
7	Minerals	Other non-metallic mineral products	D: 26
8	Metals	Basic metals and fabricated metal products	D: 27-28
9	Machinery	Machinery and equipment	D: 29-33
10	Transport Equipment	Transport equipment	D: 34-35
11	Other Manuf.	Manufacturing n.e.c.; Recycling	D: 36-37
12	Utilities and Const.	Utilities and construction	E to F
13	Trade and Hospitality	Wholesale and retail trade, hotels and restaurants	G to H
14	Transport Services	Transport, storage and communications	I
15	FIRE	Finance, insurance, real estate and business activities	J to K
16	Social and Personal	Community, social and personal services	L to P

A.1 Production and Employment Data

Data on sectoral gross output $R_{j,s}$, value added $Y_{j,s}$ and employment $L^D_{j,s}$ comes from four databases (in order of preference): World Input Output Database (WIOD) (Timmer et al. (2015)), OECD STAN Database (OECD (2011)), GGDC 10-Sector Database (Timmer et al. (2014)), and APO Productivity Database (APO (2015)). The primary source of sectoral data for each country is listed in Table A.2. Gross output and value added are measured in current U.S. dollars (for GGDC and APO values in local currency are converted using average 2006 market exchange rate from the IMF) and employment is measured as number of persons engaged. GGDC and APO databases do not contain information on gross output and only have data for the total manufacturing sector. Gross output is thus imputed based on the median values of the ratio of value added to gross output by sector $1 - \alpha_{j,s}$ in WIOD countries. To obtain disaggregated data for manufacturing sectors in GGDC and APO countries, value added and employment are allocated to individual sectors based on their respective shares in total manufacturing values in UNIDO INDSTAT2 database (UNIDO (2015)) in 2006 or the closest available year.

Table A.2: Countries

Country	Code	Source	Group	Country	Code	Source	Group
Australia	AUS	WIOD	3	Lithuania	LTU	WIOD	2
Austria	AUT	WIOD	3	Malawi	MWI	GGDC	1
Bangladesh	BGD	APO	1	Malaysia	MYS	GGDC	2
Belgium	BEL	WIOD	3	Mexico	MEX	WIOD	2
Brazil	BRA	WIOD	1	Morocco	MAR	GGDC	1
Bulgaria	BGR	WIOD	2	Nepal	NPL	GGDC	1
Canada	CAN	WIOD	3	Netherlands	NLD	WIOD	3
Chile	CHL	GGDC	2	New Zealand	NZL	STAN	2
China	CHN	WIOD	1	Norway	NOR	STAN	3
Colombia	COL	GGDC	1	Pakistan	PAK	APO	1
Costa Rica	CRI	GGDC	1	Peru	PER	GGDC	1
Czech Republic	CZE	WIOD	2	Philippines	PHL	GGDC	1
Denmark	DNK	WIOD	3	Poland	POL	WIOD	2
Egypt	EGY	GGDC	1	Portugal	PRT	WIOD	2
Estonia	EST	WIOD	2	Romania	ROU	WIOD	2
Ethiopia	ETH	GGDC	1	Russia	RUS	WIOD	2
Finland	FIN	WIOD	3	Slovakia	SVK	WIOD	2
France	FRA	WIOD	3	Slovenia	SVN	WIOD	2
Germany	DEU	WIOD	3	South Africa	ZAF	GGDC	2
Ghana	GHA	GGDC	1	Spain	ESP	WIOD	3
Greece	GRC	WIOD	2	Sri Lanka	LKA	APO	1
Hungary	HUN	WIOD	2	Sweden	SWE	WIOD	3
India	IND	WIOD	1	Switzerland	CHE	STAN	3
Indonesia	IDN	WIOD	1	Taiwan	TWN	WIOD	3
Ireland	IRL	WIOD	3	Tanzania	TZA	GGDC	1
Israel	ISR	STAN	3	Thailand	THA	GGDC	1
Italy	ITA	WIOD	3	Turkey	TUR	WIOD	2
Japan	JPN	WIOD	3	United Kingdom	GBR	WIOD	3
Korea	KOR	WIOD	2	United States	USA	WIOD	3
Latvia	LVA	WIOD	2	Viet Nam	VNM	GGDC	1

Notes: Source: Primary source of sectoral production and employment data. Group: Tercile of real GDP per worker within the sample.

Input-output coefficients $\alpha_{j,ks}$ for WIOD countries are computed directly as shares of intermediate input from sector k in the total intermediate consumption of sector s, ensuring that the shares of total intermediate consumption sum to $\alpha_{j,s}$. For all other countries, input-output coefficients are imputed through their median values among WIOD countries, but rescaled so their sum is equal to $\alpha_{j,s}$.

A.2 International Trade Data

Bilateral trade data $M_{ij,s}$ comes from from the CEPII BACI database (Gaulier and Zignago (2010)). Trade flows at the 6-digit HS rev.2 (2002) level are converted to 4-digit ISIC rev.3 sectors using a concordance table available from World Integrated Trade Solutions (WITS) of the World Bank, and then aggregated up to sectors 1-11 treated as tradable in this paper. Tariff data comes from the UNCTAD Trade Analysis and Information System (TRAINS) accessible via WITS. Tariffs $t_{ij,s}$ correspond to effectively applied tariffs and are collected at the 4-digit ISIC rev.3 level. Bilateral tariffs at that level are then weighted by trade flows to calculate an average applied tariff for each importer in each of the 11 tradable sectors.

A.3 Derived Measures

Given production and trade data, the unobserved domestic sales of an industry (imports from home) are calculated implicitly as the the difference between gross output and exports, $M_{jj,s} = R_{j,s} - \sum_{i \neq j} M_{ji,s}$. For a small number of country-sector observations this procedure generates negative values, perhaps because reexports are not properly accounted for in the data. In those cases, following the lead of Costinot et al. (2012), exports to all partner countries are rescaled proportionally until the ratio of exports to gross output is as in the sector with the highest ratio still less than one in the country.

Sectoral expenditures are computed by adding all import flows (including from home) and tariff payments in the sector, $E_{j,s} = \sum_i X_{ij,s} = \sum_i (1 + t_{ij,s}) M_{ij,s}$. Sectoral final demand is then calculated as the difference between sectoral expenditure and expenditure on intermediates from that sector, $F_{j,s} = E_{j,s} - \sum_k \alpha_{j,sk} R_{j,k}$. This procedure generates negative values of sectoral final demand for some observations, most commonly in sectors like Mining where the true final consumption is very small. In those cases raw data is subjected to a two-step adjustment. First, trade flows are adjusted so that sectoral value added exceeds sectoral trade surplus, which guarantees that final demand is positive in the absence of intersectoral linkages (i.e. with diagonal input-output matrix). Second, for country-sectors with negative final demand the use of these sectors as inputs to other sectors is lowered. This is achieved by shifting the weight in input-output matrix away from the problematic sector towards the diagonal (in a way that preserves the total share of intermediate consumption in each country-sector and hence does not affect gross output and value added). This adjustment procedure is performed iteratively in small steps until final demand is positive for all observations. In practice, the required adjustments to the input-output matrices are small: averaged across countries the maximum (across sectors) change in the diagonal term $\alpha_{j,ss}$ is 0.044. These adjustments have quantitatively negligible effect on the substantive results of the paper.

A.4 Aggregate Data

Version 8.1 of the Penn World Table (Feenstra and Timmer (2015)) is used to derive a measure of real income per worker. Specifically, real GDP per worker is constructed as real output side

GDP at current international prices (*cgdpo*) from the PWT divided by total employment (from summing sectoral employment levels). Classification of countries based on terciles of this measure into developing, middle-income, and developed countries is reported in Table A.2.

B Alternative Measures of Wedges

The model in this paper assumes that homogenous labor is the only primary factor of production. In this Appendix I show that the baseline empirical measure of wedges (15) (i) takes account of other factors of production; and (ii) is robust to allowing for labor heterogeneity in terms of broad skill groups.

Suppose that production requires inputs of homogeneous labor and capital (additional factors of production could be accommodated in a similar way). Specifically, capital and labor are combined using Cobb-Douglas technology with constant returns to scale, so that the the cost of an input bundle for a producer in sector s in country i (multiple-factor analogue of (1)) is given by

$$c_{i,s} = \left(w_{i,s}^{\eta_s} r_{i,s}^{1-\eta_s}\right)^{1-\alpha_{i,s}} \prod_{k=1}^{S} P_{i,k}^{\alpha_{i,ks}},$$

where $r_{i,s}$ is the rental cost of capital and η_s is the share of labor in value added in sector s. Labor share is sector-specific but assumed to be common for all countries, as is standard in development accounting literature.

Under those assumptions we can use the data on sector value added $Y_{i,s}$ and employment $L_{i,s}$ to compute the correct measure of the labor wedge as

$$\xi_{i,s} = \frac{VMPL_{i,s}}{VMPL_{i,1}} = \frac{w_{i,s}}{w_{i,1}} = \frac{\eta_s}{\eta_1}\frac{Y_{i,s}/L_{i,s}}{Y_{i,1}/L_{i,1}}.$$

Observe that given factor shares, value added and employment data are sufficient to calculate the wedge between $VMPL$ across sectors, regardless of whether there are distortions to capital allocation (whether r differs across sectors or not). In order to identify capital distortions in a similar way we would need data on capital stocks by sector, which is only available for a small set of countries. But lack of this data does not prevent us from calculating the correct labor wedges.

A separate concern is that measured labor wedges might be driven primarily by differences in labor quality across sectors. In Section 3.2 I discuss the literature suggesting otherwise, and here I explicitly calculate alternative measures of wedges that take into account two dimensions of heterogeneity across sectors: differences in broad skills and in hours worked. This calculation is possible for the WIOD subset of my sample, as for those countries we have information on hours worked and on labor compensation split by three skill groups (High, Medium and Low). I therefore calculate three new sets of wedges: for each skill group $g \in \{L, M, H\}$ I directly compare the labor compensation of $g-$skilled workers per hour in sector s relative to sector 1.

Column 1 of Table B.1 reports the geometric mean of the baseline wedge by sector, calculated for the WIOD subsample. Columns 2-4 report the mean wedges for each of the three skill groups. While the magnitude of the wedges tends to be reduced by controlling for skills in this fashion, large differences across sectors remain. As the last row reports, within-country dispersion of wedges for each skill group is 2/3 as large as dispersion of baseline wedges. Thus even within the same skill group firms in different sectors appear to be facing significantly different hourly labor costs.

Table B.1: Skill-Adjusted Wedges

Sector	(1) Baseline	(2) $L-$skill	(3) $M-$skill	(4) $H-$skill
	Mean Wedge			
Agriculture	1	1	1	1
Mining	3.68	2.59	2.66	2.76
Food	2.05	1.63	1.69	1.76
Textiles	1.44	1.19	1.23	1.29
Wood and Paper	1.99	1.56	1.62	1.68
Chemicals and Fuels	2.99	2.27	2.38	2.51
Minerals	2.15	1.78	1.81	1.90
Metals	2.42	1.84	1.90	1.94
Machinery	2.61	1.96	2.03	2.12
Transport Equipment	2.89	2.07	2.16	2.22
Other Manuf.	1.59	1.24	1.27	1.31
Utilities and Const.	2.17	1.63	1.73	1.90
Trade and Hospitality	1.77	1.34	1.38	1.47
Transport Services	2.49	1.82	1.85	1.94
FIRE	2.95	1.71	1.98	2.12
Social and Personal	2.08	1.46	1.67	1.73
	Correlation with Baseline			
	-	0.54	0.57	0.54
	Coefficient of Variation (Mean)			
	0.43	0.30	0.28	0.31

Notes: Mean Wedge: Geometric mean of wedge b/w the row sector and Agriculture, calculated across 37 WIOD countries in the dataset. Correlation with Baseline wedges calculated across sectors and 37 WIOD countries. All correlations are significant at a level below 0.0001. Coefficient of Variation (Mean): Within-country Coefficient of Variation of wedges averaged across 37 WIOD countries.

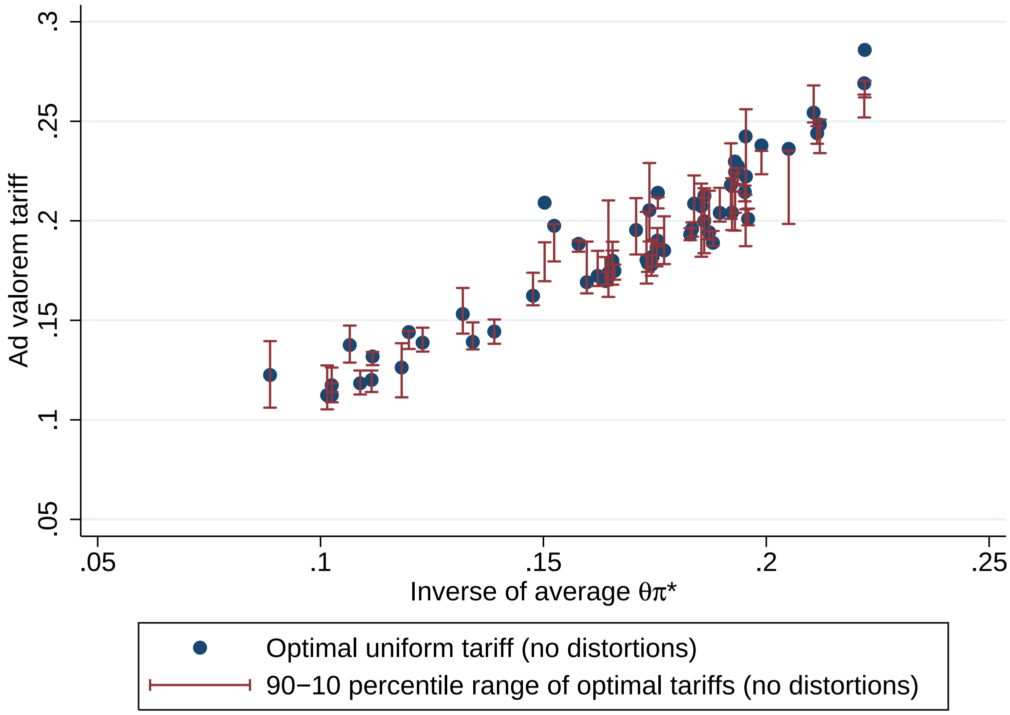
Furthermore, all skill-adjusted measures of distortions are strongly positively correlated with the baseline wedges used in the paper.

C Sectoral Trade Elasticities

In this Appendix I report the main results for trade policy simulations when trade elasticities differ by sector. The first column in Panel A of Table C.1 lists the values of $\{\theta_s\}$ used in the counterfactuals. The dispersion parameters (which are equal to (minus) partial trade elasticity) are based on Caliendo and Parro (2015) for sectors with a clear correspondence to sectors used in this paper. For the remaining sectors (Wood and Paper, Chemicals and Fuels, Machinery) the elasticities are estimated on Caliendo and Parro's data using their methodology. For Chemicals and Fuels the estimated θ is negative and is therefore replaced with $\theta = 5$. The same value is also used for nontradable sectors, though dispersion of productivity in nontradables does not affect any calculations.

The remaining columns of Table C.1A show optimal tariffs by sector in a model with distortions and without distortions, averaged across countries. The main point is that without distortions

Figure C.1: Optimal Tariffs without Distortions: Uniform and Unconstrained



Notes: Each dot represents an optimal uniform ad valorem tariff in one country calculated in the absence of inter-sectoral distortions. Each bar represents a range of sectoral tariffs in a corresponding unconstrained optimization. The range excludes the highest and lowest tariff to reduce the risk of relying on sectors with little trade and hence solutions with lower numerical accuracy. The horizontal axis shows an inverse of $\overline{\theta\pi_{jj}^{*}}$, where $\overline{\theta\pi_{jj}^{*}}$ is an average of $\theta_s\pi_{jj,s}^{*}$ weighted by sector's s share in exports of country j and $\pi_{jj,s}^{*}$ is the share of expenditure in countries other than j on sector s goods coming from countries other than j. Values on the horizontal axis can be interpreted as a simple approximation to optimal uniform tariffs.

tariffs are similar across sectors and, in particular, are not sensitive to sector's own θ_s. In contrast, with distortions there are large differences in optimal tariffs across sectors. Panel C shows that high tariffs are correlated with high wedges and are not driven by low own-sector trade elasticity (if anything, sectoral tariffs and elasticities tend to be positively correlated conditional on country's average tariff). Panel B and Figure C.1 further make the point that the wedges are the main determinant of optimal tariffs, as discussed in the main text.

Table C.1: Optimal Tariffs with Heterogeneity in θ_s

(A) Productivity Dispersion and Optimal Tariffs across Sectors

Sector	(1) θ_s	(2) Mean Opt. Tariff	(3) Mean Opt. Tariff$^{\text{ND}}$
Agriculture	8.11	-16.8	18.6
Mining	15.72	103.2	17.9
Food	2.55	11.9	19.2
Textiles	5.56	11.8	18.5
Wood and Paper	7.36	16.4	18.1
Chemicals and Fuels	5.00	34.9	18.5
Minerals	2.76	21.2	18.6
Metals	7.99	27.1	17.6
Machinery	5.98	18.0	17.9
Transport Equipment	1.01	23.5	25.7
Other Manuf.	5.00	8.7	18.2

(B) Optimal Tariffs across Countries

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	With distortions			No distortions			No distortions: uniform	
	Mean	SD	Gains	Mean	SD	Gains	Mean	Gains
Developing	32.1	52.4	11.21	16.2	0.9	0.52	16.1	0.52
Middle-income	22.9	30.3	4.74	19.7	3.4	1.46	19.4	1.41
Developed	15.4	32.8	1.96	21.1	3.3	1.02	20.8	0.99
Mean	23.6	38.8	6.05	19.0	2.5	0.99	18.7	0.96
Std. Dev.			6.82			0.84		0.79

(C) Optimal Tariffs vs. Wedges

	(1)	(2)	(2)
	Opt. Tariff	Opt. Tariff	Opt. Tariff
Dependent variable:	$\ln\left(1+t^*_{j,s}\right)$	$\ln\left(1+t^*_{j,s}\right)$	$\ln\left(1+t^*_{j,s}\right)$
$\ln \xi_{j,s}$	0.330***	0.329***	0.279***
	(0.021)	(0.020)	(0.023)
$\ln \theta_s$		0.058***	
		(0.014)	
Country FE	Yes	Yes	Yes
Sector FE			Yes
Observations	671	671	671

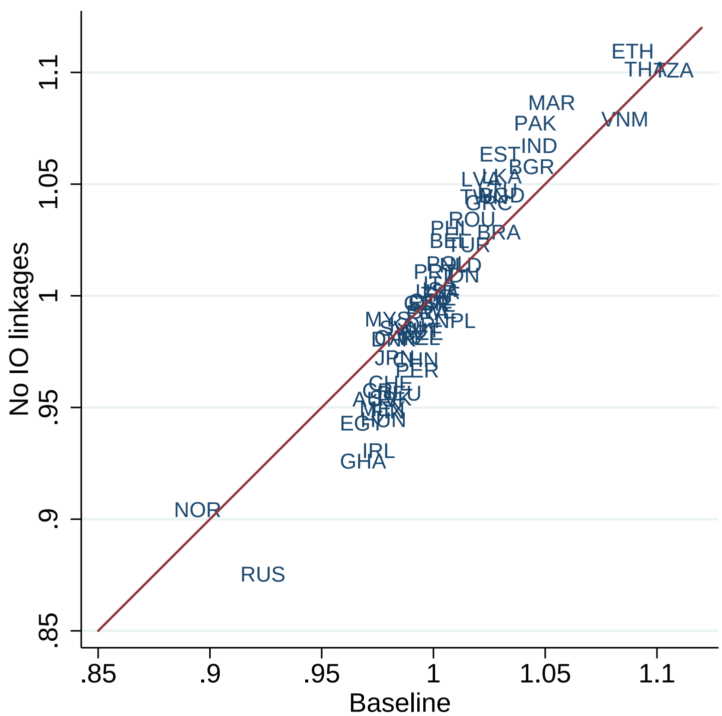
Notes: Panel A: θ_s: Productivity dispersion parameter based on Caliendo and Parro (2015). Mean Opt. Tariff: unilaterally optimal tariff in a model with distortions (col. 2) and without distortions (col. 3) averaged across countries expressed in ad valorem percentage terms. Panel B: Mean and SD: Mean and standard deviation of unilaterally optimal tariffs (expressed in ad valorem percentage terms) across tradable sectors within each country, averaged across the country group given in the row. Gains: welfare gains [in %] from unilaterally setting optimal tariffs. Sector-specific tariffs in a model with distortions (col. 1-3) and without distortions (col. 4-6). Tariffs restricted to be uniform across sectors in a model without distortions in col. 7-8. Panel C: Regression of the logarithm of (1+tariff) on the logarithm of wedges and logarithm of θ_s (col. 3), with unilaterally optimal tariff (in a model with distortions) expressed in ad valorem terms. Robust standard errors in parentheses. Significance levels: *** p<0.01.

D Input-Output Linkages

In this Appendix I report the main results for a model without input-output linkages across sectors. To clearly isolate the role of linkages, the no-linkages model sets the input-output matrix to diagonal while matching the same initial data on gross output, value added, and trade flows as the baseline model. This involves setting $\alpha_{j,ks} = \alpha_{j,s}$ if $k = s$ and zero otherwise, where $\alpha_{j,s}$ is computed as in Section 3.2. Notice that since sectoral final demand is a derived measure, changing the input-output structure also changes the final demand shares $\beta_{j,s}$ to maintain internal consistency of the system of revenues and expenditures. Similarly as for the baseline model, the aggregate trade deficits are eliminated prior to conducting any counterfactual calculations.

Figure D.1 summarizes the effect of input-output linkages on the relationship between distortions and the gains from trade. Table D.1 summarizes patterns of optimal unilateral trade policy, while Table D.2 summarizes the benefits of removing distortions in a model without linkages. These results are discussed in Section 4.4 in the main text.

Figure D.1: Υ with and without IO Linkages



Notes: Distortions adjustment term Υ in a model without input-output linkages (using only own-sector intermediates) plotted against baseline values. To increase readability the plot omits extreme values at the lowest (Chile, RoW) and highest (Malawi) end.

Table D.1: Optimal Tariffs without IO Linkages

(A) Optimal Tariffs across Countries

	(1) Mean	(2) SD	(3) Gains	(4) Gains^{ND}
Developing	70.4	69.7	6.65	0.81
Middle-income	28.9	27.6	4.11	2.24
Developed	18.8	24.4	1.43	1.59
Mean	39.9	41.0	4.11	1.53
Std. Dev.			3.86	1.13

(B) Optimal Tariffs vs. Wedges

Dependent variable:	(1) Opt. Tariff $\ln\left(1+t^*_{j,s}\right)$	(2) Opt. Tariff $\ln\left(1+t^*_{j,s}\right)$
$\ln \xi_{j,s}$	0.322***	0.301***
	(0.018)	(0.021)
Country FE	Yes	Yes
Sector FE		Yes
Observations	671	671

Notes: Panel A: Mean and SD: Mean and standard deviation of unilaterally optimal tariffs (expressed in ad valorem percentage terms) across tradable sectors within each country, averaged across the country group given in the row. Gains: welfare gains [in %] from unilaterally setting optimal tariffs. Gains^{ND}: welfare gains [in %] from unilaterally setting optimal uniform (across sectors) tariffs in a model without distortions. Panel B: Regression of the logarithm of (1+tariff) on the logarithm of wedges, with unilaterally optimal tariff (in a model with distortions) expressed in ad valorem terms. Robust standard errors in parentheses. Significance levels: *** p<0.01. Model without input-output linkages (using only own-sector intermediates).

Table D.2: Removing Intersectoral Labor Distortions without IO Linkages

	(1) Gains	(2) Gains^{CE}
Developing	69.27	34.80
Middle-income	27.94	11.57
Developed	13.12	4.84
Mean	37.31	17.36
Std. Dev.	33.51	17.03

Notes: Gains: welfare gains [in %] from removing intersectoral distortions simultaneously in all countries. Gains^{CE}: welfare gains [in %] from removing distortions in a closed economy. Model without input-output linkages (using only own-sector intermediates).

E Supplementary Tables

Table E.1: Welfare Gains from Preferential Elimination of Agricultural Tariffs

Country	(1) Tar. ch.	(2) Gains	(3) GainsND	Country	(1) Tar. ch.	(2) Gains	(3) GainsND
Australia	Yes	0.04	-0.01	Malaysia	Yes	0.03	0.00
Austria	Yes	0.00	-0.01	Mexico	Yes	0.03	0.01
Bangladesh	No	-0.10	0.03	Morocco	No	-0.13	0.15
Belgium	Yes	-0.02	-0.02	Nepal	No	-0.02	0.00
Brazil	No	-0.67	0.09	Netherlands	Yes	-0.02	-0.02
Bulgaria	Yes	0.02	-0.01	New Zealand	Yes	-0.05	-0.06
Canada	Yes	0.01	0.00	Norway	Yes	0.06	0.00
Chile	Yes	0.09	-0.01	Pakistan	No	-0.08	0.03
China	No	-0.98	0.12	Peru	No	-0.39	0.05
Colombia	No	-0.25	0.11	Philippines	No	-2.26	0.60
Costa Rica	No	0.12	0.33	Poland	Yes	0.01	0.00
Czech Republic	Yes	-0.02	-0.01	Portugal	Yes	-0.01	-0.01
Denmark	Yes	0.01	0.00	Rest of World	No	-0.26	0.06
Egypt	No	-0.10	0.07	Romania	Yes	-0.01	0.00
Estonia	Yes	-0.03	-0.02	Russia	Yes	0.09	0.01
Ethiopia	No	0.08	0.37	Slovakia	Yes	0.02	0.02
Finland	Yes	0.00	0.00	Slovenia	Yes	0.00	0.00
France	Yes	-0.01	-0.01	South Africa	Yes	0.01	0.00
Germany	Yes	-0.01	-0.01	Spain	Yes	-0.01	-0.01
Ghana	No	0.39	0.47	Sri Lanka	No	-0.49	0.22
Greece	Yes	0.03	0.00	Sweden	Yes	0.00	0.00
Hungary	Yes	0.00	0.00	Switzerland	Yes	-0.01	0.00
India	No	-0.33	0.03	Taiwan	Yes	0.00	0.02
Indonesia	No	-1.07	0.14	Tanzania	No	-0.43	0.26
Ireland	Yes	0.00	0.00	Thailand	No	-3.16	0.55
Israel	Yes	-0.02	-0.01	Turkey	Yes	0.10	-0.01
Italy	Yes	-0.01	-0.01	United Kingdom	Yes	0.00	0.00
Japan	Yes	0.00	-0.01	United States	Yes	0.00	-0.01
Korea	Yes	2.87	0.34	Viet Nam	No	-3.17	0.92
Latvia	Yes	0.00	0.00	Developing	No	-0.63	0.32
Lithuania	Yes	0.00	0.00	Middle-income	Yes	0.16	0.01
Malawi	No	0.14	2.15	Developed	Yes	0.00	-0.01
				Mean		-0.16	0.11
				Std. Dev.		0.77	0.32

Notes: Counterfactual in which all developed and middle income countries eliminate tariffs in agriculture levied against developing countries. Tar. ch.: whether a country changes its import tariffs. Gains: welfare gains [in %]. GainsND: welfare gains in a model without distortions. Bottom-right panel: means for each country income group as well as overall mean and standard deviation.