Complements or Substitutes?
Labor Market Effects of Foreign Inputs in Developing Economies

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Abstract

This paper examines how import liberalization affects labor markets when labor and intermediate inputs can act as complements or substitutes. We incorporate a constant-elasticity-of-substitution (CES) production function into a dynamic quantitative trade model and show that the labor market effects of imports depend on the elasticity of substitution between labor and intermediate inputs, which varies across sectors. Exploiting exogenous tariff reductions in Colombia and applying a difference-in-differences strategy, we separate the reduced-form effects of trade into an input shock and a competition shock. Import competition reduces the wage bill across sectors, whereas cheaper intermediate inputs increase it. This increase is driven by the service sector, with imprecise effects in manufacturing and an opposite-sign effect in agriculture. Combining the model with the reduced-form parameters, we implement indirect inference to recover sector-specific elasticities of substitution and find that labor and intermediates are substitutes in agriculture and manufacturing but complements in services. Allowing for a more flexible production structure meaningfully changes the labor market response to trade by generating a larger reallocation of workers toward services and fewer into agriculture. These adjustments translate into differential welfare effects relative to a Cobb–Douglas benchmark, raising gains in services while reducing them in manufacturing and agriculture.

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1. Introduction

A classic question in the international trade literature is: What are the labor market consequences of import liberalization? Higher imports can affect labor markets through two main channels. The first is the *import competition channel*, where increased exposure to foreign goods directly reduces demand for domestic labor in import-competing industries. The second is the *input channel*, in which trade reduces the cost of imported intermediate inputs, thereby indirectly influencing labor demand by changing firms' production costs. A large body of research has analyzed the first channel, documenting the adverse effects of import competition on employment and wages (Autor et al., 2013).[1] More recently, several studies have explored the input channel, showing that access to cheaper foreign inputs lowers marginal costs and impacts earnings and other labor market outcomes (Adão et al., 2022; Caliendo and Parro, 2015). However, most of these studies assume a fixed expenditure share between labor and intermediate inputs, ignoring differences in how easily firms can substitute between them.

This paper focuses on this *substitution mechanism* within the input channel. When imported inputs become cheaper, firms may respond not only by lowering prices or expanding production, but also by reallocating expenditure between labor and intermediate inputs, depending on their degree of substitutability. If labor and intermediates are substitutes, cheaper inputs reduce the labor share; if they are complements, the labor share may increase. Therefore, the elasticity of substitution (EoS) between labor and intermediate inputs becomes a central statistic of how trade affects labor market outcomes. Moreover, because this elasticity can vary across sectors, trade shocks can generate heterogeneous effects across industries and regions. Of particular interest are the effects on the service sector, where the direct impact of import competition is limited, but benefits from cheaper inputs can be substantial —a phenomenon especially relevant for developing economies, where services account for a large share of the economy (Fan et al., 2023).

To study this mechanism, we extend the dynamic trade model of Caliendo et al. (2019, henceforth CDP) to allow for different degrees of substitutability between labor and intermediate inputs. We assume a nested production function with a constant elasticity of substitution (CES), in which firms combine labor and intermediates. In the lower nest, firms substitute inputs across sectors. In the upper nest, they allocate resources between a composite input and labor. We show that changes in tariffs affect labor earnings through two channels: (i) a *competition shock*, and (ii) an *input shock*. The competition shock is always negative, as domestic firms lose market share when they face higher import competition, leading to a lower wage bill. The input shock, in contrast, can have ambiguous effects. It operates through two forces: reductions in marginal costs, which increase firm competitiveness and labor demand; and the degree of substitutability

[1] See also Attanasio et al. (2004); Autor et al. (2014); Bernard et al. (2006); Dix-Carneiro and Kovak (2017); Erten et al. (2019); Hanson and Harrison (1999); Jenkins et al. (2008); Moreira (2007); Pierce and Schott (2016); Wood and Mayer (2011).

between labor and intermediate inputs, which determines how changes in input prices affect the labor share. When labor and intermediate inputs are substitutes, lower input prices reduce the wage bill, whereas when they are complements, lower input prices increase it.

Guided by this theoretical framework, we then estimate the effects of the competition and input shocks using variation in tariff reductions in Colombia. We exploit two exogenous policy changes. The first, in 2010, was a unilateral tariff reduction on imported intermediate inputs following a transition from one presidential administration to another. The second, in 2012, was the implementation of a free trade agreement (FTA) with the United States (US), which further reduced tariffs on US imports. Importantly, neither reform affected Colombian export tariffs, which allows us to isolate the effects of import liberalization from the effects of export exposure.

At the core of our analysis is a rich collection of microdata. Previous studies have faced challenges in quantifying the effects of access to foreign inputs due to limited data connecting input use and exposure to competition.[2] To address this issue, we combine detailed administrative import records with tariff data, labor market information, firm-level import data, and input-output matrices. Using these data sources and following the dynamic trade model, we construct an empirical measure of the input shock at the industry-region level. We define this measure as the weighted sum of tariff reductions on imported inputs, with weights given by the industry's baseline import shares. We combine this measure with an empirical import competition shock, which captures the change in exposure following trade liberalization. Both shocks are then linked to employment outcomes from household surveys to analyze the impact on labor earnings.

Our empirical strategy exploits variation across regions and industries, combining the unexpected timing of tariff reductions in 2010 and 2012 with their exogenous magnitudes in a difference-in-differences framework.[3] This approach enables reduced-form estimates of the effects of import competition and foreign input access on labor earnings. Although the tariff reductions were largely unanticipated, we follow Goldberg and Pavcnik (2005) and instrument the change in tariffs with their pre-liberalization levels. In the absence of renewed protection, trade liberalization typically drives tariffs toward zero, making the pre-reform tariff level a valid instrument of the tariff change.

The identification assumption relies on the common trends between industries with and without tariff cuts, which would have behaved similarly in the absence of the tariff reductions. We use dynamic event-study estimates to test the common-trends assumption, finding balanced point estimates before the reform. We also present robustness of our specification to address potential threats stemming from the implementation of continuous or heterogeneous treatment effects (Callaway and Sant'Anna, 2021; de Chaisemartin and D'Haultfœuille, 2020; Goodman-Bacon, 2021; Sun and Abraham, 2020).

[2] This limitation is particularly pronounced in developing countries, where data quality is often lower.

[3] Throughout the paper, regions are defined as departments, the primary administrative divisions in Colombia, comparable to states or provinces.

The main empirical findings suggest that import competition *decreases* employment, whereas foreign inputs *increase* it. However, the latter effect is heterogeneous across sectors, primarily increasing employment in the service sector, where complementarities between inputs and labor seem to exist. A one-percentage-point reduction in Colombian tariffs (i.e., an increase in import competition) *decreases* Colombian employment by an estimated 1 to 4 percent. In contrast, a one-percentage-point reduction in the prices of foreign inputs *increases* employment by around 3 to 4 percent. The service sector drives this increase, whereas the effect in manufacturing is less precisely estimated, and of opposite sign, in agriculture.

We then combine the model with the reduced-form evidence through an indirect-inference approach. We calibrate the model for 26 regions: 24 Colombian departments, the United States, and the rest of the world (RoW); 13 two-digit economic sectors, and a home production sector. To compute the EoS between labor and intermediate inputs, we match the coefficients of the input shock implied by the model with the ones from the reduced-form. We construct the input and competition shocks using the data simulated by the model and then run the same regression relating changes in the wage bill to the input and competition shocks. We find an EoS of around 9.6 for agriculture, which suggests very high substitutability; an EoS of around 3.4 for manufacturing, also suggesting substitutability; and an EoS of around 0.5 in services, suggesting that inputs and labor are complements.

Armed with the model and the estimated EoS in the production function, we conduct our main counterfactual analysis, which captures the unexpected change in the tariff path due to the reform, including both the unilateral tariff reduction in 2010 and the Colombia–US FTA implemented in 2012. We analyze how this reform influenced the evolution of employment across industries to study structural transformation and compute a compensated variation measure to assess welfare effects. We put special emphasis on comparing the CES with the Cobb-Douglas (CD) cases.

Our findings show that the substitution mechanism—-governed by the EoS between labor and intermediate inputs—-is crucial to accurately assess the effects of trade liberalization. Using a CD production function, in contrast, effectively ignores this substitution mechanism and thereby overestimates gains in agriculture and manufacturing while underestimating benefits in the service sector. Under CD, estimated agricultural employment rises by 1.32 percent, compared with 0.63 percent under CES; manufacturing employment increases by 0.71 percent versus 0.25 percent under CES. Service employment grows slightly more under CES (0.47 percent) than under CD (0.39 percent), representing over 5,000 additional workers. These shifts translate into differential welfare impacts between CES and CD, with workers in manufacturing and agriculture experiencing roughly 31 and 25 percent smaller gains under CES. Overall, the substitution mechanism plays a key role in shaping structural transformation and sectoral reallocation, increasing vulnerability in agriculture and manufacturing while amplifying gains in services, a key sector for current developing economies.

Related Literature: Our main contribution is to embed heterogeneous substitution patterns between labor and intermediates into a dynamic quantitative trade model, allowing us to disentangle and quantify different channels through which trade shocks generate distributional effects. We also estimate the key elasticities driving these mechanisms using variation from tariff reforms. In doing so, the paper contributes to four related strands of the literature.

First, we contribute to the literature on international trade that uses quantitative trade models to measure the distributional and labor effects of trade. Studies such as CDP, Galle et al. (2022), and Rodriguez-Clare et al. (2025) study the impact of the China shock. These papers find that China contributed enormously to wage inequality in the United States. Similarly, other papers, such as Adão et al. (2022), collect rich microdata to study the effects of trade on inequality in Ecuador. Consistent with our framework, they find that input shocks explain a significant fraction of the impacts of trade on inequality. We contribute to this literature by incorporating the substitution channel, using a richer production process to enhance our understanding of the effect of trade shocks on labor market outcomes.

Second, our results also serve as a benchmark for studies examining the effects of external "shocks" on labor market outcomes. In this sense, they relate closely to recent work highlighting how inputs shape aggregate outcomes through more flexible production structures. For instance, Peter and Ruane (2023) estimate a CES production function that allows for different degrees of substitution across intermediate inputs, finding larger gains from trade. Huneeus et al. (2021) study how firm networks shape wage inequality by allowing for substitutability between labor and intermediate inputs, and Chan (2021) examines substitutability between labor and intermediates in the Danish manufacturing sector. We contribute to this literature by analyzing the distributional effects of trade within a dynamic trade model and by documenting how the EoS between labor and intermediate inputs varies across one-digit sectors. Furthermore, we show that even when expenditure shares between labor and inputs are not directly observed, researchers can recover these elasticities by combining first-order approximations with indirect inference methods.

Third, we contribute to the growing literature that quantifies the effects of input liberalization on the local economy. A large body of this work has estimated the extent to which access to foreign inputs is associated with positive gains in productivity (Amiti and Konings, 2007; Goldberg et al., 2010; Halpern et al., 2015; Olper et al., 2017; Pavcnik, 2002; Topalova and Khandelwal, 2011), quality upgrading (Bas and Strauss-Kahn, 2015; Bustos, 2011; Fieler et al., 2018), and technology implementation (Bustos, 2011). Other work has focused on the effects of access to foreign inputs on the demand for skills in the labor market (Amiti and Cameron, 2012; Bas and Bombarda, 2023; Bas and Paunov, 2021; Chen et al., 2017; Edmonds and Pavcnik, 2006; Kamal et al., 2019; Leblebicioğlu and Weinberger, 2021; Verhoogen, 2008). This latter group of papers has predominantly examined aggregate labor-market effects without separating the marginal cost responses from the substitution mechanisms triggered by access to cheaper intermediate inputs. We complement this work by relaxing the assumption of common EoS across sectors and showing that the impact on labor markets is especially important in the service sector, which covers a larger portion of the economy, and which is very relevant for developing economies (Fan et al., 2023).

Fourth, our work speaks to the literature that quantifies the results of import competition in local labor markets. Most of the existing empirical research has focused on analyzing the effects of import competition from developing countries, such as China and Mexico, on high-income countries in North America and Europe (Autor et al., 2013,1,1; Bernard et al., 2006; Bloom et al., 2016,1; Branstetter et al., 2019; Feenstra and Hanson, 1999; Hummels et al., 2014; Pierce and Schott, 2016). Other research has examined the effect of import competition among developing countries such as Brazil, South Africa, and Colombia (Attanasio et al., 2004; Dix-Carneiro, 2014; Dix-Carneiro and Kovak, 2017; Erten et al., 2019; Moreira, 2007; Wood and Mayer, 2011). We contribute to this literature by decomposing the effect of trade shocks on different channels and studying the substitution between labor and intermediates.

The rest of the paper is organized as follows. Section 2 presents the dynamic trade model and introduces two structural equations that link the model to the data. Section 3 presents the setting by describing the tariff reductions in Colombia and details the data used. Section 4 presents the empirical strategy used for the reduced form estimation of the structural equations and their results. Section 5 describes the calibration of the model and main counterfactual results. Finally, Section 6 concludes.

2. Model

We extend the dynamic trade model developed by CDP and Artuc et al. (2010) by incorporating a CES production function that allows for substitution between labor and intermediate inputs. The model features a set of N locations—representing regions within Colombia or different countries—and J sectors in the economy.[4] We define a labor market, nj, as the combination of a region $n \in N$ and sector $j \in J$.

At $t = 0$, a mass of households are either employed or not employed (home production sector). Households are forward-looking and solve a dynamic problem. As in CDP, preferences are CD across sectors:

$$C_t^{nj} = \prod_{k=1}^{J} \left(\frac{c_t^{nj,k}}{\alpha^{nk}} \right)^{\alpha^{nk}},$$

where $c_t^{nj,k}$ is the consumption of sector k goods in market nj at time t and α^{nk} is the final consumption share in goods from sector k in location n. By the CD properties, the ideal price index is given by $P_t^n = \prod_{k=1}^{J} \left(P_t^{n,k} \right)^{\alpha^{nk}}$. Non-employed households obtain consumption in terms of home production $b^n > 0$. We index the home production sector as 0; thus, $C_t^{n0} = b_n$.

Workers can move each period across regions and sectors. These decisions are subject to

[4] We define regions in Colombia at the department level and used interchangeably throughout the paper.

mobility costs denoted by $f^{nj,ik} > 0$ that correspond to the cost of moving from market (n, j) to market (i, k). These costs are measured in utility terms. Since we are interested in the trade channel, we assume that these costs are time-invariant and additive, and households take them as given. We assume that people do not migrate from Colombia to foreign countries and vice versa.

In each period, workers receive additive idiosyncratic shocks, ϵ_t^{ik}, which are drawn from a nested Gumbel distribution (Rodriguez-Clare et al., 2025). In the first nest, they decide the location, and in the second nest, the sector:

$$F(\epsilon) = \exp\left(-\sum_{i=1}^{N}\left(\sum_{k=0}^{J} -(\epsilon_t^{ik}/\nu)\right)^{\frac{\nu}{\eta}}\right),$$

where $\eta \geq \nu$. This allows us to have different elasticities of reallocating across regions and sectors. The value function of market (n, j) at time t is:

$$v_t^{nj} = U(C_t^{nj}) + \max_{\{i,k\}_{i=1,k=0}^{N,J}} \left\{\beta E[v_{t+1}^{ik}] - f^{nj,ik} + \epsilon_t^{ik}\right\},$$

where $C_t^{nj} = b_n$ corresponds to the consumption of households that are employed in the home-production sector and $C_t^{nj} = \frac{w_t^{nj}}{P_t^{nj}}$ if they are employed in market nj. Defining the expected value measure as $V_t^{nj} = \mathbf{E}(v_t^{nj})$ and following the properties of extreme value type shocks, the expected value function is:

$$V_t^{nj} = U(C_t^{nj}) + \eta \ln\left(\sum_{i=1}^{N}\left(\sum_{k=0}^{J} \exp(\beta V_{t+1}^{ik} - f^{nj,ik})^{\frac{1}{\nu}}\right)^{\frac{\nu}{\eta}}\right) + \gamma_\eta. \tag{2.1}$$

This equation captures the current value of each market and the mobility opportunity to reallocate into new markets. The parameter γ_η is the Euler-Mascheroni constant. The share of workers from market nj who decide to reallocate to any market ik is:

$$\mu^{nj,ik} = \mu_t^{ij,ik|i} \cdot \mu_t^{nj,i\#},$$

where $\mu_t^{ij,ik|i}$ correspond to the share of workers who, conditional on living in i decide, to work in sector k, and $\mu_t^{nj,i\#}$ to the share of people from location n who decide to migrate to i:

$$\mu_t^{ij,ik|i} = \frac{\exp\left(\beta V_{t+1}^{ik} - f^{ij,ik}\right)^{1/\nu}}{\sum_{h=0}^{S} \exp\left(\beta V_{t+1}^{ih} - f^{ij,ih}\right)^{1/\nu}}.$$

The parameter $1/\nu$ measures the labor supply elasticity across sectors. The second term corresponds to:

$$\mu_t^{nj,i\#} = \frac{\left(\sum_{h=0}^{S} \exp\left(\beta V_{t+1}^{ih} - f^{nj,ih}\right)^{1/\nu}\right)^{\nu/\eta}}{\sum_{m=1}^{I}\left(\sum_{h=0}^{S} \exp\left(\beta V_{t+1}^{mh} - f^{nj,mh}\right)^{1/\nu}\right)^{\nu/\eta}},$$

where $1/\eta$ represents the migration elasticity. This equation suggests that workers reallocate to locations with better option values net of migration costs. Labor markets evolve over time using the following expression:

$$L_{t+1}^{nj} = \sum_{i=1,k=0}^{N,J} \mu_t^{ik,nj} L_t^{ik}.$$

This equilibrium condition determines the labor supply.

2.1. Production

Firms in each sector and region produce a set of varieties of intermediate goods. The technology to produce these intermediates requires labor and materials. The total factor productivity of an intermediate good in market nj is composed of two terms: a sectoral-location component A_t^{nj}, common to all intermediate producers, and a specific variety component, z^{nj}, that is drawn from a Fréchet distribution (Eaton and Kortum, 2002). The production function is:

$$q_t^{nj} = z_t^{nj} A_t^{nj} \left[\zeta^{nj} (l_t^{nj})^{\frac{\sigma^j - 1}{\sigma^j}} + (1 - \zeta^{nj}) (M_t^{nj})^{\frac{\sigma^j - 1}{\sigma^j}} \right]^{\frac{\sigma^j}{\sigma^j - 1}},$$

where ζ^{nj} corresponds to the relative productivity of labor inputs, and $(1 - \zeta^{nj})$ to the relative productivity of intermediate inputs. Our main parameters of interest are σ^j, which correspond to the sector-specific degrees of substitutability between labor and intermediate inputs.[5] We also assume that the intermediate inputs are a CES composite input:

$$M_t^{nj} = \left[\sum_{k=1}^{J} \tilde{\gamma}^{nj,nk} (M_t^{nj,nk})^{\frac{\delta^j - 1}{\delta^j}} \right]^{\frac{\delta^j}{\delta^j - 1}},$$

where δ^j corresponds to the EoS of inputs across sectors, capturing how easy it is to substitute intermediate inputs across sectors. We assume that the relative efficiencies across sectors add up to 1, meaning that $\sum_{k=1}^{J} \tilde{\gamma}^{nj,nk} = 1$.

The unit cost of an input bundle, x_t^{nj}, is:

$$x_t^{nj} = \left[(\zeta^{nj})^{\sigma^j} (w_t^{nj})^{1-\sigma^j} + (1 - \zeta^{nj})^{\sigma^j} (s_t^{nj})^{1-\sigma^j} \right]^{\frac{1}{1-\sigma^j}},$$

where w_t^{nj} is the wage per efficiency unit of labor and ς_t^{nj} is the unit cost of an input bundle of intermediate inputs, defined as:

$$\varsigma_t^{nj} = \left[\sum_{k=1}^{J} \tilde{\gamma}_{nj,nk}^{\delta^j} (P_t^{nk})^{1-\delta^j} \right]^{\frac{1}{1-\delta^j}}.$$

[5] Most of the literature, including CDP, Galle et al. (2022), and Adão et al. (2022), assumes CD production functions, implying that $\sigma^j = 1$.

P_t^{nk} represents the sectoral price of sector k in region n. The unit cost of an intermediate good indexed by z_t^{nj} is given by $\frac{x_t^{nj}}{z_t^{nj}}$.

We denote the iceberg trade costs as $\kappa_t^{nj,ij} \geq 1$. One unit of any variety in sector j shipped from i to n requires producing $\kappa_t^{nj,ij}$ units. The iceberg trade cost can be decomposed into two terms:

$$\kappa_t^{nj,ij} = \tilde{\kappa}_t^{nj,ij}(1 + \tau_t^{nj,ij}),$$

where $\tilde{\kappa}_t^{nj,ij}$ captures the technological and geographical component of trade cost, and $\tau_t^{nj,ij}$ captures ad-valorem tariffs imposed by location n to i in sector j. In this setting, competition implies that the price paid for a variety of good j in region n is given by the minimum unit cost across regions. The vector of productivity draws for each variety by the different regions in good j is $z^j = (z^{1j}, z^{2j}, ..., z^{NJ}, z^{Fj})$, implying that:

$$p_t^{nj}(z^j) = \min \left\{ \frac{\kappa_t^{nj,ij} x_t^{ij}}{z^{ij} A_t^{ij}} \right\}$$

2.2. Local Sectoral Aggregate Goods

Intermediate goods from sector j and from all locations are aggregated into a sectoral good:

$$Q_t^{nj} = \left(\int \tilde{q}_t^{nj}(z_j)^{\frac{\eta^j - 1}{\eta^j}} d\phi^j(z^j) \right),$$

where $\phi^j(z^j)$ is the joint distribution over the vector z^j that we assume is Fréchet. Local sectoral aggregate goods are used as intermediate inputs by other sectors or for final consumption. The price of good j in location n at time t is:

$$P_t^{nj} = \Gamma^{nj} \left(\sum_{i=1}^{N} (x_t^{ij} \kappa_t^{ij})^{-\theta^j} (A_t^{ij})^{\theta^j} \right)^{\frac{-1}{\theta^j}},$$

where Γ^{nj} is a constant term and θ^j is the trade elasticity.[6] The share of expenditure in location n from location i of good j is:

$$\pi_t^{nj,ij} = \frac{(x_t^{ij} \kappa_t^{ij})^{-\theta^j} (A_t^{ij})^{\theta^j}}{\sum_{m=1}^{N} (x_t^{mj} \kappa_t^{mj})^{-\theta^j} (A_t^{mj})^{\theta^j}}. \tag{2.2}$$

Then, a region exports more if it is more productive, the cost of producing a unit of the good is cheaper (one of our main mechanisms), or the iceberg trade cost is lower.

2.3. Market Clearing Condition-Static Subproblem

Let X_t^{nj} be the total expenditure on sector j good in location n. The market-clearing conditions are:

[6] A standard assumption in the Eaton and Kortum (2002) is that $\theta^j > \eta^j - 1$.

$$X_t^{nj} = \sum_{k=1}^{J} \gamma_t^{nk,nj} \underbrace{\sum_{i=1}^{N} \frac{\pi_t^{ik,nk}}{1+\tau_t^{ik,nk}} X_t^{ik}}_{Y_t^{nk}\text{: Gross production } nk} + \alpha^{nj} \underbrace{\left(\sum_{k=1}^{J} w_t^{nk} L_t^{nk} + D_t^n + R_t^n \right)}_{\text{Final consumers}}. \tag{2.3}$$

The first term captures the total demand for intermediate inputs, and the second term the demand for final consumption. Final consumption depends on labor earnings, $w_t^{nj} L_t^{nj}$, trade deficits, D_t^n, and the tariff revenue R_t^n. The key difference with the CD production function is that the parameter $\gamma_t^{nj,nk}$ is not constant. By the CES properties:

$$\gamma_t^{nj,nk} = \left(\frac{(1-\zeta^{nj})^{\sigma^j} (s_t^{nj})^{1-\sigma^j}}{(\zeta^{nj})^{\sigma^j} (w_t^{nj})^{1-\sigma_j} + (1-\zeta^{nj})^{\sigma^j} (s_t^{nj})^{1-\sigma^j}} \right) \left(\frac{\tilde{\gamma}_{nj,nk}^{\delta^j} (P_t^{nk})^{1-\delta^j}}{\sum_{h=1}^{J} \tilde{\gamma}_{nj,nh}^{\delta^j} (P_t^{nh})^{1-\delta^j}} \right),$$

where the first term corresponds to the expenditure share on intermediate inputs relative to labor, and the second term to the expenditure share within intermediate inputs of sector k. Thus, the labor market clearing condition is:

$$L_t^{nj} = \left(\frac{\phi_t^{nj}}{w_t^{nj}} \right) \sum_{i=1}^{N} \frac{\pi_t^{ij,nj}}{1+\tau_t^{ij,nj}} X_t^{ij}, \tag{2.4}$$

where ϕ_t^{nj} corresponds to the labor share:

$$\phi_t^{nj} = \frac{(\zeta^{nj})^{\sigma^j} (w_t^{nj})^{1-\sigma_j}}{(\zeta^{nj})^{\sigma^j} (w_t^{nj})^{1-\sigma_j} + (1-\zeta^{nj})^{\sigma^j} (s_t^{nj})^{1-\sigma^j}}. \tag{2.5}$$

Given the CES functional form, and opposed to the CD case, the labor share is not constant and depends on the EoS between intermediate inputs and labor, σ^j.

The market-clearing conditions solve the equilibrium in the static framework. Following CDP, we define three different equilibria: i) the static equilibrium; ii) the sequential equilibrium that solves the dynamic problem; and iii) the counterfactual equilibrium that solves the model considering changes in the sequence of economic fundamentals.

2.4. Welfare

Since this is a dynamic model, we can study the distributional implications by analyzing the ex-ante welfare effect on the average worker in each sector and location. We measure welfare as the net present value of the equivalent variation in real income for workers initially employed in region n - sector j. This measure is:

$$\ln(\zeta^{n,j}) = \sum_{t=1}^{\infty} \beta^t \ln \left(\frac{\hat{\omega}_t^{n,j}}{(\hat{\mu}_t^{nn,jj|n})^{\nu} (\hat{\mu}_t^{nn,j\#})^{\kappa}} \right), \tag{2.6}$$

where β^t is the discount factor and $\hat{\omega}_t^{n,j} = \frac{\hat{w}_t^{nj}}{\hat{P}_t^n}$ corresponds to the change in real income. The parameters $\hat{\mu}_t^{nn,jj|n}$, $\hat{\mu}_t^{nn,j\#}$ measure how the outside options of workers in location n-sector j evolve due to the shock. If the outside options improve due to the shock, more workers will reallocate to these new opportunities, and the change in welfare will be greater. On the other hand, if the outside options experience a negative shock, more workers will stay in the initial market, and the welfare gains will be smaller, as this means that markets for which it is easier to reallocate experience declines in real income.

2.5. Structural equations

The model yields two *structural equations* that link the model to the data by allowing us to recover key parameters directly from empirical coefficients. The first links tariff changes to labor market outcomes, and the second identifies the trade elasticities.

1) Structural Equation for the Labor Market: From the labor market–clearing condition in Equation 2.4 (omitting the time subindex), the total wage bill in market nj is:

$$w^{nj} l^{nj} = \phi^{nj} \sum_{i=1}^{N} \frac{\pi^{ij,nj}}{1+\tau^{ij,nj}} X^{ij}. \tag{2.7}$$

Assuming small changes in iceberg trade costs, we decompose the change in the wage bill in Equation 2.7 using a first-order approximation. This yields the first structural equation expressing how changes in labor earnings depend on the EoS between labor and intermediate inputs, σ_j. Formally, this structural equation is:

$$\Delta \ln(w^{nj} l^{nj}) = \beta^{i,j} InpShock^{nj} + \beta^{c,j} CompShock^{nj} + \epsilon^{nj}, \tag{2.8}$$

where $\beta^{i,j}$ and $\beta^{c,j}$ capture, respectively, the average effects across regions of *input* and *competition* shocks in sector j, and ϵ^{nj} collects higher-order and general equilibrium effects.[7] The input and competition shocks, along with their respective effects, $\beta^{i,j}$ and $\beta^{c,j}$, are described below.

Competition shock: When foreign producers gain market access, domestic firms lose sales, which reduces employment and labor earnings. This *competition* shock is captured by:

$$CompShock^{nj} \equiv \left(\sum_{i=1}^{N} \psi^{ij,nj} \sum_{m=1}^{N} \pi^{ij,mj} d \ln \kappa^{ij,mj} \right), \tag{2.9}$$

where

$$\psi^{ij,nj} = \frac{\pi^{ij,nj}(1+\tau^{ij,nj})^{-1} X^{ij}}{\sum_{m=1}^{N} \pi^{mj,nj}(1+\tau^{mj,nj})^{-1} X^{mj}}$$

corresponds to the share of sales from market nj to market ij. This share captures how important region i is for market nj, and how much i imports from trading partners that experience tariff

[7] The derivation is conducted in partial equilibrium, assuming that other variables—such as wages or the composition of intermediate inputs—remain fixed in response to the shock.

reductions. The magnitude of the competition shock thus depends on the exposure of firms in market nj to tariff declines ($\pi^{ij,mj}$) and on the relevance of those markets to their total sales ($\psi^{ij,nj}$).

Under the structural equations, the coefficient of the competition shock, $\beta^{c,j}$, corresponds to the trade elasticity. Hence, $\beta^{c,j} = \theta^j$ is always positive, indicating that as tariffs increase, the wage bill also increases, and that the effect depends on how easily consumers can substitute domestic and foreign goods.

Input shock: Changes in intermediate input prices also affect the wage bill. This *input* shock is:

$$InpShock^{nj} \equiv \sum_{k=1}^{J} \gamma^{nj,nk} \left(\sum_{i=1}^{N} \pi^{nk,ik} d \ln \kappa^{nk,ik} \right), \tag{2.10}$$

where $\gamma^{nj,nk}$ is the share of sector j's inputs sourced from sector k, $\pi^{nk,ik}$ is the initial share of goods from region i in n's use of sector k, and $d \ln \kappa^{nk,ik}$ represents the change in trade costs. Thus, the input shock is a weighted average of tariff changes, where weights reflect the initial composition of inputs by origin and sector.

From the structural equation in 2.8, the coefficient, $\beta^{i,j}$, of the input shock is equivalent to:

$$\beta^{i,j} = (1 - \phi^{nj}) \left[\underbrace{(\sigma^j - 1)}_{\text{Substitution}} - \underbrace{\theta^j \left(\sum_{i=1}^{N} \psi^{ij,nj} (1 - \pi^{ij,nj}) \right)}_{\text{Marginal cost}} \right]. \tag{2.11}$$

Equation 2.11 implies that changes in input prices affect the wage bill through two mechanisms:

1. *Substitution:* The labor share depends on the EoS between labor and intermediate inputs, σ^j. If labor and intermediate inputs are complements ($\sigma^j < 1$), higher input costs reduce the labor share, which reduces the wage bill. If they are substitutes ($\sigma^j > 1$), higher input costs raise the labor share, increasing the wage bill. Under CD ($\sigma^j = 1$), the labor share is constant and, as a result, the substitution effect disappears.
2. *Marginal cost:* Changes in input costs alter firms' marginal costs and, hence, their market shares across regions, which ultimately impacts total revenue. Lower input costs reduce production costs, enabling firms to expand and increase employment and earnings. The magnitude of this effect depends on the trade elasticity θ^j, the relevance of each market ($\psi^{ij,nj}$), and the potential for market share expansion ($1 - \pi^{ij,nj}$).

The overall effect of the input shock on the wage bill, therefore, can be positive, negative, or zero, depending on the relative magnitudes of these two mechanisms. The marginal cost mechanism is always negative, while the substitution mechanism depends on the elasticity between labor and intermediate inputs. Consequently, the sign of $\beta^{i,j}$ depends on σ^j and the relative magnitude with respect to the marginal cost channel:

- $\beta^{i,j} > 0$: The substitution mechanism dominates the marginal cost mechanism, then labor and intermediate inputs are substitutes.

- $\beta^{i,j} = 0$: Both mechanisms offset each other, then labor and intermediate inputs are substitutes.

- $\beta^{i,j} < 0$: The marginal cost mechanism dominates the substitution mechanism, or both effects go in the same direction, then labor and intermediate inputs can be complements, substitutes, or the production function could be CD.

We estimate $\beta^{i,j}$ and $\beta^{c,j}$ by exploiting a trade liberalization episode in Colombia, and then take the model to the data, recovering σ^j through an indirect-inference approach (Section 5 provides more details).

2) Structural equation for the trade elasticities: Equation 2.2 describes the relationship between trade shares and trade costs. Taking logs, we obtain the following estimating equation:

$$\ln M_{i,nj,t} = -\theta_j \ln(1 + \tau_{i,j,t}) + \lambda_{i,nj} + \lambda_{it} + \epsilon_{i,nj,t}, \tag{2.12}$$

where $M_{i,nj,t}$ denotes imports from country i in market nj at time t into Colombia, $\tau_{i,j,t}$ is the tariff imposed by Colombia on imports from i in sector j, $\lambda_{i,nj}$ is an origin-market fixed effect, λ_{it} is an origin-year fixed effect, and $\epsilon_{i,nj,t}$ is the error term. The coefficient θ_j captures the trade elasticity specific to sector j.

3. Background and Data

3.1. Trade reforms in Colombia

Recent Colombian tariff reductions provide an ideal context to study the labor market effects of import competition and to estimate the model described in Section 2. We focus on a trade liberalization episode that unfolded in two stages. The first was implemented in 2010, when Colombia unilaterally reduced tariffs, and the second in 2012, following the implementation of the FTA between Colombia and the United States.

Tariff reduction before the FTA: Over the last decades of the twentieth century, Colombia underwent a trade liberalization process that substantially reduced average tariffs, from roughly 50 percent in the 1970s to about 12 percent by 2008 (Nieto, 2016). This process took place through several waves of tariff reductions. Between 1970 and 1990, average tariffs declined steadily from 50 percent to 29 percent as part of broader government efforts to open the economy. During the 1990s, a second and more pronounced liberalization phase further lowered tariffs to approximately 12 percent.[8] However, in 1995, Colombia joined the *Comunidad Andina de Naciones* (CAN), which established a common external tariff for all member countries—Colombia, Ecuador, Peru, and Bolivia—stopping any further efforts of trade liberalization.[9] This common tariff regime remained

[8] A detailed discussion of Colombia's trade liberalization during the 1990s can be found in Eslava et al. (2004).

[9] The CAN, created in 1995, is a regional integration initiative aimed at promoting economic development through trade liberalization among its Andean members.

in place until 2008, when the common tariff scheme ended.

In 2010, a newly elected Colombian presidential administration unexpectedly decided to further decrease tariffs on imported products, from an average of 12 percent to 8.3 percent. The tariff cuts were implemented under Decree 4114 of 2010, signed on November 5, 2010. The decree, which mandated immediate reductions in tariffs on almost half of the consumption goods and intermediate inputs, aimed to boost productivity and employment by reducing the cost of foreign inputs and cutting the effective protection of some sectors. The reform also intended to simplify the tariff structure, equalizing rates across products and industries. The reductions applied to all incoming products irrespective of their country of origin. Agricultural products were mostly unaffected by the measure (Torres and Romero, 2013).

The U.S.-Colombia Free Trade Agreement: Since the 1990s, the U.S. has been Colombia's biggest trade partner, accounting for around 25 to 30 percent of Colombia's imports.[10] Trade between the two countries grew remarkably after the beginning of the 1990s, when both countries took measures to facilitate the flow of products. In 1991, the U.S., under the Andean Trade Preference Act (ATPA), eliminated tariffs on a large number of Colombian products.[11] At the same time, Colombia's own liberalization decreased tariffs charged to the U.S. to around 15 percent. Later, in 2003, both countries started negotiations on the FTA, which were officially concluded with a final text in 2006 (Romero, 2013).

The agreement required approval from both the U.S. and Colombian congresses before implementation. However, the process took much longer than expected because of the strong opposition faced in both countries. In Colombia, the agreement was approved by Congress in 2007 and declared constitutional in 2008. The process faced strong opposition from syndicalists, Indigenous associations, left and center-left parties, and pharmaceutical companies, among others. The opposition persists as of 2025, with multiple political parties claiming that the FTA should be revoked because its implementation was not approved via popular referendum.

On the U.S. side, the process was even more complicated. After then-President George W. Bush presented the final text to Congress in 2006, a vote on the FTA was postponed until after 2008 due to opposition from Speaker of the House Nancy Pelosi and the Democratic Party. Moreover, during the presidential campaign of 2008, then-candidate Barack Obama claimed it was irresponsible to implement an agreement with a government that he presented as responsible for human rights violations. The opposition in the U.S. thus proved much stronger than expected due to the confluence of political elections, the change in government, and strong Democratic

[10]Colombian imports from the U.S. are mainly composed of manufacturing products. Appendix Figure A.1a, which plots U.S. imports according to their one-digit sector codes, shows that manufacturing represents 93 percent (6,273 products) of the U.S. products Colombia imports, accounting for 92 percent of the total import dollar value. By contrast, agriculture represents 8 percent of the dollar value (367 products), and mining and services account for less than 1 percent (126 products).

[11]ATPA was established to promote Colombia's export industries, as well as to help fight drug production. It was continuously renewed after 2002, when it was called the Andean Trade Promotion and Drug Eradication Act (ATPDEA).

opposition. However, almost six years after the text was officially signed in 2011, the U.S. Senate approved the agreement after the Colombian president stated that if it was not approved by 2011, Colombia would begin negotiating agreements in other markets. In Colombia, the agreement was implemented in May 2012 under Decree 730 of 2012.[12]

The FTA renewed the existing tariff exemptions granted to Colombian products under the ATPA. In return, Colombia reduced tariffs on U.S. products. Tariffs were dropped for most manufacturing, services, and mining products. Some other goods, most of which are agricultural products, remained protected for an additional period of years (in most cases, five years), allowing local producers to adapt gradually to the incoming competition.[13]

Figure 1 plots the evolution of the tariffs charged by Colombia to the U.S. (Panel 1a), and the evolution of tariffs charged by the U.S. to Colombia (Panel 1b). Panel 1a shows that tariffs on manufacturing and service goods decreased after 2010, whereas tariffs on agricultural and mining goods decreased with the FTA. Even though a significant share of agricultural goods remained protected for an additional period, the sector was strongly liberalized in 2012. Panel 1b shows that tariffs for Colombian products entering the U.S. were minimal, renewing the already low tariff rates that were in place years before.

Tariff reductions considerably increased Colombian imports from the U.S. Between 2010 and 2014, the value of U.S. products subject to the reduced tariffs grew from approximately 9 billion to 15 billion dollars. Starting in 2015, there was a generalized drop in Colombian imports, irrespective of their origin, triggered by a strong devaluation of the Colombian peso.[14] Among imports from the U.S., decreases were lower for products that faced larger tariff cuts.

No Anticipatory Effects: Both reforms were overall unexpected. The tariff reduction in 2010 was implemented shortly after a newly elected government took office, as part of its strategy to boost productivity and employment. Tariff reductions were embedded in a large package of reforms, and the details of the reform, including the product selection criteria and the magnitude of the tariff cuts, were only known once the reform decree was signed. The 2012 cuts were part of the FTA, which faced opposition in both the U.S. and Colombia, and was only implemented after a five-year wait for U.S. Senate approval. Firms and consumers in Colombia could hardly have predicted whether the agreement would be approved, and it would have been even more difficult for them to predict the timing of its implementation. We provide empirical evidence for this in

[12] More information about the negotiation process can be found in Iragorri (2008) and EFE (2012).

[13] The main protected products were rice, chicken, milk, cheese, butter, corn, meats, motorcycles, paper, ink, iron and steel products, glass, and plastics. The agreement additionally regulated competition, customs, environmental rights, intellectual property, and investment procedures.

[14] In Appendix Figure A.1b, we present the dollar value of imports from the U.S. by year of tariff reduction. The solid line depicts products for which tariffs were cut in both years (3,621 products); the dashed line shows products for which tariffs dropped due to the 2012 FTA (2,716 products). Tariffs for the remaining 150 products either did not change or decreased only in 2010. We observe a continuous increase in the value of imports from the moment of liberalization until 2014, when they decrease drastically. The trend is similar for total imports. The decline was triggered by a strong Colombian peso devaluation, which resulted from a shock in international oil prices (see Appendix Figures A.1a, A.1b, and A.2).

section 4.1.4.

3.2. Data

Our empirical analysis is based on rich administrative data from multiple Colombian authorities. We use five complementary data sources:

1. *Tariff Records:* We combine three official Colombian decrees with information on tariff records to measure the trade reforms. First, we employ Decree 4589 of 2006, which stipulated the level of tariffs charged on every incoming product after January 1 of 2007. This decree does not reflect actual tariff changes, but was published to adapt Colombian tariffs to the nomenclature established under the "NANDINA" 2007, constituting a baseline measure of the tariffs before the reforms.[15] Second, we combine this information with data provided under Decree 4114 of 2010, which contemplated the unilateral tariff cuts of 2010. Third, we merge the Decree 730 of 2012, which regulated the FTA between Colombia and the U.S.[16] The three decrees provide information at the 10-digit product-code level, and, thus, they constitute a very detailed source of variation. We complement these with information about tariffs charged by the U.S. to Colombia from the U.S. International Trade Commission.

2. *Trade Records:* We use detailed records on imports and exports from the Colombian Tax and Customs Department (DIAN, for its Spanish initials). Imports and exports are measured between 2007 and 2018 at the product level (using 10-digit industry codes). We complement this information with data from the Economic Commission for Latin America and the Caribbean's official classification of products by economic destination (CUODE) to classify the imported products as capital, consumption, or raw materials.[17]

3. *Imports by Firm Records:* We use import records for firms from 2008, also gathered by the Tax and Customs department. The records include the quantity and value of imported products (at the 10-digit level) for each firm in the country. These data enable us to construct a matrix that maps imported inputs to economic sectors by aggregating the data to the firms' industry level (more details are provided in Section 4.1.1). The resulting matrix captures the share of foreign inputs used by each industry prior to the tariff reductions.

4. *Household Surveys:* We use the Colombian household survey, *Gran Encuesta Integrada de Hogares*, to measure labor market outcomes. The survey is administered monthly and includes approx-

[15]NANDINA nomenclature, which resembles quite closely the harmonized system, was designed by the CAN to help with the identification and classification of commodities and to conform with international trade statistics. Decision 653 of the CAN ordered Andean countries to adapt their nomenclature. The Colombian government's Decree 4589 of 2006 was adopted for this purpose.

[16]The data for the mentioned decrees can be found in http://www.suin-juriscol.gov.co.

[17]The CUODE classifies merchandise by its economic destination at the three-digit level. More information can be found in: https://www.dian.gov.co/dian/cifras/AvancesComEx/Avance_Comercio_Exterior_786_30_enero_2020.pdf

imately 9.6 million observations between 2007 and 2018.[18] In our main analysis, we collapse these records at the four-digit industry, department, and year level. The surveys include both formal and informal workers and provide additional information, such as their education level. However, they are only collected in 24 departments (out of 33) and 402 industries (out of 416).[19]

5. *Input-Output Matrix:* As a complementary source of information, we use the official two-digit input-output matrix compiled by the Colombian statistical offices, as well as a regional input-output matrix for Colombia based on Amaral Haddad et al. (2019), and the *World Input-Output Database*, reflecting bilateral trade flows among regions (Colombian departments and other countries) and sectors. These datasets are used to compute the input and competition shocks employed in our empirical strategy (more details in section 4.1.1), and to calibrate the model.

We merge all the data sets and create different estimating samples. We provide additional details about the data construction and aggregation in Appendix B.

4. Reduced Form Estimates of Structural Equations

4.1. Labor Market Estimates

4.1.1 Input and Competition Shocks. We combine the data with the *structural equation for the labor market* (Equation 2.8) to construct the empirical analogues of the *competition* and *input* shocks. These measures guide the estimation of the reduced-form estimates of the tariff reductions on labor market outcomes.

Competition Shock: The *competition* shock corresponds to the direct change in tariffs at year t with respect to the value before the reductions of tariffs in industry j. Formally, it is equivalent to:

$$\tilde{\tau}_{jnt} = \psi_{d(j),n,col}[\ln(1+\tau_{jt}) - \ln(1+\tau_{j,2010})], \tag{4.1}$$

where τ_{jt} denotes the tariff imposed by Colombia on U.S. imports in industry j in year t, and $\psi_{d(j),n,\text{col}}$ is the domestic revenue share of the two-digit sector d associated with industry j in region n.[20] The change in tariffs measures the extent of trade liberalization by industry, while $\psi_{d(j),n,col}$ captures how exposed each industry-region pair is to that change. Before 2010, $\tilde{\tau}_{jnt}$ equals zero since tariffs remained constant. Starting in 2010, tariffs began to decline gradually. Between 2010

[18]The survey is available starting in August 2006. We exclude 2006 from the analysis to improve comparability, as it only covers the second semester of the year and represents a transition period for the survey design.

[19]For robustness checks, we complement the household surveys with social security records, which provide matched employer-employee data from 2008 to 2018 for all Colombian departments. We collapse these data at the four-digit sector and department level. These data only include formal workers, so the results using these data have to be interpreted with caution.

[20]Domestic revenue share is computed using the input-output matrix, detailed in Section 3.2. This implies that it is defined at the two-digit sector level, as opposed to the other terms in equation 4.1, which are computed at the four-digit level. Details about this aggregation procedure are provided in Appendix B.2.

and 2012, $\tilde{\tau}_{jnt}$ reflects the reduction applied uniformly across all trading partners, whereas after 2012, it captures the change specific to imports from the U.S. due to the FTA.

Input Shock: We use the imports by firm records to quantify the *input* shock in industry j and region n. We aggregate the firm-level data to compute the shares of the different imported inputs k by industry j and region n in the pre-period. We then multiply the respective share with the tariff reduction of each input k, and sum across inputs. Formally, the input shock is defined as:

$$\tilde{q}_{jnt} = \sum_k \omega_{jnk} \left[\ln(1 + \tau_{kt}) - \ln(1 + \tau_{k,2010}) \right], \tag{4.2}$$

where the weights are:

$$\omega_{jnk} = \sum_{r \in \{US, RoW\}} \pi_{d(k),nr} \cdot \gamma_{jn,kn}, \text{ with } \gamma_{jn,kn} \equiv \frac{X_{jnk}}{\sum_k X_{jnk}}.$$

The subindex $d(j)$ corresponds to the two-digit code of industry j, X_{jnk} represents the imports of input k by industry j in region n in 2008, and $\pi_{d(k)n}$ denotes the two-digit import share of product k for region n from country r. We use weights from 2008, prior to the tariff reforms, to avoid potential biases from endogenous adjustments in input choices. The input shock measures the weighted reduction in tariffs on imported inputs for sector j in region n and year t, where a more negative value of $\tilde{q}_{jnt}$ indicates a larger decrease in foreign input prices.[21] This definition is consistent with the input shock term of the structural equation (see Equation 2.10).

4.1.2 Identification. Our identification of the labor market effects of trade liberalization exploits exposure to tariff reductions across industries and regions.

Baseline Specification: We use the sample analog of the structural equation in 2.8 to estimate the effects of the increase in competition and the reduction of input prices. Formally, our baseline specification takes the form of:

$$y_{jnt} = \beta^c \tilde{\tau}_{jnt} + \beta^i \tilde{q}_{jnt} + \mu_{jn} + \mu_{nt} + u_{jnt}, \tag{4.3}$$

where y_{jnt} refers to the logarithm of the wage bill in industry j, in region n, at year t. The parameters of interest β^c and β^i quantify the impact of the competition and input shocks, respectively, on the wage bill. We include industry-by-region (μ_{jn}) and region-by-year (μ_{nt}) fixed effects to control for observed and unobserved heterogeneity across industry-region combinations and time. To ensure robustness, we saturate the model using baseline controls interacted with year dummies and region-specific trends.[22] Standard errors are two-way clustered at the industry and region

[21] Because import and revenue shares show little variation, we also construct an alternative version of the competition and input shocks that does not multiply by these shares and provide estimates using these as robustness checks.

[22] Baseline controls are measured in the pre-period (i.e., 2008) at the department level and include the share of college-educated workers, the share of manufacturing employment, the share of employment in services, and the share

level to account for cross-sectional correlations across regions within the same industry and across industries within the same region.

Instrumenting the Change in Tariffs: We additionally estimate our main specification using an instrumental variable approach to address potential biases in the tariff reduction process. Although tariff decreases were largely unexpected and we account for time-invariant characteristics through sector and region fixed effects, the reductions may still have been shaped by interest groups seeking to capture rents from the liberalization. For instance, industries with greater political influence may have experienced smaller tariff cuts. To mitigate this concern and isolate the impact of tariff changes from other confounding factors, we follow Goldberg and Pavcnik (2005) and instrument tariff changes with their initial levels interacted with post-shock dummy variables. The rationale behind this instrument is that tariff reforms—especially those implemented through FTAs—were designed to push tariffs toward zero. As a result, products that started with higher tariffs were expected to experience larger mandated reductions. The initial tariff, therefore, captures the change that the reform should have generated in the absence of different factors that prevented some tariffs from fully converging to zero. Consistent with this logic, we find a strong correlation between tariff reductions and their 2009 levels (Appendix Figure A.3).

Parallel Trends Assumption: Our empirical strategy behaves as a reduced-form difference-in-differences with multiple periods and a continuous treatment. Thus, the consistency of the estimating parameters depends on the validity of the parallel trends assumption (i.e., industries and regions with and without tariff cuts would have behaved similarly in the absence of the tariff reductions). The absence of any additional policies that exclusively affected the industries in which tariffs were dropped strongly supports our identification strategy. Additional empirical support for our strategy stems from the surprising and unexpected decrease in tariffs and the absence of knowledge about the timing of their implementation.

We test the parallel-trend assumption by estimating an event-study model reflecting the dynamic effects of both shocks. We define T^c_j as the negative of the initial value of the tariff before the reforms for each industry j (i.e., $-\ln(1+\tau_{j,2010})$). Likewise, T^i_{jn} is equivalent to the negative of the initial value of the input shock (i.e., $-\sum_k \omega_{jnk} \ln(1+\tau_{k,2010})$). Both measures capture the time-invariant degree of exposition to import competition and foreign inputs induced by the tariff reductions. Using these two measures, we estimate:

$$y_{jnt} = \sum_{t\neq 2010} \beta^i_t \left[T^i_{jn} \times 1(\text{Year=t})\right] + \sum_{t\neq 2011} \beta^c_t \left[T^c_{jn} \times 1(\text{Year=t})\right] + \mu_{jn} + \mu_{nt} + \varepsilon_{jnt}, \tag{4.4}$$

where $1(\text{Year} = t)$ is a dummy that takes the value of one if the observation is in year t. β^c_t and β^c_i are the time-varying effects of the competition and input shocks, respectively. We use 2010 as the excluded category of the input shock, and 2011 for the competition shock to better reflect the timing of the tariff decreases. Note that we include the same structure of fixed effects as in

of female workers.

Equation 4.3.

We test for potential pre-trends in the treatment assignment by testing the null hypothesis that the coefficients in the pre-period are equal to zero. This poses formal evidence against anticipatory effects or violations of the parallel trend assumption. In addition, it allows us to assess the impact of the tariff reductions several years after they took place.[23]

4.1.3 Labor Market Effects. The trade liberalization had relevant effects on employment, directly through the competition shock and indirectly through the input shock. Figure 2 presents the evolution of employment and wage bill among industries affected and unaffected by changes in input prices and tariffs. Both outcomes grew more consistently in industries where the prices of foreign inputs declined (as shown in Figures 2a and 2c), particularly after the implementation of Decree 4114 in 2010, which primarily focused on reducing the cost of intermediate inputs.

In contrast, employment and the wage bill declined significantly in sectors where tariffs decreased due to the FTA (as shown in Figures 2b and 2d). Notably, the decline began in 2012, the year the FTA was implemented, and foreign competition increased. While these results represent correlations and do not properly capture the reform's causal effects, they provide valuable descriptive evidence of the variation used in the empirical strategy.

Average Effects: Panel A of Table 1 presents the results of the estimation of Equation 4.3, combining both least squares (columns (1)-(4)) and instrumental variables (columns (5)-(8)) specifications.[24] A 1 percent decrease in foreign input prices *increases* the wage bill between 1 and 4 percent. In contrast, a 1 percent increase in competition *reduces* employment by around 3 to 3.5 percent.

These results suggest that: 1) increases in import competition *decrease* the wage bill; and 2) reductions in input prices *increase* the wage bill in a comparable magnitude. The first result aligns with most existing literature, which indicates that import competition has detrimental effects on employment. The second result is consistent with previous studies that have explored the effect of input reforms on local firms (Bas and Paunov, 2021; Caliendo and Parro, 2015; Fieler et al., 2018; Goldberg et al., 2010; Kamal et al., 2019; Leblebicioğlu and Weinberger, 2021; Verhoogen, 2008).

Heterogeneous Effects across Sectors: Although the input shock has an aggregate positive effect on employment, the point estimates mask heterogeneity across sectors. Panel B of Table 1 further explores this by estimating Equation 4.3, splitting the shocks across agriculture, manufacturing, and services. The employment losses associated with the competition shock are concentrated in the manufacturing and agricultural sectors, both of which have positive point estimates. In

[23]Estimates based on continuous treatment, or settings with staggered adoption, could also lead to bias due to heterogeneous treatment effects (Callaway et al., 2021; Callaway and Sant'Anna, 2021; de Chaisemartin and D'Haultfœuille, 2020; Goodman-Bacon, 2021; Sun and Abraham, 2020). To address this, we re-estimate the event study specification in Equation 4.4 using binary treatments instead of continuous ones, explicitly accounting for heterogeneity in treatment exposure. A more detailed discussion is provided in Appendix C.

[24]We provide an alternative specification in Appendix D, where we display results with the unweighted shocks, at the sector-by-year level, using social security records, and using employment as outcome.

contrast, the positive effects of the input shock are primarily driven by the services sector, which benefits most from access to cheaper foreign inputs. For manufacturing and agriculture, the estimates are less precise and, in some cases, even positive. Overall, these results provide direct evidence that the EoS between labor and intermediate inputs varies across sectors.[25]

4.1.4 Validity. Our estimation strategy requires that sectors unaffected by the reform would have evolved in parallel in the absence of the policy. In addition, our results require the absence of anticipatory effects. If firms or workers had prior knowledge of the upcoming reform, labor could have reallocated before its implementation, introducing bias into our estimates. To assess these concerns, we test for pre-trends and find no evidence of systematic differences prior to the reform.

A first glimpse of the absence of pre-trends is evidenced in Figure 2, where we compare the evolution of employment before and after the reforms. We observe no significant differences in trends prior to 2010, suggesting the absence of anticipatory effects, even in the raw data. We present more formal evidence by estimating the event study estimates detailed in Equation 4.4. Figure 3 plots the estimates for the input (Panel 3a) and competition (Panel 3b) shocks. We observe positive effects across industries in which the prices of foreign inputs were reduced, whereas there were no significant differences before the shock. The competition shock, by contrast, shows negative effects of import competition after the 2012 tariff reductions (i.e., those stipulated in the FTA), and no significant differences prior to them. These results provide no evidence of pre-trends for any of the analyzed shocks, as we fail to reject the null hypothesis that any of the pre-treatment coefficients differ from zero.[26]

Our results could also be confounded if the effects are attributable to an increase in exports induced by trade liberalization, rather than to an increase in imports. The reform had no significant effect on Colombian exports. The 2010 reduction applied only to imported products and therefore had no direct impact on exports. The implementation of the FTA in 2012 did not substantially reduce the tariffs imposed on Colombian products by the U.S. We test this and present the results in Appendix Table A.1. We observe small, statistically insignificant effects of U.S. tariff cuts on Colombian exports to the U.S. These results are consistent with the fact that

[25]We explore the heterogeneity across economic sectors in greater detail in Appendix E.1, where we present estimations at the two-digit sector level, by workers' skill level, and by input type. These analyses are limited by insufficient statistical power, as there may be insufficient within-sector variation to precisely estimate the model parameters. Nonetheless, they provide suggestive yet meaningful evidence that heterogeneity in the EoS across sectors plays an important role in determining how exposure to foreign inputs influences local labor market outcomes.

[26]We present additional event-study estimates in Appendix C. The results are broadly consistent across specifications, estimation methods, and samples. To formally assess the absence of pre-trends, we conduct two tests: (i) a joint F-test of the null hypothesis that all pre-treatment coefficients equal zero, and (ii) an F-test of the null that the sum of these coefficients equals zero. Across the 16 combinations considered (the four specifications in Table 1, both shocks, and both tests), the minimum p-value is 0.30, providing strong support for the absence of differential pre-trends. We also provide event study estimates at the one-digit sector level (i.e., agriculture, manufacturing, and services) and use a binary treatment to account for varying exposure levels. In all cases, we again fail to reject the null hypothesis that any of the pre-treatment coefficients differ from zero.

most tariffs were already close to zero by the time the FTA was implemented.

4.2. Trade Elasticities

We estimate the *structural equation for the trade elasticities* (Equation 2.12) exploiting the variation generated by the Colombia-U.S. FTA. This agreement modified only the tariffs charged to the United States, allowing us to properly identify a gravity equation comparing Colombian tariffs charged to the U.S. with those charged to other exporters.[27] Empirically, this translates into:

$$\ln M_{i,nj,t} - \ln M_{US,nj,t} = -\theta_j \tilde{\tau}^{US} + \lambda_{i,nj} + \lambda_{it} + \lambda_{nt} + \tilde{\epsilon}_{i,nj,t}, \tag{4.5}$$

where $\tilde{\tau}^{US} = \ln(1+\tau_{i,j,t}) - \ln(1+\tau_{US,j,t})$ corresponds to the difference of the tariffs charged to the U.S. relative to other countries in sector j.[28] Equation 4.5 is estimated in a panel at the origin i, sector j, region n, and year t level.[29] Therefore, as described in equation 2.12, it includes: $\lambda_{i,nj}$ an origin-sector-destination fixed effect, capturing time-invariant supply-side determinants such as initial productivity and geographical or linguistic distance; λ_{it}, an origin-year fixed effect capturing shocks common across sectors within each exporting country (e.g., political relations between Colombia and country i); λ_{nt} a destination-time fixed effect, capturing aggregate demand variables in the destination (e.g., the price index in state n), and $\epsilon_{i,nj,t}$ is the error term two-way clustered at the sector j and region n level.

Table 2 reports the results. Panel A presents the overall estimates and shows that, as expected, the Colombian–U.S. FTA increased imports from the United States relative to other countries. Panel B then interacts tariff changes with indicators for agriculture and manufacturing. The estimated trade elasticity is larger for agricultural products than for manufacturing, consistent with Caliendo and Parro (2015), who find an agricultural trade elasticity of about 8, and with Giri et al. (2021), who estimate a manufacturing trade elasticity of roughly 4.3. We also find an overall trade elasticity of approximately 1.5, consistent with the results reported in Boehm et al. (2023).

5. Model Calibration and Counterfactual Analysis

5.1. Calibration

To calibrate the model, we build on the dynamic hat algebra approach developed by CDP, which solves the model in changes using only initial data and key elasticities, without requiring knowledge of the full sequence of fundamentals. We use 2009 as the baseline, corresponding

[27] Other exporters correspond to the following high-income countries: Germany, Australia, Austria, Belgium, Canada, Denmark, Spain, Finland, France, Netherlands, Italy, Norway, Portugal, United Kingdom, Sweden, Switzerland, and Japan.

[28] We use data from 2012 to 2018 to estimate Equation 4.5 because, in earlier years, there were no differences between the tariffs charged to the U.S. and those charged to other exporters. Beginning in 2012, following the FTA, the U.S. faced differential tariffs, which enabled us to identify the equation.

[29] We use 10-digit sectors to fully exploit the granularity of the data, as both import and tariff records are reported at this level (see Appendix B for details).

to the year preceding the first liberalization. The model calibration combines our reduced-form estimates from Section 4, baseline variables constructed from the data, and parameters and elasticities drawn from the literature. Table 3 summarizes these components. Panel A reports the baseline variables for sector s in location i trading with n, constructed from observed trade flows, labor and input shares, and baseline tariffs. Consumption shares are calibrated to match the initial equilibrium data. Panel B presents the parameters and elasticities, together with their respective sources. Panel C presents the trade elasticities taken from Equation 4.5.

We calibrate the model using 26 regions (24 Colombian departments, the U.S., and RoW) and 13 two-digit sectors (three agricultural, eight manufacturing, and two service sectors), as well as a home production sector.[30] Although the model is calibrated with 13 two-digit sectors, we compute the EoS using three one-digit sectors to increase the precision of our estimates.[31] We employ an indirect inference approach that matches the reduced-form coefficients of the input shock to those implied by the model, while treating the competition shock coefficients as untargeted moments in the calibration. The vector of elasticities is then obtained by minimizing the following distance function:

$$\hat{\sigma} = argmin \;\; \mathbf{\Gamma}(\sigma)' \mathbf{W} \mathbf{\Gamma}(\sigma), \tag{5.1}$$

where $\boldsymbol{\sigma} = \{\sigma_A, \sigma_M, \sigma_S\}$ denotes the vector of EoS between labor and inputs for the three one-digit sectors. The difference between the model-implied coefficients and the reduced-form estimates corresponds to $\Gamma = \beta^i_{\text{Model}} - \beta^i_{\text{Data}}$, where W is a weighting matrix that uses the inverse of the standard errors. To compute Γ and W, we use the average point estimates and standard errors from Table 1.[32]

We simulate the model and present the results in Table 4. Column (1) reports the EoS between labor and intermediate inputs at the sector level, columns (2) and (3) present the input shock coefficients from the model and the reduced form, respectively, and columns (4) and (5) display the corresponding competition shock coefficients. Overall, the model closely replicates the reduced-form estimates for both shocks. The input shock coefficients are matched exactly, and the model's fit is strong for the competition shock, which represents an untargeted moment. The results indicate that labor and intermediate inputs are highly substitutable in the agricultural sector, with an estimated elasticity exceeding 9.0. In manufacturing, the elasticity also indicates substantial substitutability, with a value of around 3.4. By contrast, the services sector exhibits complementarity, with σ^S approximately 0.5 (< 1).

These results are consistent with the prediction from Equation 2.10, which implies that the effect of the input shock becomes more positive as the EoS between labor and intermediate inputs

[30] Appendix B.3 provides more information on the data used for the calibration exercise.

[31] This method assumes that sectors within the same one-digit category share a common EoS between labor and intermediate inputs. This approach is analogous to that of other papers, which assume a common trade elasticity across sectors but calibrate the model at a finer level of disaggregation (i.e., (Rodriguez-Clare et al., 2025)).

[32] For the model-generated data, we estimate equation 2.8 in changes between period 1 and period 10, and to simplify the analysis, we consider a one-time shock occurring from period 1 to period 2.

increases. Appendix Figure A.4 illustrates this by showing how the input shock coefficient for each sector varies with the EoS, σ^j. The diagonal panels depict the within-sector relationship and exhibit a clear monotonic pattern: as labor and intermediate inputs become more substitutable, the input coefficient rises. The off-diagonal panels display cross-sector relationships, which are flat, indicating that each elasticity primarily affects its own corresponding moment—the input coefficient of that sector. Overall, these patterns suggest that our calibration and simulation procedure successfully identifies a minimum that aligns the model-implied coefficients with those observed in the reduced form.

The values we obtain for EoS between labor and intermediate inputs are broadly consistent with magnitudes found in other contexts. Huneeus et al. (2021) study how production networks shape wage inequality in Chile using a CES production function. Instrumenting log relative prices with polynomials in lagged factor prices and input expenditures, they estimate an EoS of about 1.5, indicating that labor and intermediates are gross substitutes. Similarly, Chan (2021) analyzes Danish manufacturing within a CES framework and instruments relative prices with lagged intermediate prices, finding elasticities between 1.5 and 4.0. The cross-sector average of our estimates of the EoS falls within this range but conceals substantial heterogeneity—highlighting the importance of allowing for sector-specific elasticities, an important innovation of our analysis.

5.2. Counterfactual analysis

We analyze counterfactual scenarios involving an unexpected change in tariffs in 2009, focusing on the two shocks: (i) the tariff reduction in 2010, and (ii) the FTA between Colombia and the U.S. We evaluate their effects on the evolution of employment across sectors and on welfare, and highlight the differences between CD and CES production functions.[33]

Effects on employment: Trade liberalization led to employment growth in market production sectors, while reducing employment in home production due to changes in the price index. Figure 4a illustrates the evolution of employment following the tariff changes, as predicted by the model simulations. The results are presented at the one-digit sector level under both the CD and CES production function specifications.

Between 2010 and 2012, employment increased more in agriculture, coinciding with the first tariff reduction, which was smaller for agriculture than for manufacturing. As a result, workers reallocated toward agricultural employment. The second shock, after 2012, narrowed the differences between agriculture and manufacturing, as agricultural tariffs also declined under the FTA. Employment in the service sector rose by 0.4-0.5 percent, as these sectors were not directly exposed to foreign competition and benefited from improved access to imported inputs. Total employment in the home production sector declined by approximately 0.7 percent over the ten-year period. This result reflects higher labor force participation, as lower price indices encouraged

[33] Because our main interest lies in the degree of substitution between labor and intermediate inputs, we fix the EoS for intermediate inputs across sectors and compare the CD and CES results in the upper nest.

workers to shift from home production to market-based employment.

Comparing the CES and CD specifications reveals meaningful differences across sectors. Allowing for varying degrees of substitutability between labor and intermediate inputs (i.e., using a CES production function) amplifies employment gains in the service sector, where employment rose by 0.5 percent under the CES case compared to 0.4 percent under the CD case. In contrast, employment growth in agriculture and manufacturing is weaker under the CES specification. This difference is most pronounced in agriculture, where the high substitutability between labor and intermediates leads to a CD case showing an employment increase of about 1.4 percent, whereas the CES specification indicates an increase of only 0.6 percent. Likewise, employment in manufacturing grows by only 0.35 percent under the CES case, compared with 0.75 percent under the CD specification, pointing to a stronger reallocation of workers toward the service sector.[34]

These results indicate that the trade liberalization episode led to a reallocation of workers, which in turn altered the labor share across sectors of the economy. Figure 4b depicts the change in the labor share 10 years after liberalization across sectors, based on the CES production function. The results depict a pronounced decline in the labor share in agriculture and a small decline in manufacturing, accompanied by a very small increase in services. These estimates are computed relative to the CD case, in which the labor share remains constant (see Equation 2.5), and demonstrate that incorporating the substitution channel yields substantial cross-sectoral differences.

This estimated labor reallocation is consistent with previous evidence emphasizing the role of structural transformation in developing economies. A common finding in this literature is that access to international trade can trigger the reallocation of workers across industries, thereby shaping structural transformation (Alessandria et al., 2023; Dix-Carneiro and Kovak, 2017; Farrokhi and Pellegrina, 2023; McCaig and Pavcnik, 2018). In this context, our results suggest that sectoral differences in the EoS between labor and intermediate inputs (i.e., the substitution channel) play an important role in determining how trade liberalization affects structural transformation and the reallocation of workers across sectors.

Effects on welfare: Overall, trade liberalization generated positive welfare gains for the Colombian economy, with welfare gains varying across sectors. Table 5 reports the change in welfare across sectors, aggregated at the one-digit sector level using both simple and employment-weighted averages, where the weights correspond to initial employment in each location-sector.[35] Workers initially employed in agriculture experienced the largest welfare gains, with an average increase of about 0.35 percent. Those in the service sector benefited slightly less, with gains of roughly

[34] As with the reduced-form results, these counterfactual estimates conceal substantial heterogeneity across two-digit sectors. We further examine the counterfactual simulations at this more detailed level and report the analysis in Appendix E.2. Overall, the results indicate that the EoS between labor and intermediate inputs plays a crucial role in understanding the effects of foreign trade liberalization, as it can significantly alter the direction and magnitude of sectoral responses.

[35] As explained in Section 2.4, welfare is measured as the net present value of the equivalent variation, accounting for outside options.

0.22 percent and workers in manufacturing experienced welfare improvements of around 0.19 percent.[36]

The CES and CD cases yield similar average welfare gains for the average Colombian worker overall, but differ significantly across sectors. Comparing both cases highlights the crucial role of the EoS between labor and intermediate inputs in determining welfare outcomes. In this context, omitting this mechanism overestimates welfare gains for workers in manufacturing and agriculture, whereas gains for workers in services remain unchanged. In the service sector, average welfare gains increase slightly by 7.0 basis points. In contrast, the estimated welfare gains among agricultural workers decrease from 0.46 percent under CD to 0.35 percent under CES, a reduction of about 25 percent. This contrast is similar in manufacturing, where average welfare gains fall from 0.27 percent under CD to 0.19 percent under CES, representing an overall 32 percent decrease.

Taken together, the model simulations show that the EoS between labor and intermediate inputs is a critical statistic for understanding how trade affects local labor markets. Ignoring this mechanism leads to a substantial overestimation of the effects of trade liberalization in agriculture and manufacturing, while understating the positive gains in the service sector. Incorporating the EoS amplifies the role of trade liberalization in driving structural transformation across sectors—a well-documented finding in the literature-and emphasizes the broader relevance of international trade for economic development, particularly in the service sector, which currently accounts for the largest share of employment in most developing economies (Fan et al., 2023).

6. Conclusion

This paper examines a mechanism that may amplify or mitigate the impact of trade on labor market outcomes and welfare: the substitution between labor and intermediate inputs. We extend the dynamic quantitative model from CDP by allowing for a more flexible production function with varying degrees of substitutability between labor and intermediate inputs across sectors.

We use exogenous tariff reductions in Colombia, which lowered input prices and increased import competition from the United States. Using a differences-in-differences framework, we estimate the effects of these trade shocks, distinguishing between competition and input channels. Robustness checks, including event studies, support the reliability of our results. The results suggest that import competition reduced the wage bill, while access to foreign inputs increased it. These effects vary significantly across sectors. The service sector drives employment growth, explained by foreign inputs, whereas the effects are less pronounced in agriculture and manufacturing. These results are consistent with a mechanism where marginal cost reductions interact with the substitutability channel between labor and intermediates.

[36] We also provide welfare gain measures at the two-digit level in Appendix E.2, suggesting once again a great deal of heterogeneity consistent with our main results.

Based on these reduced-form findings, we calibrate the model to incorporate sector-specific substitutability between labor and intermediate inputs. We find that labor and intermediate inputs are substitutes in agriculture and manufacturing but complements in services. Using these parameters, we simulate a counterfactual scenario changing the tariff paths prior to trade liberalization. The results indicate that this substitution mechanism influences structural transformation by reallocating more workers toward services and fewer to manufacturing and agriculture.

With respect to welfare, the average Colombian worker experiences similar gains under both the CD and CES production functions. However, when accounting for the EoS between labor and foreign inputs (the CES case), workers in manufacturing and agriculture experience substantially smaller welfare gains, while workers in services benefit more. This finding is particularly relevant for developing economies, where services account for a large share of employment and play a central role in structural transformation (Fan et al., 2023).

The findings underscore the importance of allowing for flexible production structures when analyzing trade shocks. Although trade liberalization can yield similar aggregate gains under more flexible production settings, its sectoral effects can be substantially more adverse for certain groups of workers. In addition, the results suggest that policies aimed at reducing labor market frictions and promoting worker mobility could play a crucial role in mitigating these unequal effects and enhancing the overall benefits of trade.

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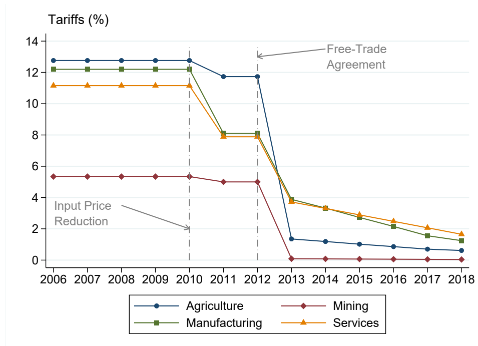
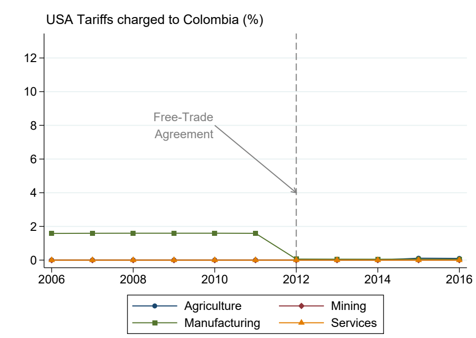
Figures and Tables

Figure 1: Tariffs Charged by Country

(a) Colombia



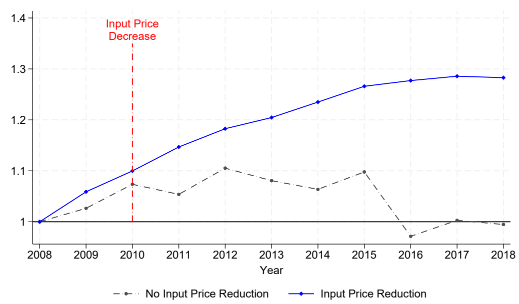
(b) United States



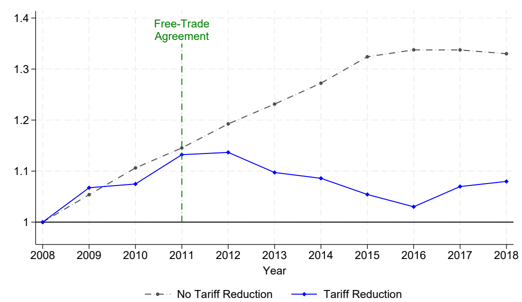
Notes: This figure plots the average tariffs applied by Colombia and the United States across four sectors: agriculture, manufacturing, mining, and services. The values are calculated as simple averages of the 10-digit industry codes. The left panel shows the historical tariffs imposed by Colombia on products imported from the United States, while the right panel illustrates the historical tariffs charged by the United States on imports from Colombia..

Figure 2: Evolution of Employment and Wage Bill

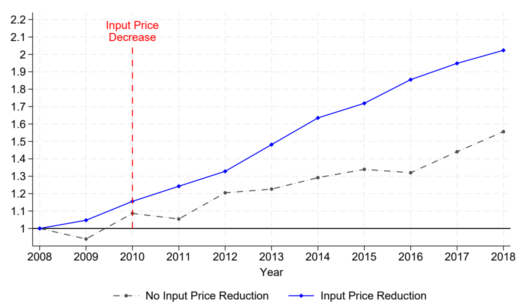
(a) Employment by sectors that changed foreign input prices



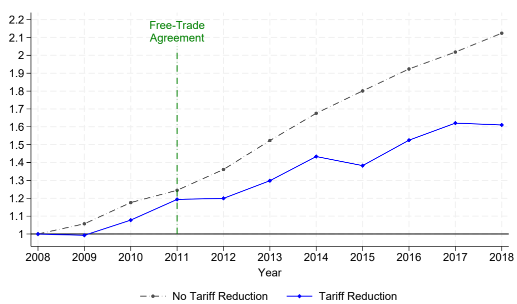
(b) Employment by sectors that changed tariffs



(c) Wagebill by sectors that changed foreign input prices



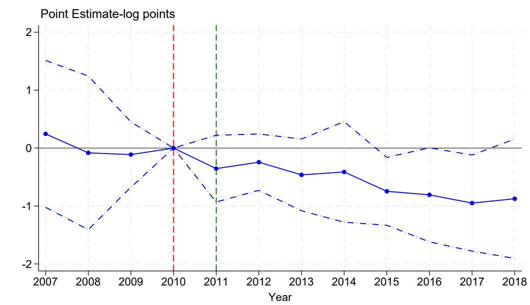
(d) Wagebill by sectors that changed tariffs



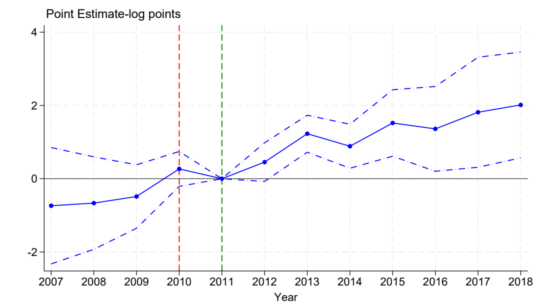
Notes: This figure plots the evolution of total employment (panels 2a and 2b) and wage bill (panels 2c and 2d) with respect to 2008 using Colombian household survey data. Panels 2a and 2c split by industries whose prices of foreign intermediate inputs did and did not decrease due to the trade liberalization. Panels 2b and 2d split by industries that did and did not reduce tariffs.

Figure 3: Event Study Estimates of Input and Competition Shocks on Wage bill

(a) Input Shock



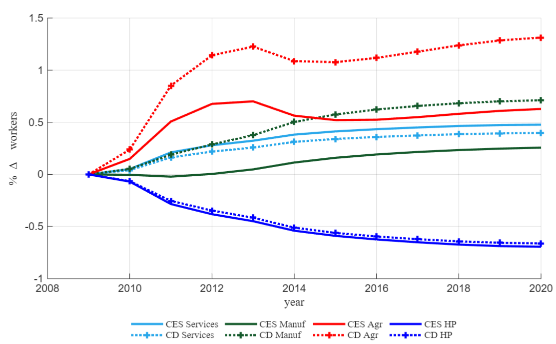
(b) Competition Shock



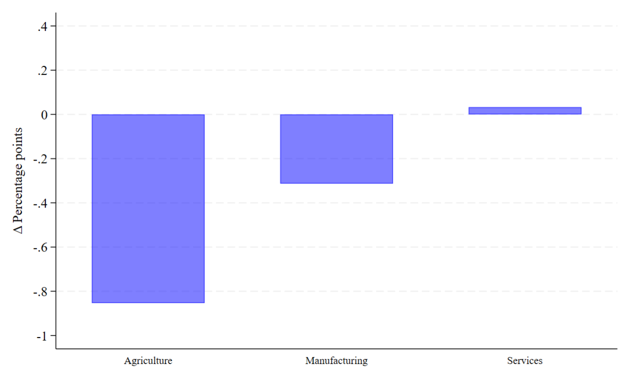
Notes: These figures plot the event study specification in Equation 4.4 at the industry-region-year level. The competition and input shocks are estimated jointly and control for region-by-industry and region-by-year fixed effects. Colombian departments are use as regions. Plotted intervals correspond to the 95 percent confidence level.

Figure 4: Effects of Tariff Reductions on Employment and Labor Share

(a) Employment effects



(b) Labor share



Notes: These figures plot the effects on employment and labor share of the tariff reduction according to the model simulations. Panel A plots the percentage change in total employment after the trade liberalization episode by industry. Panel B plots the average change in the labor share across regions after 10 periods for each one-digit sector for the case of the CES production function.

Table 1: Input and Competition Shocks on Wage Bill

	OLS				IV			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
A) All Sectors								
Input Shock	-1.365	-2.490*	-1.763*	-1.386	-3.862**	-4.825**	-3.739**	-3.562**
	(0.862)	(1.294)	(1.007)	(0.863)	(1.716)	(2.044)	(1.689)	(1.712)
Comp. Shock	3.371***	3.326**	3.360**	3.356**	3.893***	3.875**	3.856**	3.862**
	(1.192)	(1.202)	(1.211)	(1.206)	(1.356)	(1.381)	(1.392)	(1.382)
F-Stat First Stage					110.8	107.6	109	106.9
B) By Industry								
Input shock $\times$ 1(Agric.)	2.494	1.729	1.658	2.721	3.402	3.087	3.149	3.951
	(1.879)	(2.227)	(2.293)	(2.013)	(4.209)	(4.578)	(4.630)	(4.542)
Input shock $\times$ 1(Manuf.)	-0.253	-1.595	-1.072	-0.252	-1.865	-3.025	-2.332	-1.378
	(1.586)	(2.000)	(1.896)	(1.588)	(2.219)	(2.425)	(2.451)	(2.079)
Input shock $\times$ 1(Serv.)	-2.125**	-2.829**	-2.466**	-2.222**	-5.400***	-5.564**	-5.310***	-5.183***
	(1.006)	(1.309)	(1.083)	(1.017)	(1.834)	(2.124)	(1.755)	(1.759)
Comp. shock $\times$ 1(Agric.)	5.800**	5.541*	5.779**	5.726**	6.404*	6.102	6.333	6.257
	(2.669)	(2.716)	(2.790)	(2.735)	(3.545)	(3.624)	(3.743)	(3.697)
Comp. shock $\times$ 1(Manuf.)	1.522**	1.626**	1.640**	1.485**	1.355	1.686	1.504	1.258
	(0.630)	(0.661)	(0.647)	(0.630)	(1.019)	(1.087)	(1.044)	(1.015)
F-Stat First Stage					116.7	83.07	115.8	124.2
Observations	58,370	58,370	58,370	58,370	58,370	58,370	58,370	58,370
Region-Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region-Year FE	Yes				Yes			
Year FE		Yes	Yes	Yes		Yes	Yes	Yes
Baseline Controls			Yes	Yes			Yes	Yes
Region-Specific Trends				Yes				Yes

Note: This table presents the results of estimating Equation 4.3 using the wage bill as outcome. Estimations performed in a panel at the industry-region-year level. Colombian departments are use as regions. Columns (1)-(4) are estimated using ordinary least squares, whereas columns (5)-(8) present IV estimates using the tariff initial values interacted with a dummy post-reform as instrument. Panel A presents estimates pooling all sectors, whereas Panel B presents estimates interacting by industry dummies. Baseline controls include the 2008 share of college-educated workers, the share of manufacturing employment, share of employment in services, and the share of female workers in each region, all interacted with year fixed effects. Estimations are weighted by employment per industry and region in 2008. The reported first stage F statistic corresponds to the minimum across all the first stage regressions using Sanderson and Windmeijer (2016). Standard errors are two-way clustered at the industry and region level. *** p<0.01, ** p<0.05, * p<0.1

Table 2: Trade Elasticities Induced by Free-Trade Agreement

	(1)	(2)	(3)	(4)
A) All Sectors				
$\tilde{\tau}^{U.S}$	-1.555**	-1.674**	-1.661**	-1.596**
	(0.623)	(0.622)	(0.627)	(0.625)
Observations	4,929,099	4,929,099	4,823,376	4,823,376
B) By Industry				
$\tilde{\tau}^{U.S} \times 1(Agric.)$	-6.656***	-6.832***	-6.742***	-6.535***
	(2.111)	(2.142)	(2.149)	(2.106)
$\tilde{\tau}^{U.S} \times 1(Manuf.)$	-1.351**	-1.464**	-1.455**	-1.396**
	(0.623)	(0.619)	(0.625)	(0.625)
Observations	4,929,099	4,929,099	4,823,376	4,823,376
Sector-Region-Origin FE	Yes	Yes	Yes	Yes
Year-Origin FE	Yes	Yes	Yes	Yes
Region-Year FE	Yes			
Year FE		Yes	Yes	Yes
Controls			Yes	Yes
Region-Specific Trends				Yes

Note: This table presents the results of estimating Equation 4.5 using a panel at the 10-digit sector, region, country-of-origin, and year level. Colombian departments are used as regions. Estimations are performed after 2012, capturing the change in tariffs induced by the FTA. Standard errors clustered at the sector level. The outcome corresponds to the change in imports between high-income countries and the U.S.($\ln M_{i,j,t} - \ln M_{US,j,t}$). High-income countries include: Germany, Australia, Austria, Belgium, Canada, Denmark, Spain, Finland, France, Netherlands, Italy, Norway, Portugal, United Kingdom, Sweden, Switzerland, and Japan. Baseline controls include the 2008 share of college-educated workers, the share of manufacturing employment, share of employment in services, and the share of female workers in each region, all interacted with year fixed effects. Standard errors are two-way clustered at the industry and region level.*** p<0.01, ** p<0.05, * p<0.1

Table 3: Baseline Variables and Parameters used in the Model

	Symbol	Equation	Source
A) Baseline Variables (Constructed from Data)			
Gross production	$Y_{t_0}^{is}$	$\sum_n M_{t_0}^{ns,is}$	Data
Total expenditure	$X_{t_0}^{ns,is}$	$M_{t_0}^{ns,is}(1+\tau_{t_0}^{ns,is})$	Data
Government revenue	$R_{t_0}^{n}$	$\sum_{i,s} M_{t_0}^{ns,is}\tau_{t_0}^{ns,is}$	Data
Trade shares	$\pi_{t_0}^{ns,is}$	$\frac{X_{t_0}^{ns,is}}{\sum_l X_{t_0}^{ns,ls}}$	Data
Labor share	$\phi_{t_0}^{is}$	$\frac{w_{t_0}^{is}L_{t_0}^{is}}{Y_{t_0}^{is}}$	Data
Sectoral trade deficit	$D_{t_0}^{is}$	$\sum_n M_{t_0}^{is,ns} - \sum_n M_{t_0}^{ns,is}$	Data
Aggregate deficit	$D_{t_0}^{i}$	$\sum_s D_{t_0}^{is}$	Data
Domestic absorption	$I_{t_0}^{i}$	$\sum_s w_{t_0}^{is}L_{t_0}^{is} + R_{t_0}^{i} + D_{t_0}^{i}$	Data
Consumption shares	α^{is}	$\frac{X_{t_0}^{is} - \sum_k \gamma_{t_0}^{ik,is}Y_{t_0}^{ik}}{I_{t_0}^{i}}$	Calibrated
B) Parameters and Elasticities from the Literature			
Elasticity across intermediate inputs	δ^j	2.5	Peter and Ruane (2023)
Trade elasticity (Services)	θ^S	4.3	Giri et al. (2021)
Inverse migration elasticity	η	12.3	Rodriguez-Clare et al. (2025)
Inverse sectoral supply elasticity	ν	0.55	Rodriguez-Clare et al. (2025)
Annual discount factor	β	0.95	Rodriguez-Clare et al. (2025)
C) Parameters from the Reduced Form			
Trade elasticity (Agriculture)	θ^A	6.65	Gravity equation (Section 4.2)
Trade elasticity (Manufacturing)	θ^M	1.35	Gravity equation (Section 4.2)

Notes: The model is calibrated to 26 regions (24 Colombian states, the U.S., and the RoW), 13 two-digit sectors (3 agricultural, 8 manufacturing, 2 services), and a home-production sector. Panel A variables are constructed from trade flows, wages, labor, and tariffs in the baseline year t_0. Panel B parameters are taken from the literature or externally calibrated. The parameters in Panel C are drawn from column (1) of Table 2.

Table 4: Results of the Model Simulation

	(1)	(2)	(3)	(4)	(5)
	EoS (σ^j)	Input Shock (β^i)		Comp. Shock (β^c)	
Sector		Model	Data	Model	Data
Agriculture	9.58	2.77	2.77	3.26	5.99
Manufacturing	3.38	-1.47	-1.47	1.35	1.45
Services	0.50	-3.89	-3.89	0.00	0.00

Notes: This table reports the calibration of the elasticity of substitution (EoS) between labor and intermediate inputs from the inference-matching procedure. Column 1 reports the values of the EoS that we found from the minimization. Columns 2 and 3 report the coefficient of the input shock from the model simulations and the reduced-form, respectively. Columns 4 and 5 report the coefficient of the competition shock from the model simulations and reduced-form. We report the values for one-digit sectors: Agriculture, manufacturing, and services.

Table 5: Welfare Gains from the Trade Liberalization

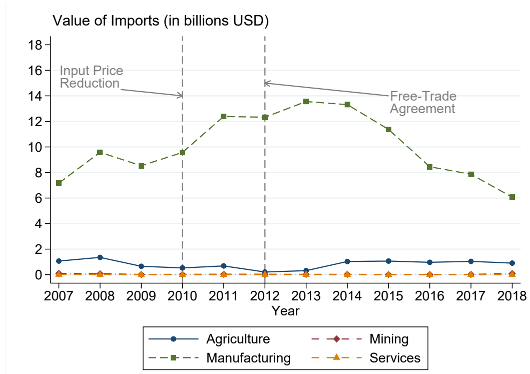
	CES production function				Cobb-Douglas production function				
	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.	Obs.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
A) Weighted average									
All industries	0.219	0.071	-0.464	0.985	0.227	0.088	-0.178	1.171	312
Agriculture	0.352	0.116	-0.108	0.985	0.463	0.157	-0.058	1.151	72
Manufacturing	0.185	0.142	-0.464	0.654	0.267	0.147	-0.178	1.171	192
Services	0.216	0.040	0.142	0.373	0.209	0.039	0.134	0.348	48
B) Simple average									
All industries	0.197	0.148	-0.464	0.985	0.260	0.159	-0.178	1.171	312
Agriculture	0.236	0.171	-0.108	0.985	0.296	0.195	-0.058	1.151	72
Manufacturing	0.172	0.150	-0.464	0.654	0.255	0.161	-0.178	1.171	192
Services	0.240	0.050	0.142	0.373	0.224	0.050	0.134	0.348	48

Notes: This table reports the average welfare gains of the trade liberalization episode across industries and states in Colombia from the model counterfactuals, which consists of a change in the tariff path in 2009. Panel A reports results using a weighted average with weights equal to initial employment, and Panel B reports the simple average across states and 2-digit sectors. Columns 1 to 4 present the results for the Cobb-Douglas production function, and columns 1 to 8 for the CES production function. We report summary statistics for all industries and within one-digit sector categories.

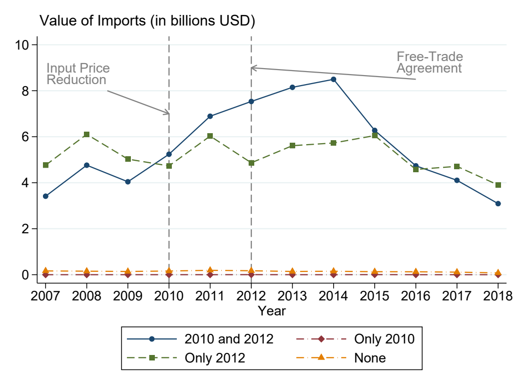
A. Additional Figures and Tables

Appendix Figure A.1: Colombian Imports from the United States

(a) By Economic Sector



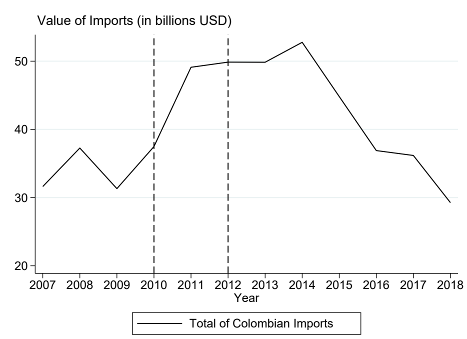
(b) By year of Tariff Reduction



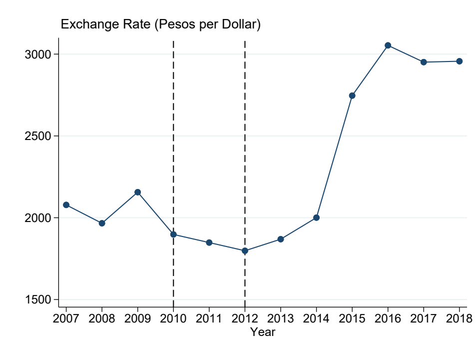
Notes: This graph plots the value of imports in billions USD. Panel A.1a plots the evolution of Colombian imports from the United States by industry. Panel A.1b plots the evolution of Colombian imports from the United States by the year in which the product's tariff was decreased. Vertical gray lines depict the years in which the two tariff reductions took place.

Appendix Figure A.2: Macroeconomic Environment

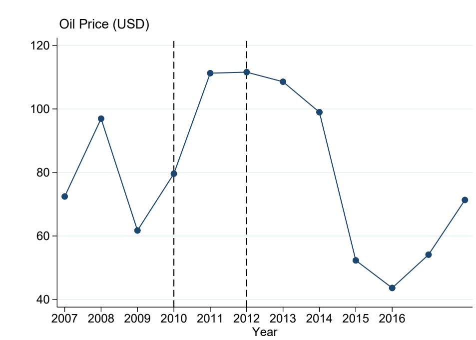
(a) Total Imports



(b) Exchange Rates

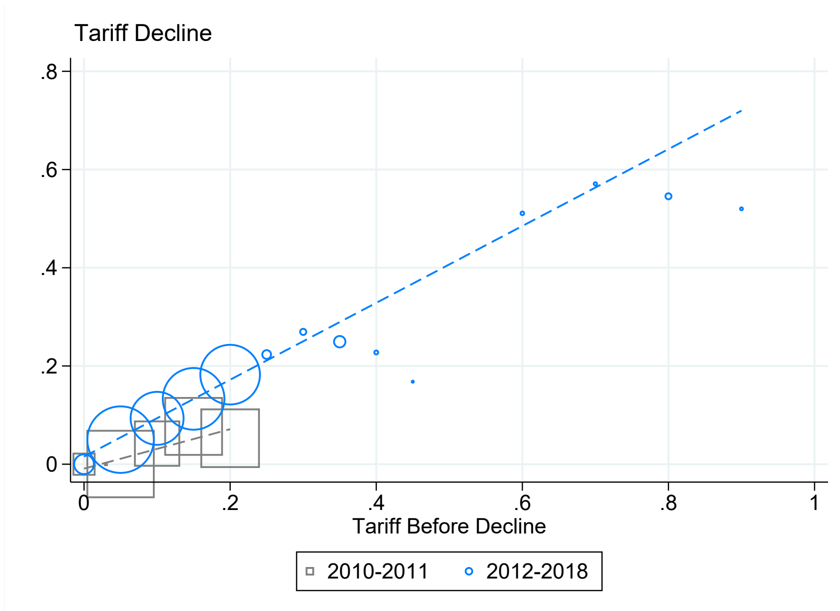


(c) Oil Prices

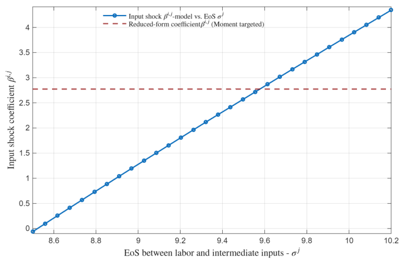


Notes: These graphs describe the macroeconomic environment around the implementation of the free-trade agreement. Panel A.2a presents the evolution of total imports in billions USD. Panel A.2b presents the evolution of the exchange rate of U.S. dollars to Colombian pesos. Panel A.2c presents the evolution of the price of oil (in dollars). The vertical dashed lines correspond to the years of tariffs reductions.

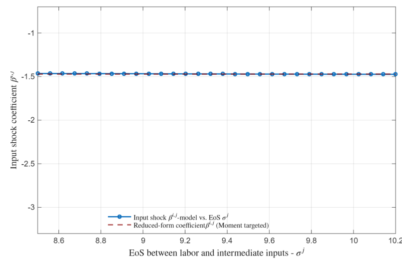
Appendix Figure A.3: Average Tariff Reductions by Baseline Level



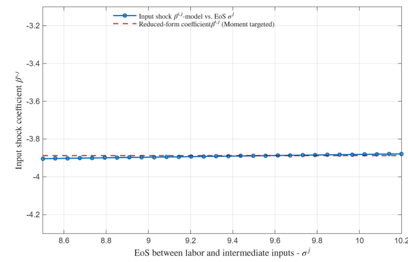
Appendix Figure A.4: Sensitivity analysis of the model parameters



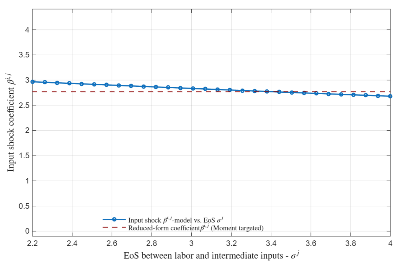
(a) σ^A vs. $\beta^{i,A}$



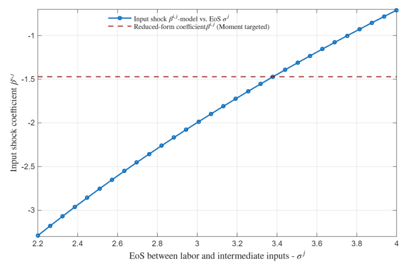
(b) σ^A vs. $\beta^{i,M}$



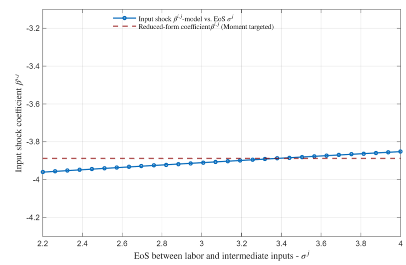
(c) σ^A vs. $\beta^{i,S}$



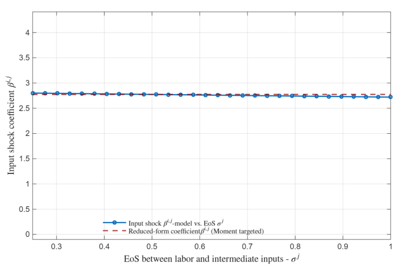
(d) σ^M vs. $\beta^{i,A}$



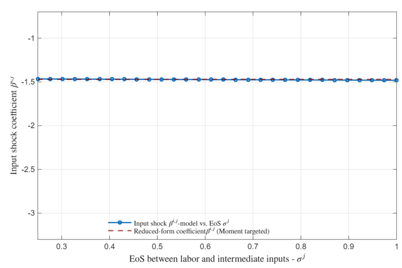
(e) σ^M vs. $\beta^{i,M}$



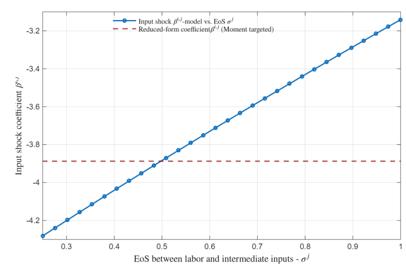
(f) σ^M vs. $\beta^{i,S}$



(g) σ^S vs. $\beta^{i,A}$



(h) σ^S vs. $\beta^{i,M}$



(i) σ^S vs. $\beta^{i,S}$

Notes: This figure plots the relationship between the EoS between labor and intermediate inputs, σ^j for each one-digit sector vs. the coefficient of the input shock implied by the model, also for each one-digit sector. The rows fix the sector for the EoS, and the columns fix the sector for the input-shock point estimate. The first row corresponds to the EoS in agriculture, the second row in manufacturing, and the third row in services. The first column corresponds to the input shock coefficient in agriculture, the second column in manufacturing, and the third column in services. The blue line illustrates the relationship between each EoS and the point estimate of the input shock according to the model simulations. The red line corresponds to the targeted moment, which is the coefficient of the input shock that we find in the reduced-form for each 1-digit sector. The intersection between the blue curve and the red line identifies the σ^j values that align the model with the reduced-form moment in that panel, providing the basis for our calibration of σ^j across sectors.

Appendix Table A.1
U.S Tariff Reductions on Colombian Exports

	Total (1)	To the U.S. (2)	To All Other (3)
U.S. Tariff Reduction	-0.008	-0.006	-0.010
	(0.010)	(0.008)	(0.011)
Observations	55,903	55,903	55,903
Industry FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

Notes: This table uses Colombian exports as outcome. Column (1) refers to total exports, column (2) refers to exports to the United States, and column (3) to exports to other countries. Estimations are done at the six-digit industry and year level. Tariff reduction in year t is computed as the tariff charged by the United States to Colombian products in 2011 minus the tariff charged in year t. All specifications control for Colombian tariff reduction. *** p<0.01, ** p<0.05, * p<0.1

B. Data Construction and Aggregation

We combine several data sources, as described in Section 3.2 of the main paper. Appentix Table B.1 describes the level at which each of these data sets exists. Most of them report information at the ten- or four-digit sector level, while the input–output matrix is available at the two-digit level. This mismatch creates limitations when aggregating the data. In this appendix, we explain how the estimating data sets are created and how we address the aggregation limitations.

Appendix Table B.1: Data Sources

	Regions		Sectors	
Data Source	Level	Number	Level	Number
Tariff Records	-	-	Ten-Digit	7,305
Trade Records	Department	33	Ten-Digit	7,920
Imports by Firm (2008)	Department	33	Four-Digit	416
Household Surveys	Department	24	Four-digit	402
Input-Output Matrix	Department	24	Two-Digit	13

B.1. Data Construction

We merge the data sets in Appendix Table B.1 to build two main estimating data sets. The first is a panel that captures Colombian imports by country of origin. This panel exploits the granularity of the data. Therefore, it is constructed at the 10-digit sector, by country-of-origin, by department, and year level. It is built merging the trade and tariff records. We restrict to imports coming from high-income countries that are comparable to the U.S.[1] In addition, we restrict the panel to observations after 2012 capturing the differential effects of tariffs charged to the U.S. and the

[1]High-income countries include: Germany, Australia, Austria, Belgium, Canada, Denmark, Spain, Finland, France, Netherlands, Italy, Norway, Portugal, United Kingdom, Sweden, Switzerland, and Japan.

rest of exporters. The panel includes information on 6,304 imported products, in 33 departments, observed during 7 years (2012-2018), for a total of 4,929,099 observations.

The second is a four-digit industry-code panel that matches data from the household surveys and the tariffs. This dataset follows 402 department-by-four-digit ISIC sectors over 11 years. We built this panel by keeping sector-department combinations with at least one employee observed in 2008, and that report imports at any point during the period 2008-2018. The panel at the department-industry-year level includes 53,371 observations, corresponding to 5,844 department-by-industry combinations (24 departments and 343 four-digit industries, excluding those with no employment in 2008 or no trade activity).[2]

Appendix Table B.2 presents descriptive statistics for both samples. We drop the mining sector from the analysis because of potential confounders due to variation in oil prices and exchange rates. This sector encompasses 21 industries, including oil and coal, constituting less than 0.5 percent of Colombia's imports.

Appendix Table B.2: Descriptive Statistics Across Samples

	Count (1)	Mean (2)	S.D. (3)	Min. (4)	Max. (5)
A) Trade Elasticity Data (10-Digit sector, country of origin, and region)					
$\tilde{\tau}^{U.S}$	4,929,099	-0.04	0.05	-0.68	0.00
$\tilde{\tau}^{U.S} \times 1(Agric.)$	4,929,099	-0.00	0.01	-0.47	0.00
$\tilde{\tau}^{U.S} \times 1(Manuf.)$	4,929,099	-0.04	0.05	-0.68	0.00
$\ln(M_{i,nj,t}) - \ln(M_{US,nj,t})$	4,929,099	4.34	5.50	-20.71	22.35
ln(Value Imports USA)	2,447,541	9.61	2.82	-3.51	21.65
ln(Value Imports USA)	2,447,541	9.61	2.82	-3.51	21.65
1(Manufacturing)	4,929,099	0.99	0.12	0.00	1.00
B) Wage Bill Data (4-Digit sector and region)					
Input Shock	58,522	-0.01	0.02	-0.14	0.00
Comp. Shock	58,522	-0.01	0.03	-0.18	0.00
Initial Input Prices ($-T^i_{jn}$)	58,522	0.02	0.05	0.00	0.68
Initial Tariffs ($-T^c_j$)	56,646	0.02	0.05	0.00	0.47
Log(Wagebill)	58,522	21.60	2.00	10.32	28.07
Log(Wagebill Low-Skilled)	52,777	21.15	1.91	8.22	27.49
Log(Wagebill High-Skilled)	46,934	21.06	1.90	10.32	28.00
1(Agriculture)	58,522	0.06	0.24	0.00	1.00
1(Manufacturing)	58,522	0.29	0.45	0.00	1.00
1(Services)	58,522	0.65	0.48	0.00	1.00

Note: This table presents descriptive statistics of the different samples used. Panel A) describes the panel at the 10 digit sector, country or origin, region, and year (2012-2018) level. Colombian departments are used as regions. Panel B) describes the panel at the industry region, and year (2008-2018) level. 1() stands for a dummy variable that takes the value of one if the condition inside parentheses is met.

[2] We address zeros by excluding region–sector combinations in which the outcome equals zero. In addition, we drop region–sector cells that do not import inputs over the entire period analyzed (2007–2018) to increase comparability. Including these cells does not alter our final results.

B.2. Data Aggregation for Reduced Form Results

We combine the regional input-output matrix, the World Input-Output Database, and the Colombian social security records to compute an *input-output* matrix specific to Colombia and an *employment transition probability* matrix:

- *Input-Output Matrix:-* Using information from the regional input-output tables, we construct bilateral trade flows, M_{ni,s,t_0}, across the Colombian regions in Colombian pesos, where n corresponds to the destination and i to the exporter. Trade flows between the United States and the rest of the world are based on *World Input-Output Database* (WIOD). We decompose the Colombian international trade flows (between the United States and the rest of the world) using imports and exports administrative records. Based on this matrix, we compute the total demand and the input share matrices. The first one reflects the total demand (intermediate inputs and final demand) of region n for goods produced by sector j in region n. The second one reflects the total sales of sector j to sector j in region n. The input-output tables also include information on the input shares and labor shares used by each sector.

- *Transition Probability:-* Based on the main job of each worker in each year, as reported in the social security records, we compute the transition probability among regions and industries, assuming no international migration. We add an additional sector accounting for adults that are out of the formal labor market in each region.[3]

The unit of observation for both matrices corresponds to the region-by-sector cell, aggregated to 13 sectors and 26 regions—of which 24 are Colombian States, and the last two corresponds to the United States and the rest of the world. Appendix Table B.3 describe the regions used.

However, the sector-level variation in the input-output matrix is not the same as the one used in our main outcomes. Unfortunately, this matrix is built at the two-digit sector level, whereas our main labor market outcomes are computed at the four-digit level. This forces us to aggregate two-digit sector shares with four-digit outcomes in the reduced form results and for the model calibration.

Recall from Section 4.1.1 that the competition and input shocks are defined, respectively, as:

$$\tilde{\tau}_{jnt} = \psi_{d(j),n,col}\left[\ln(1+\tau_{jt}) - \ln(1+\tau_{j,2010})\right]$$
$$\tilde{q}_{jnt} = \sum_k \omega_{jnk}\left[\ln(1+\tau_{kt}) - \ln(1+\tau_{k,2010})\right].$$

In these expressions, j corresponds to the economic sector. From our data, we aggregate τ_{jt} (which is originally measured at the 10-digit sector level) to the four-digit industry–year level—-this is the same level used for our outcome in Equation 4.3, which is computed from the household surveys. However, the attached weights, $\psi_{d(j),n,col}$ and $\pi_{d(k),nr}$, are constructed from the input–output matrix, which is available only at the two-digit sector level.

The weight $\psi_{d(j),n,col}$ corresponds to the revenue share of sector j-region n in Colombia relative to exports to the U.S. and the RoW:

$$\psi_{d(j),n,col} = \frac{Y_{d(j),n,col}}{Y_{d(j),n,col} + Y_{d(j),n,usa} + Y_{d(j),n,RoW}}$$

[3] We estimate the number of adults out of the formal labor market in each region using household surveys. The flow among industries and this category is given by the social security records.

Appendix Table B.3: Regions for the model

Region Code	Region
05	Antioquia
08	Atlántico
11	Bogota, Cundinamarca
13	Bolívar
15	Boyacá
17	Caldas
18	Caquetá
19	Cauca
20	Cesar
23	Cordoba
27	Chocó
41	Huila
44	La Guajira
47	Magdalena
50	Meta
52	Nariño
54	Norte de Santander
63	Quindío
66	Risaralda
68	Santander
70	Sucre
73	Tolima
76	Valle del Cauca
99	Others
100	United States
101	Rest of the World

From trade flow data at the four-digit sector level, we can directly compute total exports to the U.S. and to the RoW. This means that we can calculate $Y_{d(j),n,usa} + Y_{d(j),n,RoW}$. However, we do not observe $Y_{d(j),n,col}$ at the four-digit level, since it corresponds to internal consumption in the Colombian economy. As a result, we must rely on the regional input–output tables to estimate this component and, consequently, compute ψ at the two-digit sector level rather than the four-digit level. Then, within each two-digit sector level and Colombian state, there is no variation in ψ.

Similarly, ω_{jnk} captures the share in which Colombian firms in sector j use the intermediate input k.

$$\omega_{jnk} = \sum_{r \in \{US,RoW\}} \pi_{d(k),nr} \cdot \gamma_{jn,kn}, \text{ with } \gamma_{jn,kn} \equiv \frac{X_{jnk}}{\sum_k X_{jnk}}.$$

Since we observe trade flows between Colombia and other countries at a high granular level, we can compute $\gamma_{jn,kn}$ at the ten-digit sector level. However, we also need the trade shares to calculate the input shock. The variable $\pi_{d(k),nr}$ denotes the two-digit import share of product k for region (state) n from country r. The reason for this is that we do not observe the import share at the four-digit sector level because we require internal consumption data for the denominator. Then, we compute this variable at the Colombian state-two-digit sector level and interact with the change in the tariffs and γ.

Appendix Table B.4 describes the aggregation of the multiple parameters used. Importantly, the input and competition shocks are constructed at the four-digit, regional, and year levels to estimate our main empirical specification. The remaining parameters are aggregated at their original levels of aggregation.

Appendix Table B.4: Level of Aggregation of Parameters for Building the Input and Competition Shocks

Variable	Parameter	Sector level (digits)
Comp. Shock	$\tilde{\tau}_{jnt}$	Four
Tariffs	τ_{jt}	Four
Revenue share	$\psi_{d(j),n,col}$	Two
Exports to the U.S.	$\Upsilon_{d(j),n,usa}$	Four
Exports to the RoW	$\Upsilon_{d(j),n,RoW}$	Four
Internal consumption	$\Upsilon_{d(j),n,col}$	Two
Input Shock	$\tilde{q}_{jnt}$	Four
Tariff input k	τ_{kt}	Ten
Share of k to produce nj	ω_{jnk}	Ten
Share of Imports of k by firms in nj	$\gamma_{jn,kn}$	Ten
Imports of k by firms in nj	X_{jnk}	Ten
Import share of nk from country r	$\pi_{d(k),nr}$	Two

Appendix Table B.5 complements this description by providing the mapping between two and four-digit sectors. We additionally provide information about the number of observations in the household surveys, which are used in our main labor market estimations.

Appendix Table B.5: Sectors for the model

One-Digit	**Two-Digit**			**Four-Digit**	
Sectors	**Codes**	**Sectors**	**ISIC** (Rev4)	**Number of sub-sectors**	**Obs. HH-Survey in 2008**
Agriculture	01	Crop production and Animal Production	01	17	22,781
Agriculture	02	Forestry and logging	02	2	359
Agriculture	05	Fishing and aquaculture	05	2	923
Manufacturing	15	Foods, beverages and tobacco products	15-16	22	5,943
Manufacturing	18	Manufacture textiles, wearing apparel and leather	17-19	21	11,555
Manufacturing	20	Wood, paper, printing, and recorded media	20-21	15	2,392
Manufacturing	23	Mining, crude petroleum manufacture of coke and refined petroleum products	10-14, 23	4	2,108
Manufacturing	24	Manufacture of non-metallic mineral products chemicals	24-26	24	4,059
Manufacturing	27	Manufacture of basic and elaborated metal products except machinery	27	12	2,970
Manufacturing	30	Manufacture of electronic, electrical equipment machinery. Repair and installation of machinery and equipment.	31	30	1,075
Manufacturing	34	Vehicles, furniture, and other manufacturing	34-36	19	5,474
Services	35	Non-retail or wholesale services	40-45, 60-95	175	150,525
Services	36	Wholesale and retail trade, including trade .	50-51	72	74,929

B.3. Data Aggregation for Calibration

The model is calibrated using the regions listed in Appendix Table B.3 and the sectors in Appendix Table B.5. Due to data constraints—-particularly the limited information on expenditure shares and the small number of observations at the four-digit level—-we calibrate the model at the two-digit sector level. This is the level at which domestic absorption data are available, which is essential for implementing the dynamic hat-algebra approach. In other words, although we observe international trade flows at a more disaggregated four-digit level, we do not observe domestic trade flows across Colombian states or internal consumption at that level of detail. Because this information exists only at the two-digit level, the model must be calibrated at that level. This implies that finer within-sector variation cannot be fully captured in the quantitative exercise, and that our counterfactual results should be interpreted at the broader two-digit sector aggregation.

This limitation is common in the literature. For example, studies using the WIOD database face a similar constraint: they estimate empirical regressions at a more disaggregated level but must calibrate their quantitative models at the two-digit level due to data availability.

C. Robustness of Event Study

C.1. Event Studies Across Specifications

This appendix provides additional evidence supporting the absence of differential pre-trends before the trade reforms discussed in Section 3. We estimate our main event study specifications using within-sector and within-region variation, controlling for time trends. Appendix Figure C.1 presents the event study estimates corresponding to the four empirical specifications reported in Table 1—each row in Figure C.1 aligns with the respective column in the table. Across all specifications, we fail to reject the null hypothesis that the pre-treatment coefficients differ from zero, whereas this null is rejected in the post-treatment period.

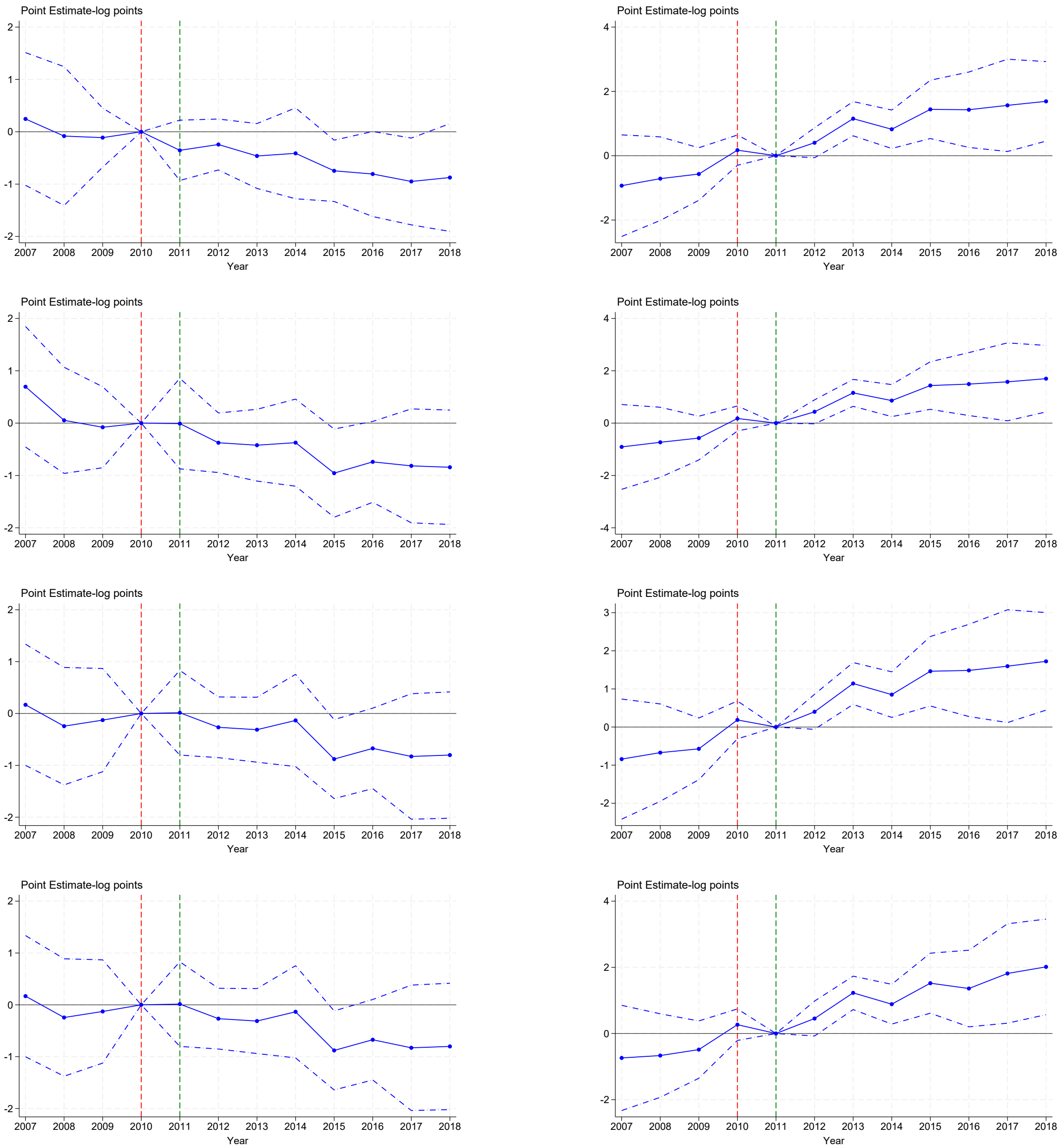
In all specifications, we observe a clear change in trends following the 2010 input shock. In the case of the competition shock, however, the change in trends is somewhat less visually pronounced, raising concerns about potential differential pre-trends. To address this, we conduct two formal tests to assess the absence of pre-trends. First, we compute a joint F-test of the null hypothesis that all pre-treatment coefficients are equal to zero ($H_0 : \beta_t = 0, \forall t < t_0$). This is a stringent test, as it assesses whether any coefficient–or at least one–differs from zero. Second, we perform a less stringent test evaluating whether the sum of the pre-treatment coefficients differs from zero ($H_0 : \sum_{t<t_0} \beta_t = 0$), which provides a formal test of the absence of pre-trends.

Appendix Table C.1 reports the p-values for both tests. The smallest p-value is 0.19, indicating that we cannot reject the null hypothesis in any of the tests, for any specification, or for either shock. This provides strong evidence in support of the validity of our research design. For completeness, we additionally provide the effects of the inputs and competition shock on employment as outcome on Appendix Figure C.2. We again observe strong evidence on the non-existence of differential trends prior to the shocks.

Binary Treatment: The previous specifications rely on a continuous treatment measure and compare treated groups to a baseline of region-industry cells that were never treated. This introduces variation in treatment intensity across sectors and regions, which may raise concerns about potential bias (de Chaisemartin and D'Haultfœuille, 2020). To address this, we re-estimate the event study specifications using binary treatments instead of continuous ones, explicitly accounting for heterogeneity in treatment exposure. Appendix Figure C.3 presents these results, which are consistent with our benchmark estimates using the continuous treatment, thereby reinforcing the robustness of our estimation strategy.

Appendix Figure C.1: Event Study Estimates using a Continuous Treatment

(a) Input Shock | **(b)** Competition Shock



Notes: These figures plot the event study specification in Equation 4.4 at the industry, region, and year level. The competition and input shocks are estimated jointly. The plotted estimates correspond to the four empirical specifications reported in Table 1—each row in Figure C.1 aligns with the respective column in the table. Plotted intervals correspond to the 95 percent confidence level.

Appendix Table C.1

P-Values of No-Pre Trends in Event Study Estimation

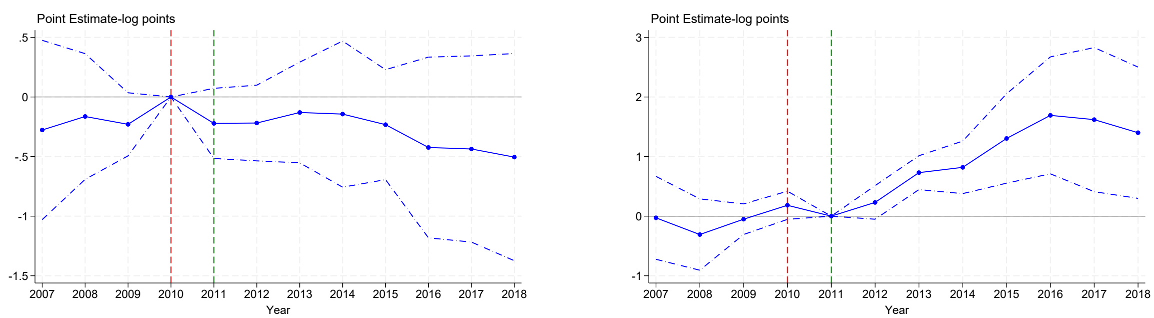
		(1)	(2)	(3)	(4)
Input	Joint	0.77	0.40	0.83	0.86
	Linear Comb.	0.34	0.66	0.33	0.32
Competition	Joint	0.31	0.31	0.30	0.30
	Linear Comb.	0.47	0.81	0.47	0.46
	Region-Industry FE	Yes	Yes	Yes	Yes
	Region-Year FE	Yes			
	Year FE		Yes	Yes	Yes
	Baseline Controls			Yes	Yes
	Region-Specific Trends				Yes

Note: This table presents the p-values of two tests of no-pretrends. The Joint test corresponds to the null hypothesis: $\beta_t = 0, \forall t < t_0$. The Linear Combination test corresponds to the null hypothesis: $\sum_{t<t_0} \beta_t = 0$. We compute the test for both shocks, and across all the specifications included in Table 1

Appendix Figure C.2

Competition and Input Shocks on Employment as Outcome

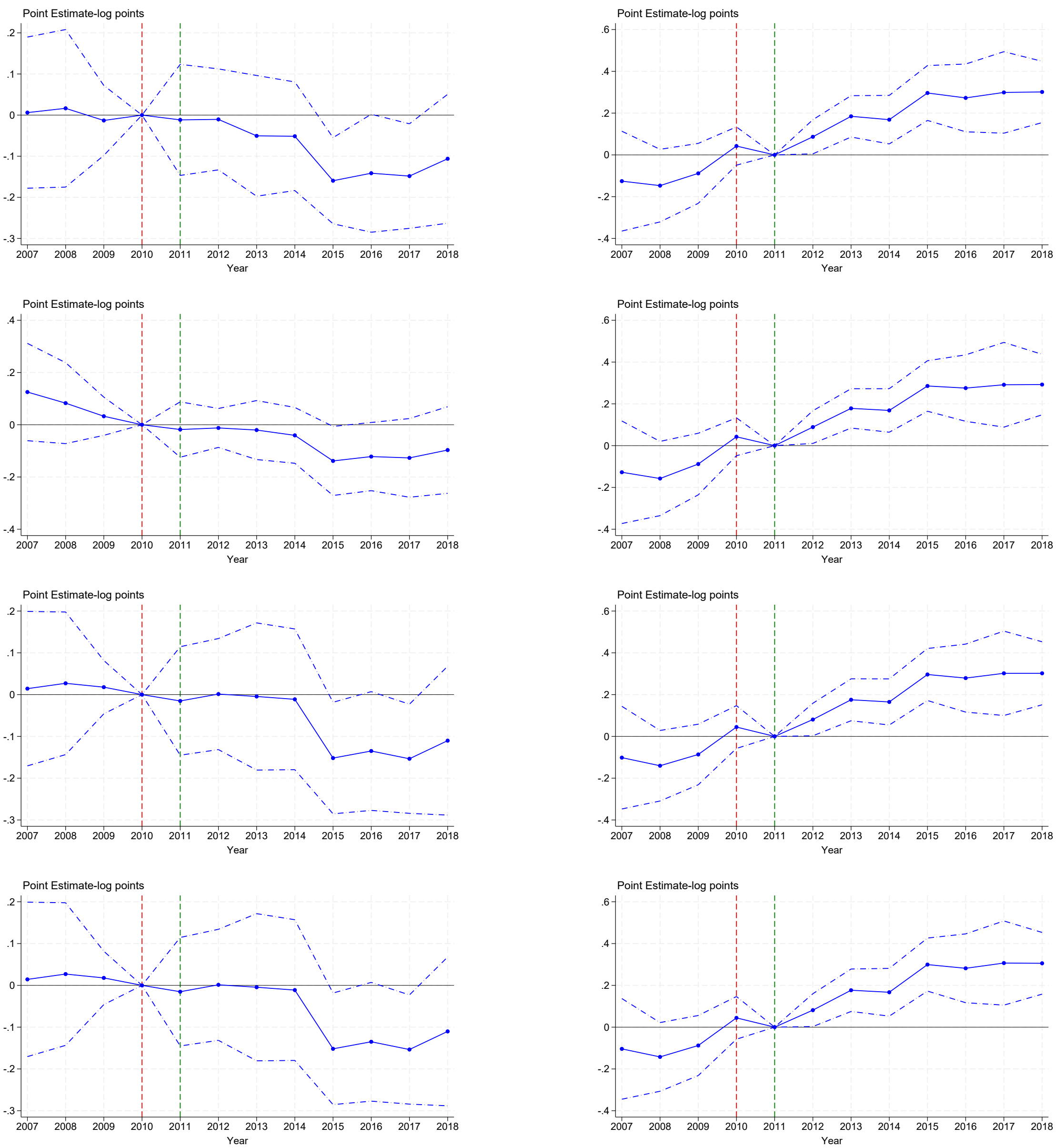
(a) Input **(b)** Competition



Appendix Figure C.3

Event Study estimates using a Binary Treatment

(a) Input Shock **(b)** Competition Shock



Notes: These figures plot the event study specification in Equation 4.4 at the industry, region and year level. The competition and input shocks are estimated jointly. The plotted estimates correspond to the four empirical specifications reported in Table 1—each row in Figure C.1 aligns with the respective column in the table. Continuous treatment variables are modified to be binary replacing by one if the region and industry changed tariffs and zero otherwise. Plotted intervals correspond to the 95 percent confidence level.

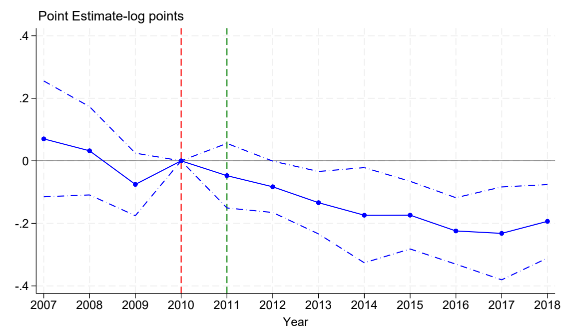
C.2. Event Studies by Economic Sectors

A substantial part of our analysis relies on estimations disaggregated by one-digit sector—-agriculture, manufacturing, and services. Accordingly, we examine the presence of potential pre-trends within each of these sectors for both the input and competition shocks. Appendix Figure C.4 reports the estimates for the input shock by sector, while Appendix Figure C.5 presents the corresponding results for the competition shock. In all cases, we fail to reject the null hypothesis that any of the pre-treatment coefficients differ from zero.

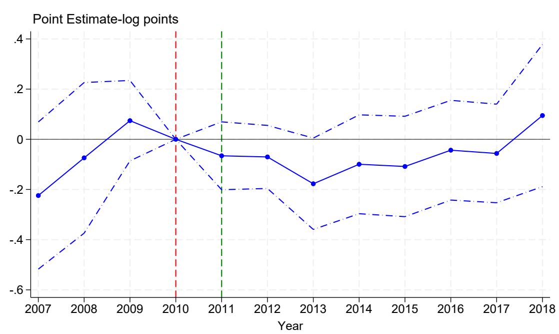
Appendix Figure C.4

Input shock on Wage Bill By Sector

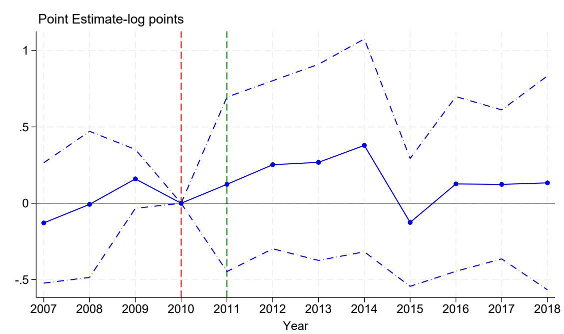
(a) Services



(b) Manufacturing



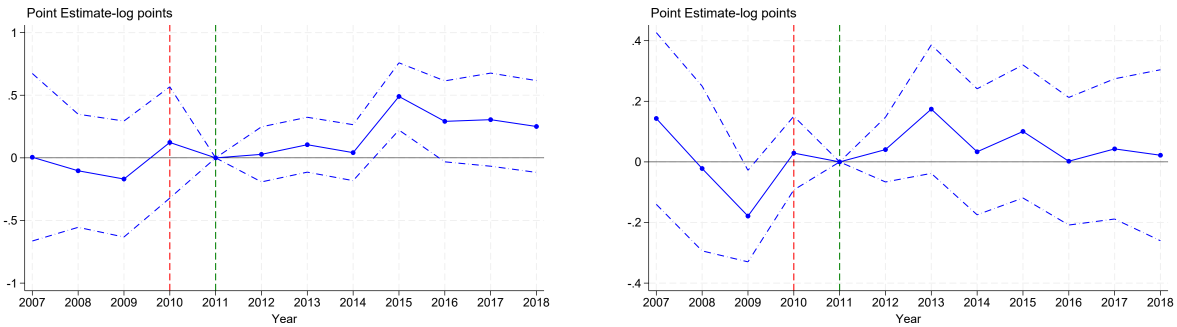
(c) Agriculture



Notes: These figures plot the event study specification at the industry level for the input shock. Plotted intervals correspond to the 95 percent confidence level.

Appendix Figure C.5
Competition shock on Wage bill by Sector

(a) Agriculture **(b)** Manufacturing



Notes: These figures plot the event study specification at the industry level for the competition shock. Plotted intervals correspond to the 95 percent confidence level.

D. Robustness of Main Specification

Appendix Table D.1

Input and Competition Shocks on Wage Bill without Shares of Import and Sales

	OLS				IV			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
A) All Sectors								
Input Shock	-1.176***	-1.577**	-1.289**	-1.205***	-1.426**	-1.944**	-1.433**	-1.326**
	(0.419)	(0.571)	(0.469)	(0.428)	(0.588)	(0.795)	(0.617)	(0.603)
Comp. Shock	3.114***	3.132***	3.110***	3.105***	3.642***	3.701***	3.613**	3.603***
	(1.039)	(1.057)	(1.061)	(1.052)	(1.252)	(1.285)	(1.290)	(1.280)
F-Stat First Stage					180.4	191.7	186.7	182.5
B) By Industry								
Input shock × 1(Agric.)	1.124	0.792	0.815	1.238	1.521	1.275	1.314	1.741
	(1.314)	(1.548)	(1.572)	(1.448)	(2.047)	(2.244)	(2.264)	(2.193)
Input shock × 1(Manuf.)	-0.275	-0.834	-0.653	-0.296	-0.528	-1.202	-0.778	-0.363
	(0.699)	(0.889)	(0.859)	(0.703)	(0.851)	(0.914)	(0.951)	(0.814)
Input shock × 1(Serv.)	-1.522***	-1.744***	-1.618***	-1.591***	-1.973***	-2.223**	-1.988***	-1.909***
	(0.434)	(0.569)	(0.475)	(0.439)	(0.639)	(0.842)	(0.654)	(0.626)
Comp. shock × 1(Agric.)	4.986*	4.847	4.993	4.891*	6.139*	5.923	6.089	5.989
	(2.754)	(2.857)	(2.918)	(2.848)	(3.426)	(3.521)	(3.634)	(3.573)
Comp. shock × 1(Manuf.)	1.228*	1.433*	1.408*	1.202*	1.357	1.705*	1.515	1.264
	(0.643)	(0.725)	(0.695)	(0.643)	(0.932)	(0.990)	(0.964)	(0.928)
F-Stat First Stage					69.09	61.42	65.33	69.18
Observations	58,370	58,370	58,370	58,370	58,370	58,370	58,370	58,370
Region-Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region-Year FE	Yes				Yes			
Year FE		Yes	Yes	Yes		Yes	Yes	Yes
Baseline Controls			Yes	Yes			Yes	Yes
Region-Specific Trends				Yes				Yes

Note: This table presents the results of estimating Equation 4.3 using the wage bill as outcome, but excluding the sector weights. Estimations performed in a panel at the industry-region-year level. Colombian departments are use as regions. Columns (1)-(4) are estimated using ordinary least squares, whereas columns (5)-(8) present IV estimates using the tariff initial values interacted with a dummy post-reform as instrument. Panel A presents estimates pooling all sectors, whereas Panel B presents estimates interacting by industry dummies. Baseline controls include the 2008 share of college-educated workers, the share of manufacturing employment, share of employment in services, and the share of female workers in each region, all interacted with year fixed effects. Estimations are weighted by employment per industry and region in 2008. The reported first stage F statistic corresponds to the minimum across all the first stage regressions using Sanderson and Windmeijer (2016). Standard errors are clustered at the industry and region level. *** p<0.01, ** p<0.05, * p<0.1

Appendix Table D.2
Input and Competition Shocks on Wage Bill at the Sector-By-Year Level

	OLS				IV			
	All	High-skilled	Low-skilled	Social Sec.	All	High-skilled	Low-skilled	Social Sec.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
A) All Sectors								
Input Shock	-1.840***	-0.434	-1.687**	-2.518*	-3.248**	-0.646	-2.646*	-4.623**
	(0.674)	(1.086)	(0.758)	(1.413)	(1.355)	(2.310)	(1.473)	(2.130)
Comp. Shock	2.715***	1.498*	2.285***	1.202*	3.173***	1.761	2.649***	1.567
	(0.844)	(0.856)	(0.837)	(0.631)	(0.963)	(1.172)	(0.955)	(0.955)
F-Stat First Stage					41.74	41.51	41.59	42
B) By Industry								
Input shock × 1(Agric.)	1.913	6.392	0.433	-0.576	-0.294	10.618**	-2.528	-2.705
	(1.176)	(4.147)	(1.190)	(1.883)	(2.394)	(5.269)	(2.540)	(3.113)
Input shock × 1(Manuf.)	0.686	1.893	0.246	-0.163	-1.084	0.323	-1.171	1.043
	(1.099)	(1.498)	(1.132)	(1.338)	(2.832)	(4.863)	(2.499)	(3.515)
Input shock × 1(Serv.)	-1.842***	-0.735	-1.650**	-2.746*	-2.879**	-0.372	-2.371*	-4.738**
	(0.679)	(1.033)	(0.772)	(1.439)	(1.183)	(2.024)	(1.423)	(2.201)
Comp. shock × 1(Agric.)	2.043	-4.097	2.591	-0.677	3.731	-6.943	5.138*	-1.170
	(2.164)	(4.269)	(2.067)	(1.553)	(3.115)	(5.985)	(3.016)	(2.180)
Comp. shock × 1(Manuf.)	-0.014	-0.080	0.093	-0.445	0.659	1.589	0.644	-2.997
	(0.933)	(1.028)	(0.996)	(0.505)	(2.707)	(4.707)	(2.384)	(3.675)
F-Stat First Stage					9.861	9.961	9.716	9.531
Observations	4,650	4,465	4,510	4,400	4,650	4,465	4,510	4,400
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: This table presents the results of estimating Equation 4.3 using the wage bill as outcome. Estimations are performed in a panel at the industry-year level. Columns (1)-(4) are estimated using ordinary least squares, whereas columns (5)-(8) present IV estimates using the tariff initial values interacted with a dummy post-reform as instrument. Panel A presents estimates pooling all sectors, whereas Panel B presents estimates interacting by industry dummies. Estimations are weighted by employment per industry in 2008. The reported first stage F statistic corresponds to the minimum across all the first stage regressions using Sanderson and Windmeijer (2016). Standard errors clustered at the level. *** p<0.01, ** p<0.05, * p<0.1

Appendix Table D.3
Input and Competition Shocks on Wage Bill using Social Security Records

	OLS				IV			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
A) All Sectors								
Input Shock	-3.057	-1.713	-3.082	-3.022	-5.522	-2.211	-4.850	-5.364
	(2.739)	(2.508)	(2.504)	(2.716)	(4.795)	(3.797)	(4.156)	(4.699)
Comp. Shock	1.450*	1.426	1.489*	1.437*	1.665	1.674	1.710*	1.635
	(0.812)	(0.836)	(0.821)	(0.813)	(0.985)	(1.015)	(0.995)	(0.989)
F-Stat First Stage					111.3	109.8	110.1	108.1
B) By Industry								
Input shock × 1(Agric.)	0.623	0.423	0.110	0.653	-0.659	1.296	0.004	-0.570
	(2.013)	(2.086)	(2.063)	(1.965)	(4.795)	(4.320)	(4.340)	(4.633)
Input shock × 1(Manuf.)	1.292	3.516	1.195	1.393	0.463	4.016	0.744	0.849
	(2.317)	(2.275)	(1.971)	(2.297)	(3.160)	(2.746)	(2.676)	(3.021)
Input shock × 1(Serv.)	-4.264	-2.529	-4.257	-4.249	-7.236	-3.524	-6.667	-7.080
	(3.011)	(2.849)	(2.759)	(2.995)	(5.131)	(4.366)	(4.535)	(5.064)
Comp. shock × 1(Agric.)	2.567*	2.376	2.797**	2.549*	1.734	1.442	1.927	1.675
	(1.376)	(1.453)	(1.283)	(1.369)	(1.544)	(1.588)	(1.360)	(1.536)
Comp. shock × 1(Manuf.)	-0.667	-0.650	-0.665	-0.701	-1.176	-0.912	-1.099	-1.265
	(0.795)	(0.842)	(0.822)	(0.798)	(1.995)	(2.130)	(2.036)	(1.996)
F-Stat First Stage					119.8	85.41	114.5	122.7
Observations	61,076	61,076	61,076	61,076	61,076	61,076	61,076	61,076
Region-Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region-Year FE	Yes				Yes			
Year FE		Yes	Yes	Yes		Yes	Yes	Yes
Baseline Controls			Yes	Yes			Yes	Yes
Region-Specific Trends				Yes				Yes

Note: This table presents the results of estimating Equation 4.3 using the wage bill computed in the social security records as outcome. Estimations performed in a panel at the industry-region-year level. Colombian departments are use as regions. Columns (1)-(4) are estimated using ordinary least squares, whereas columns (5)-(8) present IV estimates using the tariff initial values interacted with a dummy post-reform as instrument. Panel A presents estimates pooling all sectors, whereas Panel B presents estimates interacting by industry dummies. Baseline controls include the 2008 share of college-educated workers, the share of manufacturing employment, share of employment in services, and the share of female workers in each region, all interacted with year fixed effects. Estimations are weighted by employment per industry and region in 2008. The reported first stage F statistic corresponds to the minimum across all the first stage regressions using Sanderson and Windmeijer (2016). Standard errors are two-way clustered at the industry and region level. *** p<0.01, ** p<0.05, * p<0.1

Appendix Table D.4

Input and Competition Shocks on Employment

	OLS				IV			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
A) All Sectors								
Input Shock	-0.249	-0.422	-0.282	-0.288	-0.904	-0.949	-0.672	-0.790
	(0.765)	(0.721)	(0.750)	(0.752)	(1.347)	(1.061)	(1.262)	(1.358)
Comp. Shock	2.169***	2.245***	2.171***	2.172***	2.498***	2.563***	2.500***	2.483***
	(0.676)	(0.702)	(0.684)	(0.671)	(0.752)	(0.781)	(0.764)	(0.750)
F-Stat First Stage					110.8	107.6	109	106.9
B) By Industry								
Input shock × 1(Agric.)	3.298***	3.114***	2.977***	3.202***	4.746**	5.500**	4.981**	4.908**
	(0.894)	(1.023)	(1.040)	(0.865)	(1.905)	(1.960)	(2.084)	(1.890)
Input shock × 1(Manuf.)	-0.494	-0.433	-0.511	-0.518	-1.577	-1.383	-1.413	-1.354
	(1.352)	(1.327)	(1.386)	(1.351)	(1.678)	(1.616)	(1.742)	(1.682)
Input shock × 1(Serv.)	-0.964	-0.865	-0.984	-1.003	-2.113*	-1.734*	-1.940*	-2.006
	(0.810)	(0.726)	(0.789)	(0.806)	(1.190)	(0.922)	(1.131)	(1.208)
Comp. shock × 1(Agric.)	2.832**	2.957**	2.918**	2.843**	2.985**	2.953**	2.999**	2.938**
	(1.185)	(1.196)	(1.203)	(1.160)	(1.370)	(1.410)	(1.413)	(1.355)
Comp. shock × 1(Manuf.)	1.484**	1.512**	1.458**	1.482**	1.753*	1.850**	1.739*	1.710*
	(0.648)	(0.646)	(0.646)	(0.644)	(0.882)	(0.876)	(0.890)	(0.879)
F-Stat First Stage					116.7	83.07	115.8	124.2
Observations	58,370	58,370	58,370	58,370	58,370	58,370	58,370	58,370
Region-Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region-Year FE	Yes				Yes			
Year FE		Yes	Yes	Yes		Yes	Yes	Yes
Baseline Controls			Yes	Yes			Yes	Yes
Region-Specific Trends				Yes				Yes

Note: This table presents the results of estimating Equation 4.3 using employment as outcome. Estimations performed in a panel at the industry-region-year level. Colombian departments are use as regions. Columns (1)-(4) are estimated using ordinary least squares, whereas columns (5)-(8) present IV estimates using the tariff initial values interacted with a dummy post-reform as instrument. Panel A presents estimates pooling all sectors, whereas Panel B presents estimates interacting by industry dummies. Baseline controls include the 2008 share of college-educated workers, the share of manufacturing employment, share of employment in services, and the share of female workers in each region, all interacted with year fixed effects. Estimations are weighted by employment per industry and region in 2008. The reported first stage F statistic corresponds to the minimum across all the first stage regressions using Sanderson and Windmeijer (2016). Standard errors are two-way clustered at the industry and region level. *** p<0.01, ** p<0.05, * p<0.1

E. Heterogeneity Analysis

The results presented in the main text are primarily based on estimates at the one-digit sector level—–i.e., agriculture, manufacturing, and services. However, this level of aggregation conceals substantial heterogeneity across sectors. This appendix provides additional evidence by presenting estimates across 13 two-digit level sectors. Due to data limitations, the analysis at this level has reduced statistical power, so the results should be interpreted as suggestive rather than definitive. Nevertheless, these findings strengthen the main argument of the paper by highlighting the importance of the elasticity of substitution (EoS) between labor and intermediate inputs in explaining the effects of trade liberalization.

E.1. Reduced Form Estimates

To further assess the reduced form effects of the *input* and *competition* shocks, we estimate Equation 4.3 while interacting these shocks with 13 two-digit sector dummies. This specification enables us to infer the EoS between labor and foreign inputs, σ_j, at a more granular level, providing evidence of heterogeneity across sectors. Appendix Table E.1 presents the results. Some estimates display considerable volatility due to small sample sizes (as reported in column 5). Nonetheless, the impact of foreign inputs is markedly heterogeneous: some sectors exhibit negative point estimates, while others show positive ones. The competition shock effect is predominantly negative, except in two sectors with particularly small samples (fishing and aquaculture, and manufacturing of crude petroleum). Overall, these results underscore the importance of the EoS in shaping how exposure to foreign inputs influences local labor market outcomes.

In addition, we provide two additional pieces of evidence highlighting the role of the EoS determining the effects of foreign inputs on local labor markets, even though not considered in the model in Section 2 of the main text.[4] First, we investigate whether the effects of foreign inputs are heterogeneous across skill levels by splitting the outcome based on wage bill contributions from high- and low-skilled workers.[5] The results, presented in Appendix Table E.2, reveal two key findings. First, foreign inputs appear to reduce high-skilled employment in agriculture and manufacturing, indicating a substitution effect between high-skilled workers and foreign inputs. This finding is consistent with the results by Amiti and Cameron (2012) for Indonesia. Second, reductions in the prices of foreign inputs increase mostly low-skilled employment in services, suggesting potential complementarities between foreign inputs and labor in this sector.[6] This second finding aligns with previous studies showing that foreign inputs complement employment (Bas and Paunov, 2021; Fieler et al., 2018; Kamal et al., 2019; Leblebicioğlu and Weinberger, 2021; Verhoogen, 2008).

Second, consistent with our analysis of import effects in Section 4, we examine whether labor market outcomes vary with the type of intermediate inputs imported. To do so, we re-estimate Equation 4.3, this time decomposing the input shock into separate components based on declines in the prices of capital, consumption, and raw material inputs.[7] The results, reported in Appendix Table E.3, reveal notable patterns. On the one hand, increased foreign competition

[4] For tractability purposes we do not include different types of labor inputs nor types of imported inputs. However, the model could be extended to include them

[5] We define high-skilled workers as having at least some tertiary education, whereas low-skilled are those with less than tertiary.

[6] Although we cannot fully distinguish whether this is driven by reduced marginal costs or by substitution effects.

[7] We construct these shocks by restricting Equation 4.2 to inputs of each type, yielding three distinct measures of input shocks.

in all input types reduces the wage bill throughout. On the other hand, the effects differ across input categories. Declines in the prices of foreign capital and consumption inputs tend to increase the wage bill in services (columns (1)–(8)), while the effects of raw material inputs on services are less precisely estimated. For agriculture, however, reductions in consumption input prices are associated with lower wage bills. In manufacturing, point estimates are imprecise and vary in sign: positive for capital inputs, but negative for consumption and raw material inputs. These contrasting effects once again highlight the role of the elasticity of substitution in shaping how foreign input shocks affect local labor market outcomes.

Appendix Table E.1

Input and Competition Shocks on Wage Bill at Two-Digit Level

	Competition		Input		Obs.
	OLS	IV	OLS	IV	
	(1)	(2)	(3)	(4)	(5)
Crop production and Animal Production	6.108***	7.033*	2.268***	2.510	3228
	(0.777)	(3.650)	(0.691)	(4.271)	
Forestry and logging	4.772**	4.541***	-6.035***	-16.057***	264
	(1.882)	(1.063)	(2.140)	(2.079)	
Fishing and aquaculture	1.735*	-5.176***	27.020***	110.029***	189
	(0.847)	(1.466)	(2.134)	(18.214)	
Foods, beverages and tobacco products	1.561***	2.246	-3.908***	-8.759	3382
	(0.527)	(1.773)	(0.814)	(5.830)	
Manufacture textiles, wearing apparel and leather	2.243***	1.739	-2.722***	-2.410	2274
	(0.454)	(1.175)	(0.634)	(2.533)	
Wood, paper, printing, and recorded media	0.814	-5.748	13.463***	23.356	1772
	(0.476)	(8.857)	(2.593)	(21.377)	
Mining, crude petroleum manufacture	7.109***	-28.466*	-20.465***	-8.211	159
	(0.676)	(16.038)	(1.539)	(.)	
Manufacture of non-metallic mineral products	2.108**	6.473***	-0.590	-11.789***	3396
	(0.841)	(1.823)	(2.111)	(4.150)	
Manufacture of basic and elaborated metal products	-3.621***	-35.338	2.648**	29.285	1594
	(0.575)	(21.171)	(1.228)	(22.220)	
Manufacture of electronic, electrical equipment machinery	1.836***	4.762***	1.253	-4.862**	1821
	(0.628)	(1.283)	(1.487)	(1.937)	
Vehicles, furniture, and other manufacturing	0.879	3.047***	1.826	-4.760*	2136
	(0.791)	(0.781)	(2.340)	(2.756)	
Non-retail or wholesale services			-1.861	-5.252**	24156
			(1.265)	(1.895)	
Wholesale and retail trade, including trade			-2.459	-5.638**	13999
			(2.041)	(2.287)	

Note: This table presents the results of estimating Equation 4.3 using the wage bill as outcome, and interacting the input and competition shocks by 13 two-digit sector dummies. Estimations performed in a panel at the industry-region-year level. Columns (1)-(2) are estimated using ordinary least squares, whereas columns (3)-(4) present IV estimates using the tariff initial values interacted with a dummy post-reform as instrument. All estimations include region-by-industry and region-by-year fixed effects. Column (5) presents the number of observations for each two-digit sector in the estimation sample. Standard errors are two-way clustered at the industry and region level. *** p<0.01, ** p<0.05, * p<0.1

Appendix Table E.2

Input and Competition Shocks on Wage Bill by Skill Level

	High-Skilled Workers								Low-Skilled Workers							
	OLS				IV				OLS				IV			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
A) All Sectors																
Input Shock	0.971	2.242*	1.305	0.809	-0.218	2.800	1.327	0.018	-0.867	-2.236*	-1.428	-0.856	-2.996	-4.527**	-3.534*	-2.892
	(1.232)	(1.137)	(1.211)	(1.189)	(2.309)	(2.015)	(2.011)	(2.148)	(0.869)	(1.254)	(1.025)	(0.876)	(1.871)	(2.021)	(1.882)	(1.881)
Comp. Shock	2.634***	2.370***	2.511***	2.585***	2.869**	2.735**	2.787**	2.855**	2.966**	2.947**	2.969**	2.956**	3.507**	3.496**	3.475**	3.476**
	(0.861)	(0.784)	(0.834)	(0.842)	(1.098)	(1.092)	(1.140)	(1.107)	(1.146)	(1.153)	(1.162)	(1.162)	(1.309)	(1.321)	(1.326)	(1.329)
F-Stat First Stage					94.43	94.24	92.09	90.72					109.7	106.4	107.9	108.5
B) By Industry																
Input shock × 1(Agric.)	5.164***	5.211***	4.729**	4.874***	2.898	7.141**	5.829**	3.880***	1.711	1.081	1.059	2.106	2.909	1.754	1.928	3.140
	(1.760)	(1.643)	(1.901)	(1.622)	(1.845)	(2.601)	(2.472)	(1.377)	(1.979)	(2.268)	(2.363)	(2.086)	(4.282)	(4.551)	(4.724)	(4.566)
Input shock × 1(Manuf.)	2.153	4.564***	2.692*	2.121	5.399	8.176***	6.183**	5.545*	-0.254	-2.197	-1.484	-0.280	-2.624	-4.279	-3.823	-2.343
	(1.638)	(1.594)	(1.436)	(1.634)	(3.229)	(2.374)	(2.628)	(3.090)	(1.855)	(2.403)	(2.322)	(1.877)	(2.802)	(3.413)	(3.363)	(2.762)
Input shock × 1(Serv.)	0.058	1.696	0.487	-0.104	-1.352	1.930	-0.097	-1.283	-1.309	-2.380*	-1.856*	-1.399	-4.110*	-4.895**	-4.611**	-4.054**
	(1.125)	(1.112)	(1.129)	(1.127)	(2.530)	(2.025)	(2.054)	(2.336)	(0.988)	(1.200)	(1.035)	(0.999)	(2.006)	(2.046)	(1.920)	(1.957)
Comp. shock × 1(Agric.)	5.002**	3.915*	4.822**	4.797**	7.202*	5.137	6.267	6.699*	5.159*	4.873*	5.034*	5.060*	5.711	5.526	5.615	5.582
	(2.235)	(1.956)	(2.054)	(2.137)	(3.799)	(4.056)	(4.155)	(3.907)	(2.687)	(2.737)	(2.820)	(2.759)	(3.547)	(3.565)	(3.710)	(3.679)
Comp. shock × 1(Manuf.)	1.241*	1.015*	1.115*	1.192*	-0.387	-0.071	-0.261	-0.385	1.512**	1.704**	1.725**	1.491*	1.824	2.106	2.044	1.744
	(0.601)	(0.590)	(0.574)	(0.610)	(1.571)	(1.483)	(1.535)	(1.576)	(0.719)	(0.813)	(0.784)	(0.723)	(1.103)	(1.278)	(1.200)	(1.101)
F-Stat First Stage					95.41	78.12	84.69	89					117.2	82.35	110.8	125.6
Observations	46,522	46,522	46,522	46,522	46,522	46,522	46,522	46,522	52,522	52,522	52,522	52,522	52,522	52,522	52,522	52,522
Region-Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region-Year FE	Yes				Yes				Yes				Yes			
Year FE		Yes	Yes	Yes		Yes	Yes	Yes		Yes	Yes	Yes		Yes	Yes	Yes
Baseline Controls			Yes	Yes			Yes	Yes			Yes	Yes			Yes	Yes
Region-Specific Trends				Yes				Yes				Yes				Yes

Note: This table presents the results of estimating Equation 4.3 using the wage bill paid to high- (measured as having at least some tertiary education) and low-skilled (measures as less than tertiary education) workers as outcome. Estimations performed in a panel at the industry-region-year level. Colombian departments are use as regions. Columns (1)-(4) are estimated using ordinary least squares, whereas columns (5)-(8) present IV estimates using the tariff initial values interacted with a dummy post-reform as instrument. Panel A presents estimates pooling all sectors, whereas Panel B presents estimates interacting by industry dummies. Baseline controls include the 2008 share of college-educated workers, the share of manufacturing employment, share of employment in services, and the share of female workers in each region, all interacted with year fixed effects.Estimations are weighted by employment per industry and region in 2008. The reported first stage F statistic corresponds to the minimum across all the first stage regressions using Sanderson and Windmeijer (2016). Standard errors are two-way clustered at the industry and region level. *** p<0.01, ** p<0.05, * p<0.1

Appendix Table E.3

Input and Competition Shocks on Wage Bill by Type of Input shock

	Capital				*Consumption*				*Raw Materials*			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
A) All Sectors												
Input shock	-1.415	-3.078*	-1.781	-1.478	-2.653	-4.195	-2.821	-2.468	-4.153	-5.755	-3.777	-3.477
	(1.229)	(1.753)	(1.331)	(1.266)	(2.115)	(2.630)	(2.072)	(2.045)	(4.704)	(4.922)	(5.148)	(5.165)
Comp. Shock	3.703**	3.530**	3.641**	3.675**	3.775**	3.703**	3.734**	3.754**	4.243**	4.346**	4.160**	4.147**
	(1.438)	(1.514)	(1.464)	(1.454)	(1.398)	(1.454)	(1.423)	(1.416)	(1.622)	(1.695)	(1.706)	(1.694)
F-Stat First Stage	151.2	156.3	149.8	155.9	100.1	104.8	102.3	100.1	118.6	112.1	118.9	122
B) By Industry												
Input shock × 1(Agric.)	1.944	0.803	0.701	2.193	6.188**	5.181	5.438*	6.343**	15.052	17.064	16.508	17.465
	(3.422)	(3.440)	(3.518)	(3.428)	(2.870)	(3.676)	(3.149)	(2.678)	(27.739)	(31.641)	(30.001)	(30.395)
Input shock × 1(Manuf.)	1.418	0.115	1.195	1.321	-3.906	-7.087	-5.084	-3.405	-0.209	-2.467	-1.015	0.290
	(2.107)	(2.134)	(2.032)	(2.112)	(4.329)	(5.061)	(4.893)	(4.179)	(2.759)	(2.952)	(3.034)	(2.656)
Input shock × 1(Serv.)	-2.826*	-3.997*	-3.136*	-2.952*	-5.363*	-6.141**	-5.364**	-5.168*	-4.636	-5.982	-4.495	-4.339
	(1.503)	(2.094)	(1.612)	(1.545)	(2.626)	(2.900)	(2.523)	(2.558)	(3.489)	(3.677)	(3.243)	(3.449)
Comp. shock × 1(Agric.)	7.940***	7.770**	7.847**	7.814**	7.547**	7.469**	7.425**	7.466**	7.916**	7.719**	7.687**	7.772**
	(2.791)	(2.783)	(2.897)	(2.886)	(2.852)	(2.839)	(2.978)	(2.948)	(2.993)	(3.067)	(3.181)	(3.129)
Comp. shock × 1(Manuf.)	1.641**	1.460	1.579*	1.623**	1.979**	2.042**	2.043**	1.952**	2.055**	2.291**	2.186**	1.976**
	(0.774)	(0.868)	(0.772)	(0.782)	(0.835)	(0.921)	(0.848)	(0.842)	(0.828)	(0.840)	(0.829)	(0.822)
F-Stat First Stage	386.1	448.9	399.8	390.5	276.3	128.9	225.8	281.1	49.58	35.23	43.15	43.05
Observations	58,370	58,370	58,370	58,370	58,370	58,370	58,370	58,370	58,370	58,370	58,370	58,370
Region-Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region-Year FE	Yes				Yes				Yes			
Year FE		Yes	Yes	Yes		Yes	Yes	Yes		Yes	Yes	Yes
Baseline Controls			Yes	Yes			Yes	Yes			Yes	Yes
Region-Specific Treands				Yes				Yes				Yes

Note: This table presents the results of estimating Equation 4.3 using the wage bill as outcome and instrumenting. Estimations performed in a panel at the industry-region-year level. Colombian departments are use as regions. Columns (1)-(4) are estimated using the input shock only for capital goods, columns (5)-(8) use the input shock only for consumption goods, and columns (9)-(12) use the input shock only for raw materials. Panel A presents estimates pooling all sectors, whereas Panel B presents estimates interacting by industry dummies. Baseline controls include the 2008 share of college-educated workers, the share of manufacturing employment, share of employment in services, and the share of female workers in each region, all interacted with year fixed effects. Estimations are weighted by employment per industry and region in 2008. The reported first stage F statistic corresponds to the minimum across all the first stage regressions using Sanderson and Windmeijer (2016). Standard errors are two-way clustered at the industry and region level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

E.2. Counterfactual Estimates

We now present evidence on the effects of trade liberalization across the 13 two-digit sectors. Recall that while the model is estimated at this level, the EoS is calibrated at the one-digit level (i.e., agriculture, manufacturing, and services). Consequently, any variation observed across two-digit sectors within a given one-digit category reflects differences unrelated to the EoS between labor and intermediate inputs, since this parameter is held constant within each broad sector.

Manufacturing: Appendix Figure E.1b plots the evolution of employment across manufacturing sectors. The trade liberalization episode favors some industries in the manufacturing sector, such as metal goods production or petroleum products. These are the two industries within the manufacturing sector where Colombia has a comparative advantage.[8] The chemical industry also experienced a slight increase in employment because the tariff shock was small in this industry. On the other hand, other industries experience a slight decrease in employment due to the trade liberalization episode. For example, the vehicle and furniture industry experienced a drop of around 0.5 percent in total employment. Textiles experienced the largest losses, as tariffs in this sector decreased substantially due to the tariff shocks. The average tariff in this industry declined from 18 to 0 percent. Therefore, textile employment decreased by more than 1.1 percent after 2 years.

The comparison between the CES and the CD cases suggests that, because of higher substitutability between labor and intermediates, employment in all manufacturing industries increases less or decreases more in response to tariff shocks. However, the decline is larger in the sectors that initially rely more on foreign inputs, such as metals, vehicles, textiles, or chemicals. These industries initially had a higher input share, and as a result, were more exposed to the input shock that led them to substitute more labor for intermediate inputs in the CES vs. the CD case. For example, employment in the textile industry decreases by 0.35 percent in the CD case and by 1.0 percent in the CES case.

Agriculture: Appendix figure E.1c shows the employment response to the tariff shock across agricultural sectors. Since these are sectors where Colombia holds a comparative advantage, employment rises in aquaculture and forestry but falls in crop production. This pattern contrasts sharply with manufacturing, where tariff reductions were more substantial. In 2010, the average tariff in primary sectors declined only modestly, from 12 to 11 percent, compared to much larger drops in manufacturing.

The comparison between the CES and Cobb–Douglas cases reveals larger employment declines across all primary sectors since the findings suggest very high substitutability between labor and intermediates in the primary sectors ($\sigma^A = 9.6$). These effects are particularly pronounced in aquaculture and crop production that rely more on intermediate inputs. For instance, in crop production, employment growth falls from 1.3% 0.6%, highlighting the importance of incorporating flexible production functions.

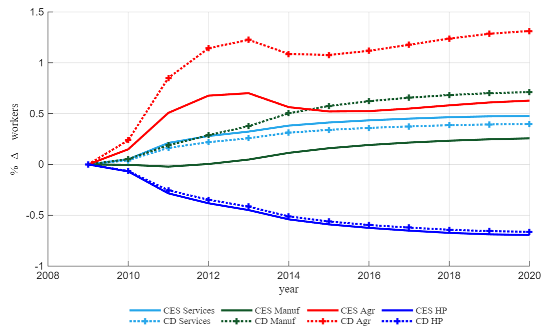
Services: Appendix Figure E.1d reports the results for the two service sectors—both benefit from the trade reform, as the agricultural and manufacturing sectors face more competition from other countries. Moreover, the service sector also benefited from access to cheaper inputs from the U.S. and the RoW. Overall, the non-retail or non-wholesale service sector experienced an employment increase of around 0.50 percent after 10 years due to the shock, while the retail and wholesale service sector experienced a rise of around 0.32 percent. In addition, the comparison between the CES and CD cases reveals that, due to the complementarity between labor and intermediates,

[8] According to OEC (2010), in 2010, exports of refined petroleum accounted for more than 7 percent of total exports, and exports of metal products more than 4 percent.

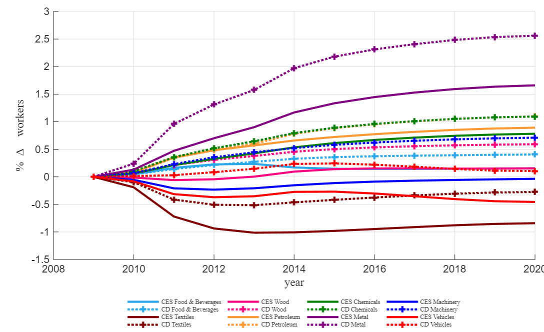
employment growth is slightly higher in the CES case. The effect is still significant in absolute terms, as this increase suggests that at least 5,000 more jobs are allocated to the service sector in the CES case relative to the CD case.

Appendix Figure E.1: Effects on Employment by Two-Digit Sector

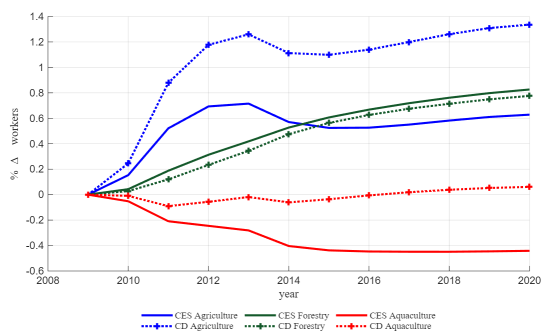
(a) Broad category of sectors



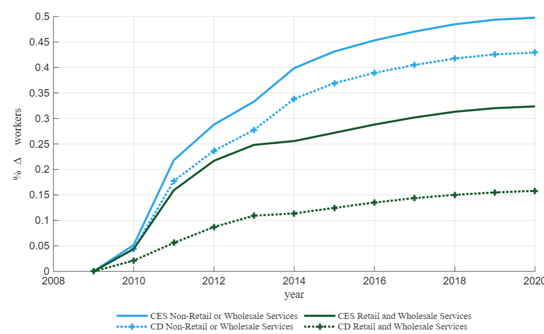
(b) Manufacturing



(c) Primary sectors



(d) Services

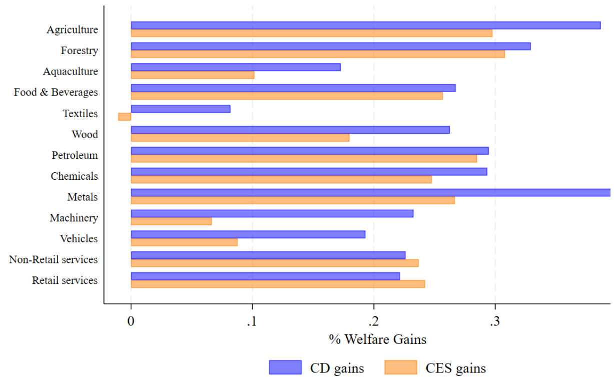


Notes: These figures plot the percentage change in total employment of the trade liberalization episode by industry from the model. Panel E.1a shows the results for the aggregate category of sectors, panel E.1b for the manufacturing sector, panel E.1c for the agricultural sector and panel E.1d for the service sector.

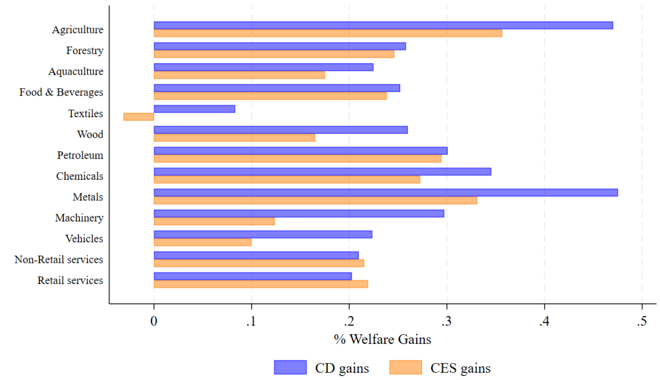
We also examine the effects of the trade shock across two-digit industries on welfare. Appendix Figure E.2 illustrates the average welfare effects. Overall, the gains in the manufacturing and agricultural sectors are substantially lower under the CES framework compared to the CD case. Workers in manufacturing industries that rely heavily on intermediate inputs experience pronounced declines in welfare gains in the CES case. For instance, in industries such as vehicles, machinery, and wood products, welfare gains drop significantly. For example, in vehicles, the average gains are reduced by half, from 0.20 percent under CD to 0.09 percent under CES. Similar declines are observed in other sectors, such as chemicals and metals, where gains decrease noticeably under the CES framework. Workers in the textile industry lose even more from the liberalization, experiencing losses in the CES case (-0.02 vs. 0.08).

Appendix Figure E.2: Welfare Gains from the Trade Liberalization by Two-Digit Sector

(a) Welfare gains: simple average



(b) Welfare gains: weighted average



Notes: This figure plots the average change in welfare across states for each sector in the economy. Panel E.2a plots the welfare gains using a simple average, while panel E.2b computes a weighted average using as weights the initial sectoral employment. We calculate welfare as the NPV of a compensated variation measure. See section 2 for more details and the exact definition of welfare.