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

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Abstract

How does trade affect labor markets when labor and intermediate inputs are complements or substitutes? This paper examines this question by analyzing a trade liberalization episode in Colombia. Exploiting exogenous tariff variation, we disentangle the effects of the reform into two channels: a foreign input shock and a competition shock. Import competition reduces the wage bill while the input shock increases it. The input shock is highly heterogeneous across 1-digit industries. It has zero negative effects on agriculture and manufacturing but positive effects on services. To analyze these dynamics, we allow for a CES production function in which labor and intermediate inputs can be complements or substitutes and incorporate it into a dynamic quantitative trade model. We calibrate the elasticity of substitution using the reduced-form coefficients and find that labor and inputs are substitutes in agriculture and manufacturing but complements in services. Armed with the model, we run a counterfactual consisting of a change in the tariff path. The results suggest that allowing for a more flexible production function has important implications for the effects of trade on structural transformation as the tariff shock reallocates more workers towards the service sector and fewer workers towards agriculture and manufacturing relative to the Cobb-Douglas case. Regarding welfare, the gains for the average worker are similar under the CES vs. Cobb-Douglas case. However, this result masks huge heterogeneity, as some workers in the manufacturing sector experience a significant decline in welfare gains.

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1. Introduction

Trade liberalization can directly impact labor markets by intensifying import competition and indirectly by reducing costs of intermediate inputs. Numerous studies have revealed the detrimental effects of import competition induced by trade liberalization on labor markets.[1] These effects are primarily attributed to declines in manufacturing employment, although recent research indicates potential positive spillovers onto other economic sectors, particularly non-tradable goods (Bloom et al., 2019; Costa et al., 2016).

Conversely, the role of foreign inputs on labor markets has been relatively understudied, with the focus mainly on gains from reduced marginal costs while overlooking potential substitution or complementarity effects with labor demand.[2] Foreign inputs may affect labor outcomes by either decreasing marginal costs (leading to firm expansions), i.e., *marginal cost* effect, or by complementing or substituting workers depending on the elasticity of substitution between labor and intermediate inputs, i.e., *substitution* effect. Previous trade models, including those that add input-output linkages (Adão et al., 2022; Caliendo et al., 2019), assume no substitutability between labor and intermediate inputs ignoring these effects.[3]

However, the *substitution* effect appears to be a crucial channel, as foreign technologies can influence employment across both tradable (e.g., agriculture, manufacturing) and non-tradable sectors (e.g., services), impacting a larger segment of the economy. On the contrary, the effects of import competition are more concentrated on tradable goods, which account for a smaller share of the economy.[4] Consequently, past literature has predominantly focused on the manufacturing sector, overlooking employment effects in services, despite their larger share of the economy.[5]

This paper examines the impact of foreign inputs on the Colombian labor market following a trade liberalization episode, emphasizing the role of substitution between inputs and labor demand across different economic sectors. Our analysis is guided by a model featuring imperfect substitutability between labor and intermediate inputs. To evaluate the aggregate welfare and labor market impacts of trade reforms, we extend existing models to include heterogeneous degrees of substitutability by sector. We use a first-order approximation to guide the empirical strategy

[1] See, for instance: Attanasio et al. (2004); Autor et al. (2013,1); 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).

[2] The literature on the impacts of input liberalization has mostly focused on understanding the effects of foreign inputs on productivity and quality upgrading (Amiti and Konings, 2007; Bas and Strauss-Kahn, 2015; Bustos, 2011; Fieler et al., 2018; Goldberg et al., 2010; Halpern et al., 2015; Olper et al., 2017; Pavcnik, 2002; Topalova and Khandelwal, 2011). Some exceptions have focused on the effects on the skill demand of firms (Amiti and Cameron, 2012; Bas and Paunov, 2021; Chen et al., 2017; Fieler et al., 2018; Verhoogen, 2008), the substitution between formal and informal jobs (Bas and Bombarda, 2023), and the distribution of time between formal and household work (Edmonds and Pavcnik, 2006).

[3] These models assume Cobb-Douglass production functions that imply an elasticity of substitution equal to one.

[4] Tradable sectors (agriculture, mining, and manufacturing) in Colombia and France account for 14 and 23 percent of formal employment, respectively (Frocrain and Giraud, 2018).

[5] See: Bas and Bombarda (2023); Bas and Paunov (2021); Chen et al. (2017); Edmonds and Pavcnik (2006); Fieler et al. (2018); Verhoogen (2008), all of whom concentrate on manufacturing.

and derive the effect of a trade shock on local employment. We obtain that the employment effects of foreign inputs hinge on (1) reductions in the marginal production costs and (2) the degree of substitutability/complementarity with labor demand. These results reveal significant sectoral heterogeneity in the effects of foreign inputs on the labor market.

We isolate the effects of foreign inputs and import competition by exploiting the exogenous variation induced by two unexpected tariff reductions in Colombia. The first reduction, implemented in 2010, unilaterally reduced tariffs charged on the prices of intermediate foreign inputs after a change in the National Government. The second, which took effect in 2012, decreased the tariffs charged on imports from the United States, as part of the implementation of a free trade agreement between the two countries. Neither of the reforms affected Colombian exports, making it possible for us to isolate the effect of imports from that of exports.

From an empirical perspective, previous literature has struggled to analyze the effects of foreign inputs due to the ability to link input and competition measures.[6] To surmount such limitation, we use detailed administrative imports registers to compute the baseline share of foreign inputs by industry. The industry-level input shock is the sum of tariff cuts in inputs, weighted by their baseline import share. We combine the foreign input shock with a traditional measure of import competition, and link them with employment measures in household surveys and the universe of formal employer-employee administrative records. Merging all these data sources allows us to analyze changes in overall employment and earnings and contrast our results across different data sets.

Our empirical strategy uses across state and industry variation that combines the unexpected timing of the reductions in tariffs in 2010 and 2012 with their exogenous magnitudes in a differences-in-differences framework that provides reduced form estimates of the effects of import competition and foreign inputs. Even though the tariff reductions were unexpected, we follow Goldberg and Pavcnik (2005) and perform a robustness check in which we instrument the change in tariffs with baseline levels of protection per industry.

Our main identification assumption relies on the common-trends between industries with and without tariff cuts, who 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 2010. 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).

The Colombian tariff reductions raised mainly the inflow of capital (including construction goods) and consumption goods coming from the United States. Overall, the tariff reductions increased import competition among agricultural and manufacturing industries, but additionally benefited manufacturing and services firms, who profit from the situation to access cheaper foreign inputs.

[6] This issue has particularly hindered the analysis among developing countries where data quality is usually lower.

Our main empirical finding suggests that import competition *decreases* employment, whereas foreign inputs *increase* it. However, the latter effect is heterogeneous across sectors and skill levels, primarily increasing employment in the service sector, where potential complementarities between foreign inputs and employment 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 1.5 percent. In contrast, a one-percentage-point reduction in the prices of foreign inputs *increases* employment by an estimated 2.7 to 3.2 percent. This latter effect is driven by the services sector, in which a one-percentage-point reduction in the prices of foreign inputs increases employment by between 1.3 to 1.9 percent. Nonetheless, this effect varies across skill levels and sectors, indicating different levels of substitutability with employment. We find that foreign inputs decrease high-skilled employment in manufacturing, consistent with an elasticity of substitution, while increasing high- and low-skilled employment in services, consistent with complementarities in the production function.

While our estimated competition effects are similar to those found in previous studies, we show that, as opposed to previous literature, the reduction in foreign inputs prices has employment effects heterogeneous by sector and by level of skills. These results are in line with previous evidence on employment reallocation across industries (Bloom et al., 2019; Costa et al., 2016) and complement the results finding an effect of input liberalization on the skill-premia in the manufacturing sector (Amiti and Cameron, 2012; Bas and Paunov, 2021; Fieler et al., 2018; Verhoogen, 2008).

We calibrate the elasticity of substitution (EoS) using the reduced-form results and the equation derived from the first-order approximation. In particular, according to this equation, the coefficient of the input shock from the reduced-form regression depends on i) the EoS between labor and intermediate inputs, ii) the labor share, iii) the trade elasticity, and iv) an exposure measure that captures how firms expand when the marginal cost decreases. Using estimates of the trade elasticity, and an average value for the labor share and the exposure measure at the 1-digit sector level, we solve for the EoS between labor and intermediate inputs. We find that labor and inputs are substitutes in the agricultural sector ($\sigma^{Ag} = 6.4$) and the manufacturing sector ($\sigma^{manuf} = 3.7$), and complements in the service sector ($\sigma^{ser} \approx 0$).

Armed with the model and the EoS in the production function, we run our main counterfactual, which consists of an unexpected change in the tariff path in 2009. We allow for a production function in which labor and intermediate inputs complement each other in the service sector and substitute in the manufacturing and primary sectors. We analyze the impact of the reform on the evolution of employment across industries to analyze the impact of trade on structural transformation and the welfare gains across regions and sectors comparing the CES vs. the Cobb-Douglas (CD) case. We measure welfare as the net present value of the equivalent variation after the shock Caliendo et al. (2019); Rodriguez-Clare et al. (2022).

Our findings indicate that trade reallocates more workers toward the service sector and fewer workers toward agriculture and manufacturing under the CES framework compared to the CD case.

For example, in agriculture, employment increases by 1.0% under the CD scenario but only by 0.5% under CES. In manufacturing, employment slightly increases by 0.2% under the CD case, whereas it decreases by 0.2% under CES. Within the manufacturing sector, industries that rely heavily on intermediate inputs, such as vehicles, machinery, and chemicals, experience particularly large shifts when comparing the CES and CD cases. In contrast, employment in the service sector increases marginally from 0.4% under CD to 0.5% under CES. However, this small percentage difference translates to the reallocation of over 5,000 additional workers to the service sector over a ten-year period, suggesting that this mechanism has important effects for the impact of trade on structural transformation.

Regarding the welfare impact of the reform, the gains for the average Colombian worker are similar under the CES and CD cases. However, this average masks substantial heterogeneity across sectors. Workers in the manufacturing sectors experience significant declines in welfare gains under the CES framework compared to the CD case. For instance, workers in industries such as machinery, vehicles, wood, and chemicals see reductions in their welfare gains exceeding 40%. Similarly, workers in the textile industry, who are already negatively impacted by the liberalization, face even larger losses under CES. In contrast, workers in the service sector experience slightly greater gains under CES compared to CD. These results also translate at the regional level, as states specializing more in manufacturing goods experience lower gains under CES than CD. The findings suggest that shifting from a Cobb-Douglas to a CES framework increases inequality across 1-digit sectors, as workers in manufacturing face greater negative exposure to trade shocks.

Related Literature

The paper contributes to the literature in at least three specific ways. First, our paper contributes to a large literature on international trade that uses quantitative trade models to measure the distributional effects of trade. We extend the recent dynamic trade general equilibrium models, which allow for different degrees of substitutability between labor and intermediate inputs. We also show how to solve the model without knowing economic fundamentals. Classic studies such as Caliendo et al. (2019); Galle et al. (2022); Rodriguez-Clare et al. (2022) studied the impact of the China shock on the US economy by calibrating sectoral productivity shock that matches Chinese import penetration in the United States. These studies find that China has contributed enormously to wage inequality in the US. Similarly, other papers such as Adão et al. (2022) collect rich microdata to study the inequality effects of trade 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 allowing different degrees of substitution between labor and intermediate inputs across sectors, finding that this mechanism can reconcile the wage dispersion observed in the data with the ones from the quantitative models (Adão et al., 2019; Autor et al., 2021). We believe our estimates can also be used as a benchmark to other studies that aim to study the effect of "shocks" on labor market outcomes. In that sense, our paper is very related to two recent studies that have looked at the role of inputs in the aggregate by allowing for more flexible production functions. Peter and Ruane (2023) estimate CES production function allowing for different degrees of substitution across intermediate inputs, finding larger trade effects, and Huneeus et al. (2021) study the role of the firm network in explaining wage inequality allowing substitutability between labor and intermediate inputs. We contribute to this literature by analyzing the distributional effects of trade using a dynamic quantitative trade model and studying how the elasticity of substitution between labor and inputs varies across 1-digit sectors.

Second, we study the labor market effects of foreign inputs and contribute to the growing literature that quantifies the effects of input liberalization on the local economy. A great deal of this literature has estimated the positive gains of access to foreign inputs on 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). Some 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; Fieler et al., 2018; Verhoogen, 2008). This latter group of papers has prominently focused on studying the effects of employment in manufacturing. We complement this work by relaxing the assumption of common elasticity of substitution across sectors and showing that the effect on the labor markets is especially important among the service sector, which covers a larger portion of the economy.

Third, 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 coming 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). Some others have studied 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). Our results indicate that import competition from the United States can negatively impact employment in Colombia, and we complement it by showing that there are sectoral employment gains stemming from access to more affordable foreign inputs.

The rest of the paper is organized as follows. Section 2 presents a dynamic trade model incorporating heterogeneous substitution of foreign inputs and local employment across sectors. Section 3 presents the setting by describing the tariff reductions adopted in Colombia in 2010 and 2012. Section 4 details the data and the empirical strategy that identifies the causal effect of import competition and foreign inputs on Colombian labor market outcomes. Section 5 presents the main results. Section 6 describes the calibration of the model and main counterfactual results. Finally, Section 7 concludes.

2. Model

We extend the dynamic spatial general equilibrium model from Caliendo et al. (2019) and Artuc et al. (2010) to include different degrees of substitutability between labor and intermediate inputs. We assume a production function in which labor and intermediate can be complements or substitutes. We use the model for two purposes. First, the model guides our empirical strategy since we derive our main specification using a first-order approximation from the labor demand equation. Second, we use the model to compute several counterfactuals of the trade reform to analyze the aggregate and distributional impacts of the trade liberalization episode considering the complementarity and substituitability channel.

The model includes a set of N locations in the economy. These locations correspond to regions within a country, or countries themselves. In our case, we calibrate the model to Colombian states, the US, and the rest of the world (RoW). There are also J sectors in the economy. At $t = 0$, a mass of households are either employed or not employed (home production sector) in these J sectors . As in Caliendo et al. (2019), preferences are Cobb-Douglass 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 Cobb-Douglass properties, the ideal price index is given by $P_t^n = \prod_{k=1}^{J} \left(P_t^{n,k} \right)^{\alpha^{nk}}$. Following Caliendo et al. (2019), non-employed households obtain consumption in terms of home production $b^n > 0$. We follow their notation and index the home production sector as 0; thus, $C_t^{n0} = b_n$.

Households are forward-looking and solve a dynamic problem. Workers can move each period across regions and sectors. These decisions are subject to mobility costs across space and sectors denoted by $f^{nj,ik} > 0$ that corresponds 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 viceversa. Then, $f^{nj,ik} = \infty$ if $j \in \{Col\}$ and $i \in \{USA, RoW\}$.

Following the properties of discrete choice models, we assume that workers receive each period additive idiosyncratic shocks ϵ_t^{ik} and that they are drawn from a nested Gumbel distribution. In the first nest, they decide the location, and in the second nest, the sector as in Rodriguez-Clare et al. (2022). Formally, the value function is:

$$v_t^{nj} = U(C_t^{nj}) + \max_{\{i,k\}_{i=1,k=0}^{N,J}} \left\{ \beta E[v_{t+1}^{ik}] - f^{nj,ik} + \epsilon_t^{ik} \right\}, \tag{2.1}$$

where $C_t^{nj} = b_n$ corresponds to the consumption of households who are employed in the home-production sector and $C_t^{nj} = \frac{w_t^{nj}}{P_t^{nj}}$ if they are employed in the j sector in location n. As in RUV, we assume that the idiosyncratic shock ϵ_t^{ik} is drawn from a nested Gumbel distribution:

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

where $\eta \geq \nu$; the parameter η captures the shock dispersion across regions and ν across sectors.

Following the properties of extreme value type shocks Train and McFadden (1978), let's define $V_t^{nj} = \mathbf{E}(v_t^{nj})$, the expected value measures the current value and the mobility opportunity to reallocate into new markets. Then,

$$V_t^{nj} = U(C_t^{nj}) + \eta \ln\left(\sum_{i=1}^{N}\left(\sum_{k=0}^{J} \exp(\beta V_{t+1}^{ik} - f^{nj,ik})^{\frac{1}{\nu}}\right)^{\frac{\nu}{\eta}}\right) + \gamma_\eta. \tag{2.2}$$

where γ_η is a constant term. By the properties of the extreme value type shocks the share of workers from market (n, j) that decides to reallocate to any market (i, k) is:

$$\mu^{nj,ik} = \mu_t^{ij,ik|i} \cdot \mu_t^{nj,i\#}, \tag{2.3}$$

where $\mu_t^{ij,ik|i}$ correspond to the share that conditional on living in i decides to work in sector k, and $\mu_t^{nj,i\#}$ to the share of people from n that decide to migrate to i. These shares are:

$$\mu_t^{ij,ik|i} = \frac{\exp\left(\beta V_{t+1}^{ik} - f^{ij,ik}\right)^{1/\nu}}{\sum_{h=0}^{S} \exp\left(\beta V_{t+1}^{ih} - f^{ij,ih}\right)^{1/\nu}}, \tag{2.4}$$

where the parameter $1/\nu$ measures the labor supply elasticity across sectors. Look that when $\nu \to 0$, workers can switch without frictions across sectors. The second term is:

$$\mu_t^{nj,i\#} = \frac{\left(\sum_{h=0}^{S} \exp\left(\beta V_{t+1}^{ih} - f^{nj,ih}\right)^{1/\nu}\right)^{\nu/\eta}}{\sum_{m=1}^{I}\left(\sum_{h=0}^{S} \exp\left(\beta V_{t+1}^{mh} - f^{nj,mh}\right)^{1/\nu}\right)^{\nu/\eta}}. \tag{2.5}$$

where $1/\eta$ corresponds to the migration elasticity. This equation suggest that workers move to locations with better values in the future net of the total migration costs. In the case in which $\eta \to 0$, locations are perfect substitutes. The sequential equilibrium conditions imply that 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 evolution of the economy in terms of the distribution of employment and non-employment across the different labor markets. This structure is the same as

Caliendo et al. (2019), Artuc et al. (2010), and Rodriguez-Clare et al. (2022).

2.1. Production

Firms in each sector and location are able to produce a set of varieties of intermediate goods. The technology to produce these intermediate goods requires labor and materials, which consist of goods produced from all sectors. Total Factor Productivity (TFP) of an intermediate good in region n and sector j is composed of two terms: a sectoral-location component A_t^{nj}, which is common to all intermediate producers in a location and sector, and a specific variety component z^{nj} that is drawn from a Fréchet distribution as in Eaton and Kortum. We modify the production function from CDP. In particular our production function is defined as a Nested CES structure:

$$q_t^{nj} = z_t^{nj} A_t^{nj} \left[\zeta^{nj} (l_t^{nj})^{\frac{\sigma^j - 1}{\sigma^j}} + (1 - \zeta^{nj}) (M_t^{nj})^{\frac{\sigma^j - 1}{\sigma^j}} \right]^{\frac{\sigma^j}{\sigma^j - 1}}, \tag{2.6}$$

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. These terms correspond to the degree of substitutability between labor and intermediate inputs. Most of the literature including Caliendo et al. (2019), GYR, and ACCDP have assumed Cobb-Douglass production functions implying that $\sigma^j = 1$ ignoring this mechanism. We show how this mechanism can amplify or mitigate the wage inequality effects of trade. We also assume that the intermediate inputs are a CES input. In particular:

$$M_t^{nj} = \left[\sum_{k=1}^{J} \tilde{\gamma}^{nj,nk} (M_t^{nj,nk})^{\frac{\delta^j - 1}{\delta^j}} \right]^{\frac{\delta^j}{\delta^j - 1}}. \tag{2.7}$$

The parameter δ^j corresponds to the elasticity of substitution across sectors. Given the CES structure, δ^j captures how easy is to substitute intermediate inputs across different sectors, and σ^j how easy is to substitute labor with intermediate inputs. 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 x_t^{nj} of an input bundle 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. This intermediate input cost is given by the function:

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

where P_t^{nk} is the sectoral price of sector k in region n and applied to final goods and intermediate inputs used in production. The unit cost of an intermediate good indexed by z_t^{nj} is given by $\frac{x_t^{nj}}{z_t^{nj}}$.

Following the notation by CDP, we denote the iceberg trade costs as $\kappa_t^{nj,ij} \geq 1$. In particular, one unit of any variety in sector j shipped from region i to n requires producing $\kappa_t^{nj,ij}$ in region i. 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 the ad-valorem tariff imposed by location n to i in sector j. Moreover, following the EK framework, competition implies that the price paid for a particular variety of good j in region n is given by the minimum unit cost across regions taking into account the iceberg trade costs. The vector of productivity draws for each variety by the different regions in good j is $z^j = (z^{1j}, z^{2j}, ..., z^{NJ}, z^{Fj})$.

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

2.2. Local Sectoral Aggregate Goods

Intermediate goods demanded from sector j and from all locations are aggregated into a sectoral good denoted by Q as in the multisector EK model:

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

where $\phi^j(z^j)$ is the joint distribution over the vector z^j that we assume is Fréchet. As in CDP local sectoral aggregate goods are used as intermediate inputs by other sectors or for final consumption in location n. Given the properties of extreme value type shocks and from EK, the price of the sectoral aggregate good j in location n at time t is:

$$P_t^{nj} = \Gamma^{nj} \left(\sum_{i=1}^{N} (x_t^{ij} \kappa_t^{ij})^{-\theta^j} (A_t^{ij})^{\theta^j} \right)^{\frac{-1}{\theta^j}}, \tag{2.8}$$

where Γ^{nj} is a constant that corresponds to the Gamma function, θ^j is the dispersion parameter of the Fréchet distribution that also corresponds to the trade elasticity. A standard assumption in the EK model is $\theta^j > \eta^j - 1$. By the properties of the Fréchet, we also obtain that the share of expenditure in location n from location i of good j is:

$$\pi_t^{nj,ij} = \frac{(x_t^{ij} \kappa_t^{ij})^{-\theta^j} (A_t^{ij})^{\theta^j}}{\sum_{m=1}^{N} (x_t^{mj} \kappa_t^{mj})^{-\theta^j} (A_t^{mj})^{\theta^j}}. \tag{2.9}$$

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

2.3. Market Clearing Condition-Static Subproblem

Following the notation from CDP, let X_t^{nj} be the total expenditure on sector j good in location n, then the market clearing condition implies that:

$$X_t^{nj} = \sum_{k=1}^{J} \gamma_t^{nk,nj} \underbrace{\sum_{i=1}^{N} \frac{\pi_t^{ik,nk}}{1+\tau_t^{ik,nk}} X_t^{ik}}_{Y_t^{nk}\text{: Gross production } nk} + \alpha^{nj} \underbrace{\left(\sum_{k=1}^{J} w_t^{nk} L_t^{nk} + D_t^n + R_t^n \right)}_{\text{Final consumers}}. \tag{2.10}$$

In this equation, the first term captures the total demand for intermediate inputs, and the second term the demand for final consumption. The final consumption depend on total final expenditure that is the factor income, the deficits, D_t^n and the revenues from tariffs R_t^n. One of the differences with Caliendo et al. (2019) is that the parameter $\gamma_t^{nj,nk}$ is not constant. In particular, by the properties of the CES production function:

$$\gamma_t^{nj,nk} = \left(\frac{(1-\zeta^{nj})^{\sigma^j} (s_t^{nj})^{1-\sigma^j}}{(\zeta^{nj})^{\sigma^j} (w_t^{nj})^{1-\sigma_j} + (1-\zeta^{nj})^{\sigma^j} (s_t^{nj})^{1-\sigma^j}} \right) \left(\frac{\tilde{\gamma}_{nj,nk}^{\delta^j} (P_t^{nk})^{1-\delta^j}}{\sum_{h=1}^{J} \tilde{\gamma}_{nj,nh}^{\delta^j} (P_t^{nh})^{1-\delta^j}} \right), \tag{2.11}$$

where the first term corresponds to the expenditure share that firms spend on intermediate inputs relative to labor, and the second term to the share within intermediate inputs that goes to sector k. Similarly the labor market clearing condition is:

$$L_t^{nj} = \left(\frac{\phi_t^{nj}}{w_t^{nj}} \right) \sum_{i=1}^{N} \frac{\pi_t^{ij,nj}}{1+\tau_t^{ij,nj}} X_t^{ij}, \tag{2.12}$$

where ϕ_t^{nj} is the labor share that firms pay to workers relative to intermediate inputs:

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

Given the properties of the CES, the share is not constant and depends on the elasticity of substitution between intermediate inputs and labor.

These market clearing conditions solve the market equilibrium in the static framework. Following CDP, we define three different equilibriums: 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. We can solve for a baseline economy and the counterfactuals without information on the baseline fundamentals. We now focus on deriving our baseline specification considering changes in tariffs from trade reforms.

2.4. First-Order Approximation

Our main parameters of interest are the different elasticity of substitution between labor and intermediate inputs σ^j. We use the structure of the model to understand the effect of the trade liberalization on labor market outcomes and show how the effects depend on these parameters. From the labor market clearing conditions and omitting the time subindex, the total wage bill for workers in location n and sector j is:

$$w^{nj}l^{nj} = \phi^{nj}\sum_{i=1}^{N}\pi^{ij,nj}X^{ij},$$

where ϕ^{nj} corresponds to the labor share. To understand the impact of the trade liberalization on total workers' revenue, let's assume that there is a small change in the iceberg trade costs. Let's define the input shock as:

$$InputShock^{nj} \equiv \sum_{k=1}^{J}\gamma^{nj,nk}\left(\sum_{i=1}^{N}\pi^{nk,ik}d\ln\kappa^{nk,ik}\right), \tag{2.13}$$

where the term $\gamma^{nj,nk}$ captures the expenditure share of sector j in products from sector k, $\pi^{nk,ik}$ captures the initial expenditure share from location n in products from i in sector k, and $d\ln\kappa^{nk,ik}$ captures the change in the trade cost induced by the trade liberalization. This means that the foreign input shock is represented as a weighted average of tariff changes, influenced by the initial consumption shares: specifically, the share of sector k consumed by region n from region i before the shock and the share of industry j's inputs sourced from sector k in region n. Then, the change in labor earnings in (n, j) is:[7] Then, we get that the change in the wage bill of workers from the labor demand equation for sector j and location n is:

$$\begin{aligned} d\ln w^{nj}l^{nj} = (\sigma^j - 1) \quad & \underbrace{\left[(1-\phi^{nj})InputShock^{nj}\right]}_{\text{Foreign Input Shock - \textit{Substitutability}}} \\ & - \theta^j \underbrace{\left[(1-\phi^{nj})\left(\sum_{i=1}^{N}\psi^{ij,nj}(1-\pi^{ij,nj})InputShock^{nj}\right)\right]}_{\text{Foreign Input Shock - \textit{Marginal Cost}}} \\ & + \theta^j \underbrace{\left(\sum_{i=1}^{N}\psi^{ij,nj}\sum_{m=1}^{N}\pi^{ij,mj}d\ln\kappa^{ij,mj}\right)}_{\text{Import Competition Shock}}, \end{aligned} \tag{2.14a}$$

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 total sales from location n-sector j to region i.

Equation 2.14 allows us to break down the effect of foreign inputs on the total wage bill into three

[7] This equation is in partial equilibrium since we assume that other variables, such as wages or the share of sectors within the intermediate input bundle, are not responding to the shock.

distinct terms. The first term captures the direct impact of foreign inputs on the labor share, ϕ^{nj}, providing a measure of the elasticity of substitution between labor and intermediate inputs. This term disappears if the production function is Cobb-Douglas, as indicated by σ^j being equal to 1. If labor and intermediate inputs are complements $\sigma^j < 1$, a tariff increase leads to a higher marginal cost, and as a result, the labor share decreases. On the other hand, if labor and intermediate inputs are substitutes $\sigma^j > 1$, an increase in the marginal cost leads to a higher labor share.

The second term captures changes in marginal cost, a feature common to all trade models with a gravity structure. Lower input costs reduce marginal production costs, encouraging firms to expand into new markets. This expansion increases employment and labor earnings due to the rise in sales. However, in non-tradable sectors, where consumption is entirely local, firms cannot expand into other regions as the expenditure share is already at one or zero. Consequently, the reduction in marginal cost does not significantly impact sales from a first-order perspective, as firms can't increase their market shares in these markets. Therefore, in non-tradable services, the foreign input shock primarily reflects the substitutability between labor and intermediate inputs rather than market expansion effects.

The third and final component captures the effect of import competition, where increased foreign competition reduces total employment and labor earnings as domestic firms lose market share, leading to a drop in total sales. This effect arises from the expanded presence of foreign producers in domestic markets. The extent of this shock depends on the initial market share of foreign firms and the share of final consumption in sectors where trade costs decline, exposing those sectors to intensified competition.

We use this equation to separate the effect of the reform in an input and a competition shock. In particular, we build an input and competition shock consistent with the results from equation 2.14. In the next section, we proceed to describe the main trade reform in Colombia that we exploit to understand the impact of trade on labor market outcomes.

3. Trade reforms in Colombia

Recent Colombian tariff reductions provide an excellent setting to study the labor market effects of imports in developing countries. The first reduction was implemented in 2010, with a unilateral tariff decrease, and the second in 2012, under the free trade agreement signed between Colombia and the United States.

Before the Free-Trade Agreement:- Over the last decades of the twentieth century, Colombia undergone a liberalization process that reduced tariffs, irrespective of their origin, from around 50 percent in the 1970s to 12 percent in 2006 (Nieto, 2016). From 1970 to 1990, Colombian tariffs decreased continuously, from an average of 50 percent in 1970 to 29 in 1989, as part of government efforts to liberalize the country. During the 1990s, the country then embarked on a second liberalization wave that further reduced tariffs to around 12 percent on average.[8] In 1995, the country joined the *Comunidad Andina de Naciones* (CAN), which enforced a common tariff scheme for all participating Andean countries.[9] Under this scheme, the members of CAN charged a common tariff that was not altered until 2008, when the common tariff scheme ended.

In 2010, a newly elected Colombian government unexpectedly decided to decrease further tariffs on imported products passing from an average of 12 percent to 8.3 percent. The tariff cuts were implemented under the Colombian Decree 4114 of 2010, signed on November 5th, 2010. The decree, which mandated immediate cuts on tariffs of 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 was 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 Free Trade Agreement:- Since the 1990s, the United States has been Colombia's biggest trade partner, accounting for around 25 to 30 percent of Colombia's imports.[10] Trade between both countries grew remarkably after the beginning of the 1990s when both countries took measures to facilitate the flow of products. In 1991 the United States, 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 United States to around 15 percent. Later, in 2003, both countries started negotiations on the free trade agreement, which were officially concluded with a final text in 2006, after 15 rounds and more than 100 meetings (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 by syndicalists, indigenous associations, left and center-left parties, and pharmaceuticals, among others. The opposition persists nowadays with multiple political parties claiming that it should be revoked because its implementation was not approved by the popular vote.

On the U.S. side, the process was even more complicated. After George Bush presented the final text to Congress in 2006, its voting was postponed after 2008 due to the opposition by Nancy Pelosi

[8] A more detailed discussion about Colombian liberalization in the 1990s can be found in Eslava et al. (2004).

[9] The CAN is the union of the Andean countries (Colombia, Ecuador, Peru, and Bolivia) who came together to achieve development by the integration of trade in 1995.

[10] Colombian imports from the United States 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 one 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).

and the democratic party. Moreover, during the presidential campaign of 2008, Barack Obama claimed as irresponsible to implement an agreement with a government where human rights were violated, referring to Colombia. The opposition in the United States ended up being much stronger than expected because of the political elections, the change in government, and strong opposition by the democratic party. However, almost six years after the text was officially signed, in 2011, the U.S. Senate approved the agreement after the Colombian president manifested that if the agreement was not approved in 2011, then Colombia would stop insisting and will start negotiating in other markets. The agreement was then legally implemented in May 2012 under the Colombian Decree 730 of 2012, again receiving strong opposition in Colombia from political leaders asking for the agreement to be postponed until Colombia enforced tighter labor protection laws.[12]

The free trade agreement renewed the existing tariff exemptions granted to Colombian products under the ATPA. In return, Colombia reduced tariffs on products from the United States. Tariffs were dropped for most manufacturing, services, and mining products. Some other goods, most of which agricultural products, remained protected for some additional years (in most cases for five years, but for some products such as rice, the tariffs were set to continue for another 20 years), allowing local producers to adapt progressively to the incoming competition.[13]

Figure I presents the evolution of the tariffs charged by Colombia to the United States (Panel Ia), and the evolution of tariffs charged by the United States to Colombia (Panel Ib). Panel Ia shows that tariffs on manufacturing and service goods decreased after 2010, whereas tariffs on agricultural and mining goods decreased with the free trade agreement. Even though an important share of the agriculture goods remained protected for some additional years, the sector was strongly liberalized in 2012. Panel Ib shows that tariffs for Colombian products entering the United States were minimal, largely renewing the already low tariff rates that were in place years before. Nonetheless, these minor changes were officially referred to as cuts and were implemented with the 2012 agreement.

Tariff reductions considerably increased Colombian imports from the United States. Between 2010 and 2014, the value of U.S. products subject to the reduced tariffs grew from approximately 9 billion to 15 billion dollars (USD). Starting 2015, there was a generalized drop of Colombian imports, irrespective of their origin, triggered by a strong devaluation of the Colombian peso.[14] Imports coming from the United States fell less for products facing larger tariff cuts between 2010 and 2012. We present causal estimates of this in Section 5.1.

[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 (between 1500 and 3000 cc.), 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 United States by the 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 free trade agreement (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).

No Anticipatory Effects:- Both reforms were overall unexpected and were very difficult to anticipate. The tariff reduction in 2010 was implemented shortly after a newly installed 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 Decree was signed. The 2012 cuts were part of the free-trade agreement that was only implemented after a five-year-long wait for the approval of the U.S. Senate, given the opposition in both countries. Firms and consumers in Colombia could have hardly predicted whether the agreement was going to be approved or, even more difficult, the timing of the implementation. We provide empirical evidence for this in section 5.3.

4. Data and Empirical Strategy

4.1. Data

Our empirical analysis is based on rich administrative data from multiple Colombian authorities. Six complementary data sources are used for our analysis.

1. *Tariff Records:* We combine three official Colombian tariff records to measure the trade reforms. First, we employ the Decree 4589 of 2006 that stipulated the level of tariffs charged on every incoming product after January 1st 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 the Colombian Decree 4114 of 2010, which contemplated the unilateral tariff cuts of 2010. Third, we merge the Colombian Decree 730 of 2012, that regulated the free trade agreement between Colombia and the United States.[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 United States 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) and the Colombian Central Bank. 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 official classification of product by economic destination

[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 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

(CUODE) to classify the imported products as capital (which also includes construction), 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 (four-digit industry code). 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 approximately 8.7 million observations between 2008 and 2018. In our main analysis, we collapse these records at the four-digit industry, state, 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 states (out of 33) and 402 industries (out of 416).

5. *Social Security Records:* We complement the household surveys with social security records, which provide matched employer-employee data from 2008 to 2018. This administrative dataset covers the entire formal workforce in the country, with over 10 million records in any given month.[18] We use the social security records for two main purposes. First, to construct formal employment measures that serve as outcomes in our robustness analysis. Second, we leverage the records from 2009 and 2010 to build a labor mobility matrix, which is used in the model calibration. Details on the construction of this matrix can be found in Appendix D.

6. *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 WIOD, reflecting bilateral trade flows among regions and sectors. These datasets are used to compute the input and competition shocks employed in our empirical strategy (more details in section 4.2), and to calibrate the model (more details are given in Section 6 and Appendix D).

We merge all the data sets and create two different estimating samples. The first is a product-balanced panel built by merging trade and tariff information at the 10-digit level. The panel includes information on 6,663 imported products observed during 12 years (2007-2018), for a total of 79,956 observations. The second is a four-digit industry-code panel that matches data from the household surveys, the employer-employee records, and the tariffs. This data set follows 416 state-by-four-digit ISIC sectors for 11 years. We built this panel by keeping sector-state combinations with at least one

[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

[18] Formal-sector workers represent approximately 60 percent of the Colombian labor market.

employee observed in 2008 and that report imports at any point during the period 2008-2018. The panel at the state-industry-year level includes 66,759 observations, corresponding to 6,609 state-by-industry combinations (24 states and 348 four-digit industries, excluding those with no employment in 2008 or no trade) during 11 years. Appendix Table A.2 presents descriptive statistics for both samples.

Mining Sector: 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. Including this sector in the estimations does not alter the paper's main conclusions; however, adding it may bias the estimates.

4.2. Trade Shocks

We use the data previously detailed to compute *competition* and *input* shocks that quantify the increase in competition and the decrease in the prices of foreign inputs, respectively, induced by the tariff reductions.

Competition Shock:- We define the *competition* shock as the direct change of tariffs at year t with respect to the value before the reductions of tariffs in industry j. Formally, the competition shock is defined as:

$$\tilde{\tau}_{jt} = \psi^{2008}_{d(j),col}[\ln(1 + \tau_{jt}) - \ln(1 + \tau_{j,2010})], \tag{4.1}$$

where τ_{jt} represents the tariff charged by Colombia to imports from the United States of industry j at year t and $\psi^{2008}_{d(j),col}$ corresponds to the domestic revenue share at the two-digit sector of industry j. This measure quantifies the degree of liberalization per industry and the exposure of each industry. Before 2010, $\tilde{\tau}_{jt}$ is equal to zero since the tariffs did not change. After 2010, the tariffs start to decrease continuously. Notice that $\tilde{\tau}_{jt}$ between 2010 and 2012 is equal to the tariff change that applied to all the countries, but, after 2012 it takes the value charged exclusively to the United States. A more negative value for $\tilde{\tau}_{jt}$ implies a larger decrease in tariffs and, therefore, a larger increase in import competition.

Input Shock:- We use the records on imports per firm to quantify the *input* shock in industry j and state s. We aggregate the firm-level data to compute the shares of the different imported inputs k by industry j and state s, before the tariff reductions. We then multiply the respective share with the tariff reduction of each input k, and sum across inputs. Formally, the input shock is expressed as follows:

$$\tilde{q}_{jst} = \sum_k \omega^{2008}_{jsk} \left[\ln(1 + \tau_{kt}) - \ln(1 + \tau_{k,2010})\right], \tag{4.2}$$

where

$$\omega_{jsk}^{2008} = \pi_{d(k)s}^{2008} \cdot \underbrace{\frac{Xjsk^{2008}}{\sum_k X_{jsk}^{2008}}}_{\gamma_{js,ks}},$$

with X_{jsk}^{2008} representing the imports of input k by industry j in state s in 2008, and $\pi_{d(k)s}^{2008}$ denoting the 2-digit import share of product k for state s. This formulation aligns with the input shock defined in equation 2.13, where $\pi_{d(k),s}^{2008}$ captures the import share in Colombian states from sector k, and we use the import records to construct weights for the $\gamma's$ at the 4-digit product level. The input shock, $\tilde{q}_{jst}$, isolates the effect of marginal cost changes stemming from changes in the tariffs of foreign inputs. We use weights from 2008, prior to tariff reforms, to avoid potential biases arising from endogenous adjustments in input choices. The input shock here measures the weighted reduction in tariffs on imported inputs for sector j in state s in year t, where a more negative value of $\tilde{q}_{jst}$ signals a larger decrease in foreign input prices.[19]

4.3. Identification

Our identification exploits the across-industry variation of the tariff reductions to estimate the effect of the competition and input shocks.

Baseline Specification :- We use the sample analog of Equation 2.14 from the model to estimate the effects of the increase in competition and the reduction of input prices. Formally, our baseline specification takes the form of:

$$y_{jst} = \beta^c \tilde{\tau}_{jt} + \beta^i \tilde{q}_{jst} + \mu_{js} + \mu_{st} + u_{jst}, \tag{4.3}$$

where y_{jst} refers to the logarithm of the wage bill in industry j, in state s, at year t.[20] 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-state (μ_{js}) and state-by-year (μ_{st}) fixed effects to control for observed and unobserved heterogeneity across industries-state combinations and time. Standard errors are two-way clustered at the industry and state level to account for cross-sectional correlations across states within the same industry and across industries within the same state.

Instrumenting the Change in Tariffs :- We also run our main specification instrumenting the shocks to address potential biases in the tariff reduction process. Even though tariff decreases were unexpected, and we control for sector fixed-effects accounting for time-invariant characteristics, they could have been influenced by certain interest groups within the economy seeking to capture rents from the liberalization. For example, industries with greater political power might have experienced

[19]Due to the small variation in the import and revenue shares we also use a variant of the competition and input shocks that does not multiply by these shares. We show these results in Table C.1 in the appendix.

[20]We deal with zeros by excluding state-industry combinations in which the outcome is equal zero. However, we provide Poisson regression estimates as a robustness check and show that our results do not change.

smaller tariff reductions. To mitigate this concern, and isolate the the impact of the change in tariffs from other confounding factors, we follow Goldberg and Pavcnik (2005) and instrument the change in tariffs with their initial values interacted with exchange rates. The rationale of this instrument lies in the fact that, given that one of the tariff reforms was to achieve a more uniform tariff across products and industries, there were larger cuts in products with higher baseline tariffs. Consistently, we observe a strong correlation between tariffs cuts and the 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. Therefore, the consistency of the estimating parameters depends on the validity of the parallel trends assumption, i.e., industries 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 non-expected 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 total change in tariffs between 2010 and 2018 for each industry j. Likewise, T^i_j is equivalent to the reduction in the prices of foreign inputs between 2010 and 2018. 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:

$$y_{jt} = \sum_{t \neq 2010} \beta^c_t \left[T^c_j \times 1(\text{Year=t})\right] + \sum_{t \neq 2010} \beta^i_t \left[T^i_j \times 1(\text{Year=t})\right] + \mu_j + \mu_t + \varepsilon_{jt}, \tag{4.4}$$

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 in both interaction terms so that the treatment adoption is not staggered and continuous. Note that we estimate this at the industry-year level since this is the original variation of the tariff reductions.

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 to the parallel trend assumption. In addition, it allows us to assess the impact of the tariff reductions several years after they took place.[21]

[21] 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 point, we also apply the de Chaisemartin and D'Haultfoeuille (2021) bias-corrected estimator for inter-temporal treatment effects.

5. Reduced Form Results

In this section, we begin by examining the effects of tariff reductions on imports. Next, we explore the labor market impact of the input and competition shocks, and finish by presenting empirical evidence supporting the validity of our main estimates.

5.1. Effect of Tariffs on Imports

The Colombian tariff reductions increased imports, especially those from the United States. Table I presents the results of estimating a differences-in-differences specification using multiple measures of imports as outcomes at the product level.[22] Formally, the estimations take the form:

$$y_{pt} = \alpha \tilde{\tau}_{pt} + \mu_p + \mu_t + \epsilon_{pt}, \tag{5.1}$$

where y_{pt} corresponds to an outcome for product p in year t, and μ_p and μ_t are product and year fixed effects, respectively.[23] A (positive) negative value for α implies that the outcome (decreases) increases with the tariff reduction. Standard errors are clustered at the product level.

Column (1) of Panel A displays the effect of the tariff reductions on total imports. A one percentage point decrease in tariffs increases imports by around 1.4 percent, and, as shown in column (2), there are no differences before and after 2012. We then test whether the increase in imports is explained exclusively by imports from the United States. In columns (3) and (4) the outcome is the share of U.S. imports with respect to total imports. Tariff reductions significantly increase imports from the United States, particularly after 2012. As a contrast, columns (5) and (6) present the same estimations for imports from other countries, finding reductions in the imported share from countries different than the United States.[24]

Panel B of Table I present the same estimations, but focusing on products that were imported by Colombian firms before the tariff reductions.[25] Products imported by local firms increased significantly with both tariff reductions. These results imply that the liberalization led to an increase in U.S. imports, which in turn increased import competition but also led to a reduction in the prices of foreign inputs used by local firms.

To better understand the import shock, we split the estimations between imports of capital,

[22] We estimate this at the product level to better exploit the variation induced by the free trade agreement. However, the results are very consistent when collapsing the data at the four-digit level.

[23] We use the logarithm of imports in columns (1) and (2). We additionally provide estimations using the inverse hyperbolic sine transformation for these columns in Appendix Table A.4.

[24] We additionally present these results in event-study form in Appendix Figure A.4. We use two treatment groups: products that reduced tariffs in both reforms (2010 and 2012) and those that reduced tariffs only in 2012, and estimate a joint model. The control group includes all the products that did not change tariffs during this period. We do not observe any significant differences before 2010, which confirms that the common trends assumption holds. Consistent with the difference-in-differences estimates, imports from the United States started to increase after the tariff reductions.

[25] We identify the products that were imported in 2008.

consumption, and raw material goods, and present the results in Panel A of Table A.5.[26] The increase in U.S. imports was driven by capital and consumption goods, whereas any sizable effect is observed among raw materials. This result is expected as the United States do not have strong comparative advantage in the production of raw materials but it does have in the production of capital and consumption goods.

Local firms seem to have profit from the new cheaper access to international products. We assess such situation by analyzing the effects of the tariff reductions among products that were imported by firms before the tariff reductions (i.e. 2008) from different economic sectors, and present the results in Panels B to D of Table A.5. Panel B, for instance, computes the effects of tariff reductions among products that we identified as imported by firms in agriculture in 2008. It is possible to observe positive point estimates on consumption goods because firms can also import goods that are destined for individual consumption. It might be the case that a manufacturing firm imported a TV (which is a consumption good) in 2008 and this will enter the estimation as a consumption good for firms in manufacturing. Many of the products imported by firms are also bought by regular consumers.

The tariff reductions induced positive and substantial increases of imports of capital and consumption goods, especially among goods that were previously imported by manufacturing and services firms. We do not observe precise point estimates among goods imported by agricultural firms, although the point estimates on capital and consumption goods are positive (especially consumption goods between 2010 and 2012). We do observe robust increases among capital and consumption goods imported by firms in manufacturing and services in panel C and D. The point estimates corresponding to raw materials are systematically non-significant indicating that the tariff reductions did not imply an increase in imports of raw materials. These results suggest that the increase in imports was driven by capital and consumption goods consumed by firms in the manufacturing and services sector, which explain the nature of the foreign input shock.

In general, liberalization fostered Colombian imports from the United States, and induced an increase in import competition and a decrease in the prices of foreign inputs. Import competition is expected to mostly affect tangible products, such as those produced in agriculture and manufacturing sectors. Cheaper foreign inputs, on the contrary, benefit firms in manufacturing and services by increasing the imports of capital and consumption goods.

5.2. Labor Market Effects of Input and Competition Shocks

Raw Estimates:- Both reforms seem to have had relevant effects on employment. Figure II presents the relative gains in the raw evolution of employment among industries affected and unaffected by changes in input prices and tariffs. Employment grew more consistently in industries where the prices of foreign inputs declined (as shown in Figure IIa), particularly after the implementation of Decree 4114 in 2010, which primarily focused on reducing the cost of intermediate

[26] We identify each type of imports using the CUODE categories.

inputs. These industries may have benefited from access to cheaper inputs during the trade liberalization.

In contrast, employment suffered a significant trend decline among sectors where tariffs were reduced by the free-trade agreement (as shown by Figure IIb). Reassuringly, the decline starts in 2012 which was the year in which the agreement was implemented. Sectors that experienced heightened competition from U.S. imports, potentially lead to a reduction in workforce.

These results, however, represent simple correlations. They do not properly capture the within-industry variation needed to identify our estimation strategy accurately. Nonetheless, they provide valuable descriptive evidence of the underlying identifying variation in our main results.

Average Effects:- Panel A of Table II presents the results of the estimation of Equation 4.3, combining both least squares (columns (1)-(3)) and instrumental variables (columns (4)-(6)) specifications. The competition shock reduces the wage bill, whereas the input shock increases it. We observe persistently negative effects of the competition shock, and positive effects of the foreign input shock. A one percent increase in the competition shock *reduces* employment in around 3 percent. In contrast, a one percent decrease in the prices of foreign inputs *increases* the wage bill in between 1 and 4 percent.

The above results suggest that: 1) import competition *decreases* employment; and 2) reductions in input prices *increase* employment in a comparable magnitude. The first result is in line with most existing literature, which shows that import competition can have detrimental effects on employment. The second result is consistent with previous studies, including some based on Colombia, showing that there is a complementarity between imported inputs and labor demand (Bas and Paunov, 2021; Fieler et al., 2018; Kamal et al., 2019; Leblebicioğlu and Weinberger, 2021; Verhoogen, 2008).

Heterogeneous Effects:- Although the input shock had an aggregate positive effect on employment, the point estimates mask substantial heterogeneity across sectors. Panel B of Table II further explores this by estimating Equation 4.3, splitting the shocks across agriculture, manufacturing, and services. The losses from the competition shock are concentrated in both the manufacturing and agricultural sectors, while the positive gains from the input shock are largely driven by the services sector, which benefits from access to cheaper foreign inputs.

However, the effects of the input shock on manufacturing sectors show no discernible overall impact. This lack of a clear effect can be attributed to the heterogeneous responses within different manufacturing sectors, which offset each other in the aggregate. To explore this further, we estimate Equation 4.3 while disaggregating the effects across two-digit manufacturing sectors, with results presented in Figure III.[27] We provide the point estimates for the competition shock for completeness.

[27] We also disaggregate the input shock in services between retail and non-retail sectors, finding that the effects are evenly distributed between the two.

A significant degree of heterogeneity is observed in the impact of foreign inputs on manufacturing sectors, with some sectors experiencing labor complementarity, while others labor substitution. This heterogeneity underscores the role of the elasticity of substitution between labor and foreign intermediate inputs, as discussed in section 2.

We provide two additional pieces of evidence highlighting the role of the elasticity of substitution determining the effects of foreign inputs on local labor markets. First, we investigate whether the effects of foreign inputs are heterogeneous across sectors and skill levels by splitting the outcome based on wage bill contributions from high- and low-skilled workers. The results, presented in Appendix Table A.6, reveal two key findings. First, foreign inputs appear to reduce high-skilled employment in 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 both high- and low-skilled employment in services, suggesting potential complementarities between foreign inputs and labor in this sector.[28] This second finding aligns with previous studies showing that foreign inputs complement high-skilled employment (Bas and Paunov, 2021; Fieler et al., 2018; Kamal et al., 2019; Leblebicioğlu and Weinberger, 2021; Verhoogen, 2008).

Second, we examine whether the effects of foreign inputs vary depending on the type of intermediate inputs imported. We estimate Equation 4.3 again, but with the input shock separated into distinct components based on decreases in the prices of capital, consumption, and raw material inputs.[29] The results, presented in Appendix Table A.7, reveal important patterns. Reductions in the prices of foreign capital inputs tend to decrease employment in manufacturing (as shown in columns (1)-(3)), while price reductions for consumption inputs are associated with increased employment in services. These opposing effects provide again evidence of the importance of the elasticity of substitution when analyzing the impact of foreign inputs on local labor market outcomes.

5.3. Validity

Anticipatory effects, non parallel trends, or an increase in exports induced by the free-trade agreement could be adding bias to our estimated effects. We provide evidence against this.

Parallel trends:- Our estimation strategy requires that sectors that were not affected by the reform would have had evolved in parallel in the absence of the reforms. In addition, our results require the absence of anticipatory effects. Anticipated knowledge about the reforms would have induced labor reallocation prior to the reform, leading to biases in our estimations. We provide evidence in favor of both by analyzing the nonexistence of pre-trends.

A first glimpse of the absence of pre-trends is evidenced in Figure II, where we compare the evolution of employment before and after the reforms. We observe no significant differences in

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

[29] We create these shocks by including only inputs of each type when computing the input shock in Equation 4.2, resulting in three different types of input shocks.

trends prior to 2010, suggesting the absence of anticipatory effects before that date. This evidence, however, is driven by simple correlations posing only weak evidence for our claims.

Therefore, we additionally present more formal evidence by estimating the event study estimates detailed in Equation 4.4. Figure IV plots the estimates for the competition (Panel IVa) and input (Panel IVb) shocks. We observe negative effects of import competition after the 2012 tariff reductions (i.e. those stipulated in the free trade agreement), and not significant differences prior to it. The input shock, on the contrary, displays positive effects among industries in which the prices of foreign inputs were reduced, and no significant differences prior to it. These results imply no evidence about the existence of pre-trends for any of the analyzed shocks.[30]

Isolating imports from exports:- Our results could be also confounded if the estimated effects are explained by an increase in exports induced by the trade liberalization, rather by the increase in imports. The reforms analyzed herein, however, had no significant effect on Colombian exports. The reduction of 2010 applied only for imported products and, therefore, had no direct impact on exports. The implementation of the free-trade agreement in 2012 did not considerably reduce the tariffs placed on Colombian products by the United States to Colombian products. We test this and show the results in Appendix Table A.1. We observe small and statistically insignificant effects from the U.S. tariff cuts on Colombian exports to the United States. These results are consistent with the fact that most of the tariffs were already close to zero by the time the free-trade agreement was implemented.

6. Model Calibration and Counterfactuals

6.1. Trade Parameters

We estimate the model presented in Section 2 following the calibration method described by Caliendo and Parro (2015).[31] We define the following variables for sector s in location i that trades with country n as :

[30] We present additional event study estimates in Appendix B. Overall, the results are similar across specifications, estimation methods, and samples.

[31] Details about the data used in the estimation of the model are provided in Appendix D.

Parameter	Equation
Gross Production	$Y^{is}_{t_0} = \sum_n M^{ns,is}_{t_0}$
Total Expenditure	$X^{ns,is}_{t_0} = M^{ns,is}_{t_0}(1+\tau^{ns,is}_{t_0})$
Total Revenue	$R^n_{t_0} = \sum_{i,s} M^{ns,is}_{t_0}\tau^{ns,is}_{t_0}$
Trade Shares	$\pi^{ns,is}_{t_0} = \frac{X^{ns,is}_{t_0}}{\sum_l X^{ns,ls}_{t_0}}$
Share of Value Added or labor share	$\phi^{is}_{t_0} w^{is}_{t_0} L^{is}_{t_0}/Y^{is}_{t_0}$
Trade Deficits per Sector	$D^{is}_{t_0} = \sum_n M^{is,ns}_{t_0} - \sum_n M^{ns,is}_{t_0}$
Total Deficits	$D^i_{t_0} = \sum_s D^{is}_{t_0}$
Absorption	$I^i_{t_0} = \sum_s w^{is}_{t_0} L^{is}_{t_0} + R^i_{t_0} + D^i_{t_0}$
Consumption Shares	$\alpha^{is} = \frac{X^{is}_{t_0} - \sum_k \gamma^{ik,is}_{t_0} Y^{ik}_{t_0}}{I^i_{t_0}}$

We calibrate the initial consumption shares to match the data and assure that the model starts from equilibrium. In other words, we find the α^{is} that solve the system described by equation 2.10 before the trade liberalization episode.

6.2. Elasticities

Combining the initial data with the trade and production function elasticities we are able to compute the counterfactuals using dynamic hat algebra. In this section, we discuss first how do we recover the trade elasticities for the Colombian economy, and then, the calibration of the elasticities of substitution between labor and intermediate inputs.

Trade Elasticities: We estimate directly the trade elasticities at the two-digit sector by exploiting the variation from the free-trade agreement between Colombia and the United States. Following the gravity structure from the Armington or EK model, we get the following equation that relates trade flows to tariff changes:

$$\ln M_t^{n(Col)j,USAj} - \ln M_t^{n(Col)j,RoWj} = \theta_j[\ln(1+t_t^{n(Col)j,USAj}) - \ln(1+t_t^{n(Col)j,RoWj})] + \gamma_{nj} + \gamma_t + \epsilon_{njt}, \quad (6.1)$$

where $M_t^{nj,ij}$ corresponds to total imports from country i to region n in sector j and $\tau_t^{nj,ij}$ to the tariff imposed by region n to products from country i. We exploit the exogenous variation from the free-trade agreement, comparing imports of Colombian regions from the US to imports from the RoW and how they respond to tariff changes. We include different sets of fixed effects to control for supply and demand shock that can confound the effects. For example, γ_{nj} controls for demand shocks that affect product j in region n, and the fixed effect γ_t controls for shocks that overall affect the Colombian economy. Our parameters of interest are the terms θ_j that correspond to the trade elasticity and measure how easy it is for consumers to substitute across locations products from sector j.

We find values of the trade elasticity between the values of the recent literature (see tables E.3

and E.4 in the Appendix that report the trade elasticities after estimating specification 6.1). The first table reports the result at the industry level, while in the second table, the observation unit corresponds to the state-industry cell. Overall, we find a value of the trade elasticity between 2.5 and 3.0. This finding is consistent with the recent evidence from Boehm et al. (2023) that finds very low values in the long run.[32] Columns (2) and (3) estimate heterogeneous trade elasticities by sector. Consistent with some of the estimates from Caliendo and Parro (2015) that exploit variation from Nafta, we find larger values for the agricultural sector than in manufacturing. For instance, in the primary sector, the trade elasticity is around 4.7, while in the manufacturing sector, it is around 3.0. This result suggests that agricultural goods are more substitutable than manufacturing goods. Finally, column (3) reports the results at the 2-digit sector level. We find that some products, such as fishing, have a very high trade elasticity. In contrast, other manufactured goods, such as Chemicals and Vehicles, have a very low value, implying less substitution across locations. Within the manufacturing sector, food and beverages have the highest elasticity, around 4.5. We use these values at the 2-digit sector level to run our main counterfactuals.

Production-function elasticities: The production function consists of two nests. In the first nest, firms substitute intermediate inputs from different sectors with an elasticity of substitution δ^j. In the second nest, they substitute labor with intermediate inputs with an elasticity of substitution σ^j. For the elasticity in the lower nest δ^j, we use the values from Peter and Ruane (2023) that find an average intermediate input elasticity of 2 for the case of India. For the upper nest, the empirical evidence suggests that labor and intermediate inputs are substitutes in the primary and manufacturing sector and complements in the service sector. In particular, according to the first-order approximation from equation 2.14, the results of equation 4.3 imply:

Summary of the effects of the reduced-form

Point estimate	Implication	Labor and intermediate inputs
$\beta^i > 0$	Substitution effect dominates marginal cost effect	Substitutes
$\beta^i = 0$	Substitution effect dominates marginal cost effect	Substitutes
$\beta^i < 0$	Marginal cost and subst. effect go in the same direction	Cobb-Douglas or complements

Based on our empirical results, we find a negative coefficient of the input shock for the service sector and a zero or positive coefficient for the primary and manufacturing sector. Then, to calibrate the parameters for the model, we recover the elasticities solving the following equation for the average state-sector cell within each 1-digit sector:

$$\frac{\beta^i}{1-\phi^{nj}} = (\sigma^j - 1) - \theta^j \sum_{i=1}^{N} \psi^{ij,nj}(1 - \pi^{ij,nj}), \tag{6.2}$$

[32] Boehm et al. (2023) exploit variation in most-favored-nation clauses and find a trade elasticity of around 2.0 in the long run.

where ϕ^{nj}, $\psi^{ij,nj}$ and $\pi^{ij,nj}$ corresponds to the initial labor share, revenue shares, and trade shares observed in the initial period. We solve this equation for the average firm within 1-digit sectors in the Colombian economy and use the point estimates from specifications 1 and 4 from table II. Table A.3 reports summary statistics across sectors and states for the labor share, ϕ^{nj} (panel A), and $\vartheta \equiv \sum_{i=1}^{N} \psi^{ij,nj}(1-\pi^{ij,nj})$ (panel B) in the initial period. The average labor share in the Colombian economy is 48%. Agriculture and services have a higher labor share, 65.2%, and 57.5% relative to 40.3% in manufacturing. We also obtain that the average exposure to the input shock is lower for services than for agriculture and manufacturing. The reason for this is that there are more non-tradable goods in services, and as a result, the exposure is lower. On average, the variable ϑ takes a value of 0.8 for agriculture, 0.9 for manufacturing, and just 0.5 for services. Solving equation 6.2 for σ^j using these average values and the trade elasticities from table E.3, we obtain the following values at the 1-digit sector level: $\sigma^{\text{Ag}} = 6.4$, $\sigma^{\text{Manuf}} = 3.7$, and $\sigma^{\text{Ser}} \approx 0$. Therefore, labor and intermediate inputs are substitutes in the primary and secondary sectors and complements in the service sector.

6.3. Counterfactuals

We run our main counterfactual that consists of an unexpected change in 2009 in the path of tariffs in the dynamic general-equilibrium model. We ensure that the employment matrix across sectors and locations is at steady-state in the initial path. This means that without a shock in the model, there is no change in the number of workers in each sector and location. Then, we analyze the effect of the trade liberalization episode on the evolution of employment across sectors and regions to study the impact of trade on structural transformation and the impact on welfare. Since this is a dynamic model, we can study the distributional implications of this episode by analyzing the ex-ante welfare effect on the average worker in each sector and location cell. We measure welfare as the net present value of the permanent equivalent variation in real income for workers initially employed in region i in sector s (Adão et al., 2022; Caliendo et al., 2019; Rodriguez-Clare et al., 2022):

$$\ln(\zeta^{i,s}) = \sum_{t=1}^{\infty} \beta^t \ln\left(\frac{\hat{\omega}_t^{i,s}}{(\hat{\mu}_t^{ii,ss|i})^{\nu}(\hat{\mu}_t^{ii,s\#})^{\kappa}}\right), \tag{6.3}$$

where β^t is the discount factor and $\hat{\omega}_t^{i,s} = \frac{\hat{w}_t^{is}}{\hat{P}_t^i}$ corresponds to the change in real income that consists of the change on the wage in the numerator and the change in the price index in the denominator. The parameters $(\hat{\mu}_t^{ii,ss|i}$, $(\hat{\mu}_t^{ii,s\#})$ measure how the outside options of workers in sector s and location i evolve due to the shock. If the outside options of sector s and location i improve because of the shock, more workers will move to these new opportunities, and the change in welfare will be higher. On the other hand, if the outside options experience a negative shock, more workers will stay in the initial sector s and location i, and the gains on welfare will be smaller since this means that cells for which it is easier to reallocate experience declines in real income.

The following section describes the main results, emphasizing the differences between the Cobb-Douglas and CES production functions. In both cases, we allow substitutability in the lower nest as in Peter and Ruane (2023) and compare the effects of substitutability only in the upper nest between labor and intermediate inputs.[33]

6.4. Results of the Counterfactuals

We focus on two different outcomes, the evolution of employment across sectors, to understand trade's impact on structural transformation and the distributional effects on welfare across regions and sectors. Our main counterfactual consists of a change in the path of tariffs in the initial period of 2009. We consider two changes: i) the decline in tariffs in 2010 that affected Colombian imports with the US and the RoW, and ii) the decline in tariffs due to the FTA between Colombia and the US, which only impacted trade flows from the US to the Colombian economy.

Employment Effects The trade liberalization shock generates a change in employment that favors the service and primary sectors to the detriment of the manufacturing and home production sectors. This result is consistent with a story in which the trade liberalization episode led to more foreign competition in the secondary sectors. Figure V plots the evolution of employment due to the unexpected change in tariffs in 2009. Panel A plots the results at the 1-digit sector level. Overall, the results suggest that the 2010 shock favors agriculture and services relative to manufacturing. Employment in the initial periods increases in these two sectors relative to manufacturing. The decline in tariffs in 2010 in the agricultural sector is very small relative to manufacturing; as a result, workers moved towards this sector. However, the second shock mitigates some of these differences between the primary and secondary sectors as agricultural tariffs also experience a significant decline with the FTA between Colombia and the US. Total employment in the home production sector decreased by around 1.0 percent after 10 years of the shock. Workers increase their labor force participation because a decrease in the price index incentivizes workers to shift to market production instead of home production. On the other hand, total employment in the service sector increased between 0.8 and 1.0 percent since these sectors did not experience the direct competition shock from foreign goods, and they acquired cheaper inputs from the two liberalization shocks. These results mask enormous heterogeneity within the 1-digit sector categories.

Comparing the CES vs. the Cobb-Douglass production case, panel A suggests that allowing for different degrees of substitutability in the production function tends to favor the service sector relative to the other sectors. For instance, the service sector experiences a higher increase in employment under the CES production function, 1.0% vs 0.8%. In contrast, employment decline in the primary and manufacturing sectors is more pronounced. This effect is especially very meaningful in the manufacturing sector; under the Cobb-Douglass case, employment in the manufacturing

[33] In the CDP model, there is no substitutability across intermediate inputs since the production function in the lower nest is also Cobb-Douglas. Since we are interested in the effects between labor and intermediate inputs, we fix this elasticity and just compare the results in the upper nest.

sector experiences a positive increase of around 0.2%, while in the CES case, employment in the manufacturing sector decreases due to the substitutability between labor and intermediate inputs. Similarly, the employment increase in agriculture is much lower under the CES case vs. the Cobb-Douglass case. In the Cobb-Douglass case, employment increases by 1.0%, while in the CES case, it is only half, 0.5%, reallocating more workers toward services.

The other panels from figure V show that the one-digit comparison masks enormous heterogeneity across 2-digit sectors. For example, panel b shows the evolution of employment across manufacturing sectors. The trade liberalization episode favors some industries in the manufacturing sector, such as producing metal goods or petroleum and refined petroleum products. These are the two industries within the manufacturing sector where Colombia has a comparative advantage. According to OEC data, in 2010, exports of refined petroleum accounted for more than 7% of total exports, and exports of metal products more than 4%. Similarly, the chemical industry experienced a slight increase in employment because the tariff shock was small in this industry since the decline in tariffs was only around 5%. This is also true for the machinery industry or food and beverages, which did not experience a significant decline. 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 most considerable losses since tariffs in this sector decreased substantially due to the trade liberalization episode. For instance, the average tariff in this industry declined from 18% to 0%. Then, employment decreased by more than 2.0% in this sector.

Comparing the CES vs. the CD case, the figure suggests that due to the higher substitutability between labor and intermediate inputs, employment in these industries increases less or decreases more due to the tariff shocks. However, the decline is larger in the industries that experience a higher input shock because of the trade liberalization episode, such as the manufacture of metals, vehicles, or chemicals. The reason for this is that they initially had a lower labor share and 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.

Panel C reports the employment growth due to the shock in the primary sectors. The figure suggests that since these are some of the goods in which Colombia has a higher comparative advantage, there is an increase in employment for aquaculture and forestry and a decrease in agriculture. This figure behaves very differently from the manufacturing sector. The tariff shock in 2010 was relatively small in the primary sectors compared to manufacturing. For example, in the case of agriculture, the average tariff decreased in 2010 only from 12% to 11%. Allowing for substitutability between labor and intermediate inputs in the production function declines the employment growth of all goods in the primary sector since, according to the reduced form, there is substitutability between labor and intermediate inputs, and this substitutability is very large, $\sigma^{ag} = 6.4$. These effects are substantial, especially for aquacultural and agricultural goods. In the case of aquaculture, the CES decreased the employment growth from 0% to a negative value close to

-0.4%, a substantial decrease, and in the case of agriculture, the decline in the CES case is more than 40% of the increase in employment. While in the CD, employment in this industry grows by around 1.0%. In the CES case, the increase is only 0.6%. These results show the importance of allowing for a more flexible production function when analyzing employment dynamics across sectors, even across 1-digit sector categories, since trade can have higher impacts on structural transformation.

Finally, panel D reports the results for the two service sectors—both benefit from the trade reform, as the primary and secondary sectors face more competition from other countries. Moreover, the service sector also benefits from access to cheaper inputs from the US and the rest of the world. Overall, the non-retail or non-whole service sector experienced an employment increase of around 0.7% after ten years due to the shock, while the retail and wholesale service sector experienced a rise of around 0.2%-0.4%. In addition, when we compare the CES and CD cases, the figure suggests that allowing for complementarity slightly increases the employment growth for the two sectors. In the case of non-retail, the growth increases by 16% (0.65 vs. 0.56) and in the case of retail by 70% (0.41 vs. 0.24). While these numbers could be small, this is partly explained because the service sector is already too big and initially employed more than 70% of the total workforce from Colombia, so the reallocation effects compared to the baseline are very low. Still, in absolute numbers, these slight increases represent around five thousand jobs reallocated to the service sector due to the substitutability between labor and intermediate inputs.

On the other hand, figure VIII shows the change in the labor share after ten years across sectors due to the trade liberalization episode in the case of the CES production function. The figure implies that the substitutability between labor and intermediate inputs can explain how trade can contribute to changes in the labor share at the aggregate and sectoral levels. For instance, the labor share for the service sectors increases by more than 0.2 p.p. due to the input liberalization shock. In contrast, firms within the manufacturing and primary sectors decline the labor share by more than 0.4 p.p. The more significant declines are in the machinery and basic metals sectors, which benefit more from access to new inputs, and in the agricultural sector, due to the high substitutability between labor and intermediate inputs in the primary sector. While our analysis focuses on a developing economy like Colombia, the substitutability or complementarity between labor intermediate inputs can be a potential explanation of how trade can contribute to the decline in the labor share in more advanced economies, such as the US, since trade can impact the labor share directly. Most explanations do not consider this mechanism and focus more on the rise of markups, concentration, and automation (see (Bergholt et al., 2022)).

Overall, the results suggest that trade may have a bigger impact on structural transformation and the labor share when we allow for a more flexible production function in which there is substitutability between labor and intermediate inputs. Trade tends to favor the service sector to the detriment of manufacturing and agriculture in a CES vs. a CD production function.

Effects on welfare: Table III reports the change in welfare due to the shock; this measure corresponds to the net present value of the equivalent variation, taking into account changes in the outside option. We compute a simple and weighted average using the initial employment in each location-sector pair as weights to aggregate welfare. Overall, the trade liberalization shock generated positive gains for the Colombian economy. The 1-digit sector that gains the most corresponds to the agricultural sectors; workers that are initially employed in this sector experience gains of around 0.4%. On the other hand, because of the liberalization episode, the service sector experience gains between 0.24% and 0.25%. Finally, while workers in the manufacturing sector experience some gains, these gains are much lower than the rest of the economy since they were directly affected by the shock, especially in the CES case where the gains are only 0.12%.

The CES and CD cases yield similar welfare gains for the average Colombian worker, but the effects vary significantly across 1-digit sectors. Comparing the CES to the CD case highlights the role of substitutability or complementarity between labor and intermediate inputs in shaping welfare outcomes. These mechanisms disproportionately affect workers in the manufacturing sector, with smaller effects observed for workers in the services and primary sectors. For instance, in the service sector, workers experience a slight increase in welfare gains under CES compared to CD. The average welfare gain in services rises from 0.24% under CD to 0.25% under CES. In contrast, the primary sector sees a decline in gains: the average worker's welfare improves by 0.42% under CD but drops to 0.35% under CES, representing a reduction of approximately 16%. The impact is even more pronounced in the manufacturing sector, where the average worker's welfare gain decreases from 0.20% under CD to 0.12% under CES—a decline exceeding 40%. These results suggest that the substitutability mechanism slightly enhances welfare gains for service sector workers but significantly reduces gains for workers in manufacturing, underscoring the sectoral heterogeneity in how labor and intermediate input complementarities influence welfare outcomes.

We also examine the effects of the trade shock across 2-digit industries. Figure VI illustrates the average welfare gains for workers in these industries. 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 when we allow for a more flexible production function. For instance, in industries such as vehicles, machinery, and wood products, welfare gains drop significantly—from 0.2% under CD to less than 0.1% under CES. Similar declines are observed in other sectors, such as chemicals and metals, where gains also decrease noticeably under the CES framework. In contrast, the substitutability mechanism has a negligible effect on workers in the service sector. Under CES, the welfare gains in services increase only slightly, suggesting limited sensitivity to the production flexibility in these industries. These findings highlight the substantial heterogeneity in the impact of production flexibility, with manufacturing industries experiencing larger declines in welfare.

Figure VII illustrates the spatial distribution of welfare gains from trade liberalization across regions. On average, welfare gains are similar under the CES and CD cases, but there are some significant regional differences that emerge. Regions with a higher concentration of manufacturing workers, such as Antioquia, Cundinamarca, and Valle, experience smaller gains under the CES framework compared to the CD case. In contrast, regions where manufacturing is less prevalent, such as Nariño and Caquetá, see relatively larger gains under CES. Overall, larger regions and areas with ports closer to international markets benefit the most from the liberalization. For instance, coastal regions in the north, such as Atlántico, La Guajira, and Bolívar, experience the largest gains. Meanwhile, interior regions like Caldas and Risaralda see smaller gains. Additionally, some of the poorer regions in the country, such as Chocó and Cauca, experience relatively low gains due to their limited market access to international trade.

These results reveal substantial heterogeneity across industries within the same region. Comparing the effects of the trade liberalization episode under CES and CD production functions shows that some workers experience significantly greater losses under the CES framework. For instance, in the wood industry, workers in interior regions such as Risaralda, Valle, and Antioquia see substantial declines in welfare gains under CES compared to CD. In Valle, gains drop from 0.18% with a CD production function to 0.05% with CES. Similar patterns emerge in other industries: workers in the textile industry in some regions face increased losses, while gains in the machinery industry decline by more than 50% in regions like Atlántico, Antioquia, and Bolívar under CES relative to CD.

These findings highlight that while the substitutability or complementarity mechanism has a limited impact on average welfare gains, certain industries and locations are disproportionately affected. A more flexible production function that accounts for varying degrees of substitutability or complementarity between labor and intermediate inputs can significantly alter the distributional effects of trade liberalization across regions and industries.

7. Conclusion

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

On the empirical side, we use exogenous tariff reductions in Colombia, which lowered the prices of foreign inputs and increased import competition from the United States. Using a differences-in-differences framework, we estimate the causal effects of these trade shocks, distinguishing between competition and input channels. Robustness checks, including event studies and validation against biases from treatment timing (Callaway and Sant'Anna, 2021; de Chaisemartin and D'Haultfœuille, 2020; Goodman-Bacon, 2021; Sun and Abraham, 2020), support the reliability of our results.

Our reduced-form results show that import competition reduces employment, while foreign inputs increase both total employment and wage bills. However, these effects vary significantly across sectors. Employment growth driven by foreign inputs is concentrated in the service sector, while it is less pronounced in manufacturing and even negative in agriculture. These results are consistent with a mechanism where marginal cost reductions expand labor demand but are offset by a substitutability channel between labor and intermediate inputs. Additionally, the competition shock primarily affects manufacturing, with smaller impacts on the primary sector.

Based on these reduced-form findings, we calibrate a dynamic quantitative model that incorporates sector-specific substitutability between labor and intermediate inputs. We calibrate the elasticity of substitution between labor and intermediate inputs, matching our reduced-form coefficients. We find elasticities in which labor and intermediate inputs are substitutes in the agricultural and manufacturing sectors and complement in the service sector.

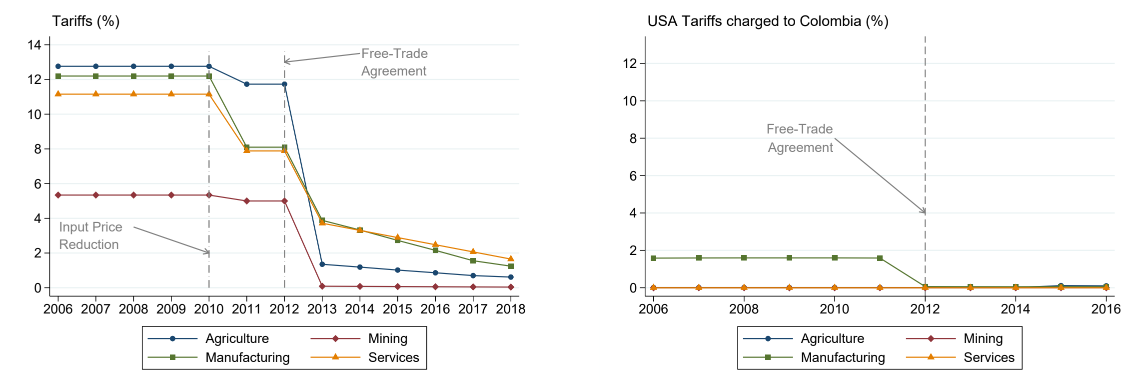
We then simulate a counterfactual scenario, changing the tariff paths before the trade liberalization. The results suggest that this mechanism significantly affects structural transformation by reallocating more workers toward the service sector and fewer toward manufacturing and agriculture. Regarding welfare, the average Colombian worker experiences minimal changes, but industries with high intermediate input shares—such as machinery, vehicles, and chemicals—experience welfare declines of more than 40% when this mechanism is included.

These findings highlight the importance of accounting for flexible production structures when analyzing the effects of trade. While trade can generate similar aggregate benefits under a more flexible production function, its sectoral impacts may be significantly more negative for specific groups of workers when labor and intermediate inputs can be substitutes or complements. It is essential to design policies to help these workers move to other sectors by reducing labor market frictions and moving costs to other sectors or regions.

Figures and Tables

Figure I
Tariffs Charged by Country

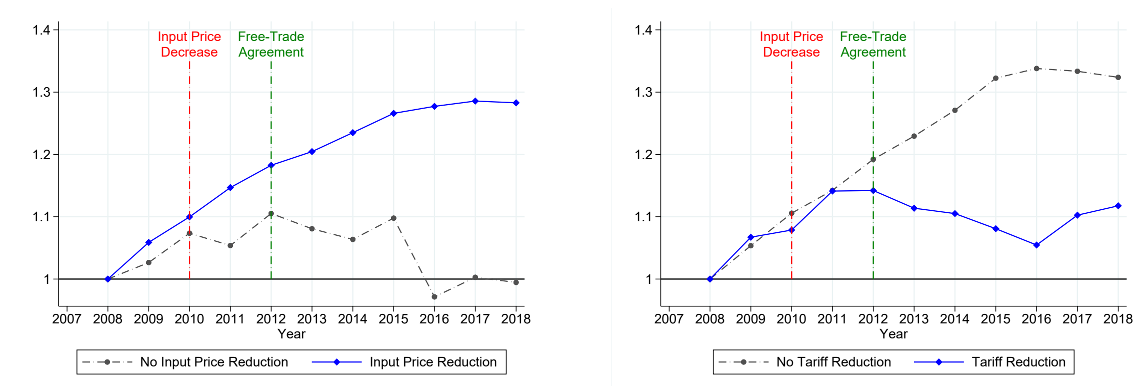
(a) Colombia **(b)** United States



Notes: These graphs display 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 II
Evolution of Employment

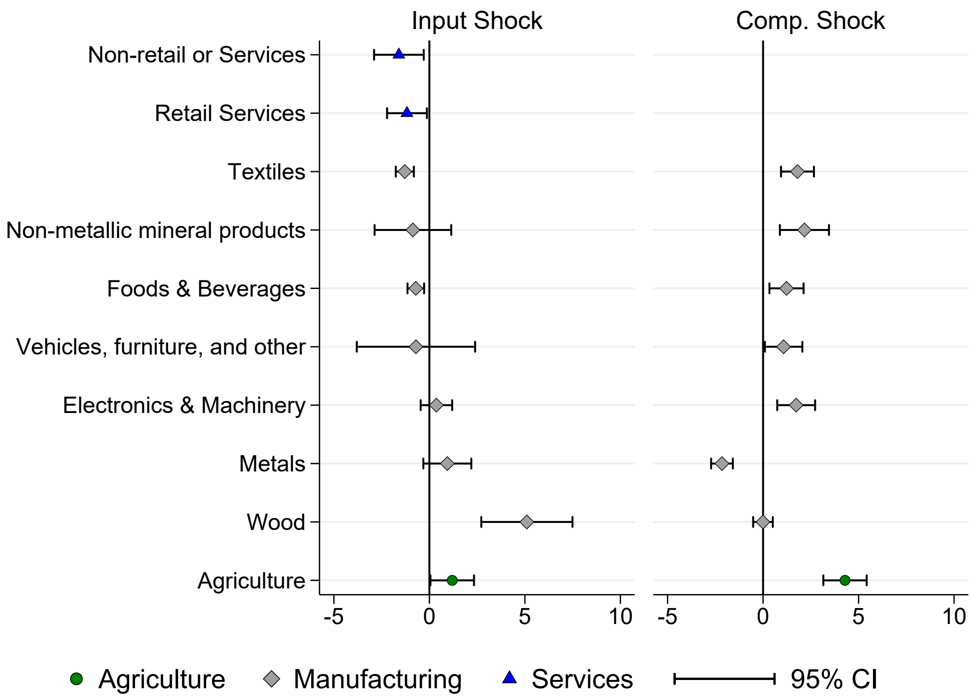
(a) By Sectors that Changed Foreign Input Prices **(b)** By Sectors that Changed Tariffs



Notes: These graphs present the evolution of total employment with respect to 2008 using Colombian household survey data from 2008 to 2018. Panel IIb splits by industries that did and did not reduce tariffs. Panel IIa splits by industries that did and did not reduce the price of inputs. We compute total employment as the weighted sum of all employed individuals using survey weights.

Figure III

Effects of Input and Competition Shocks by Sectors on Wage Bill

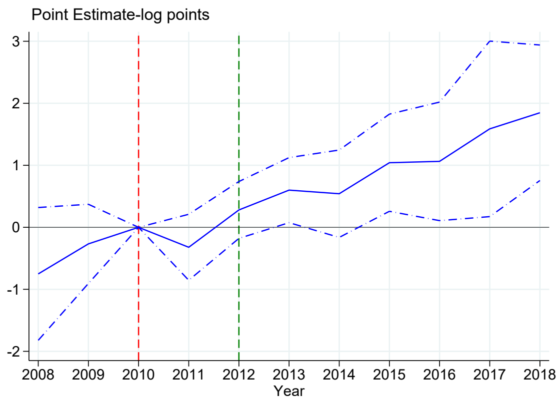


Notes: This figure presents the point estimates of Equation 4.3 interacting the input and competition shocks with dummy variables for the sectors detailed in the y-axis. Input and competition shocks are not multiplied by the shares of imports and sales. Plotted intervals correspond to the 95 percent confidence level.

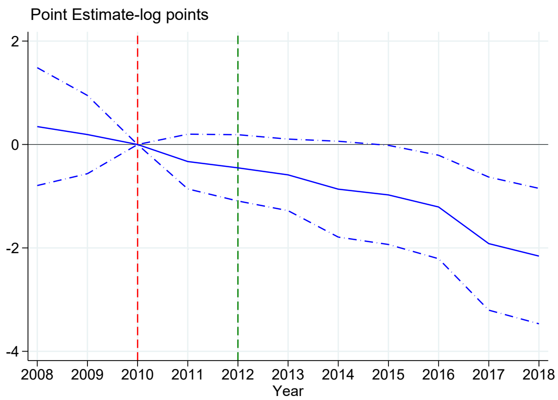
Figure IV

Event Study Estimates of Input and Competition Shocks on Wage bill

(a) Competition Shock

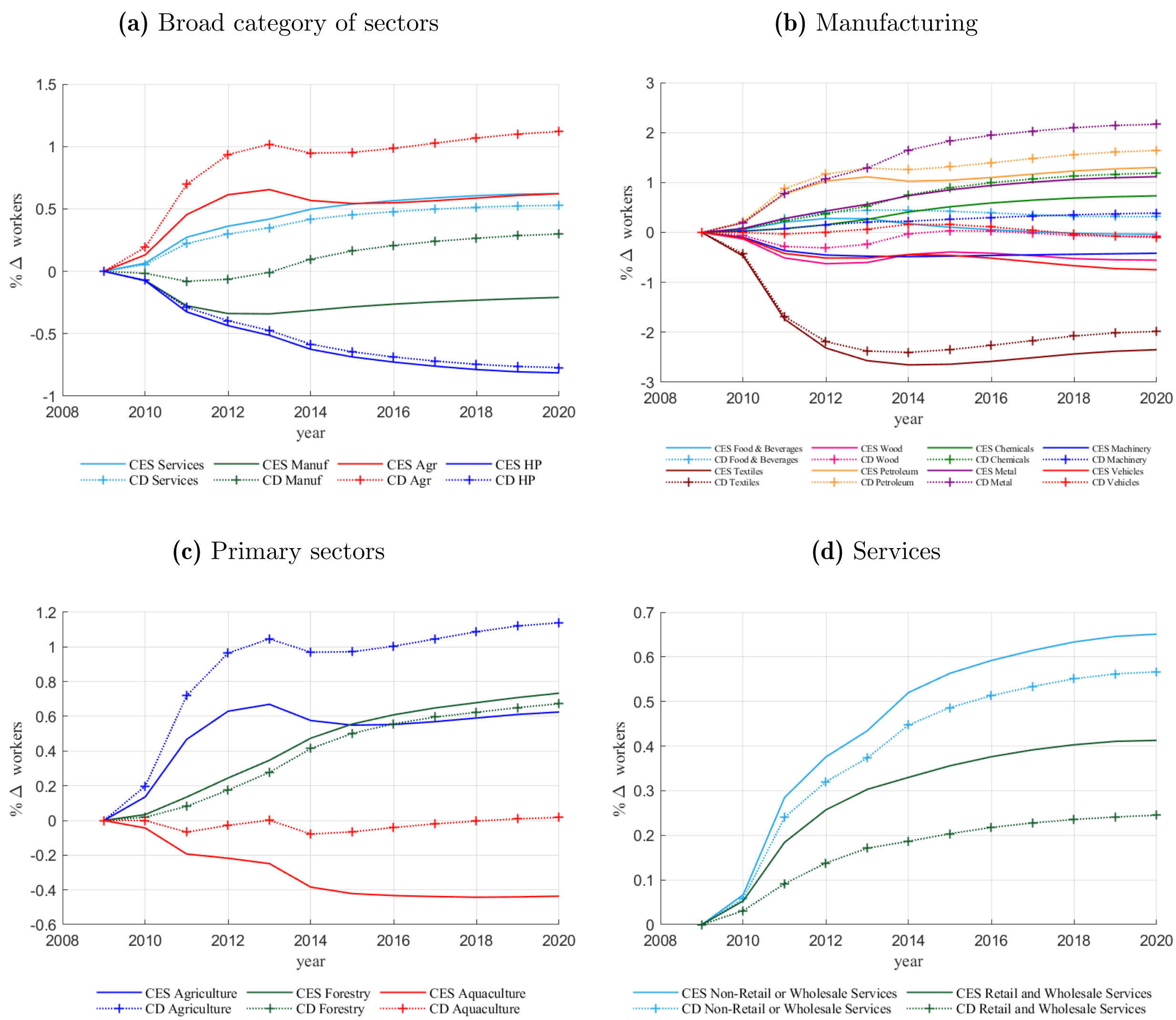


(b) Input Shock



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

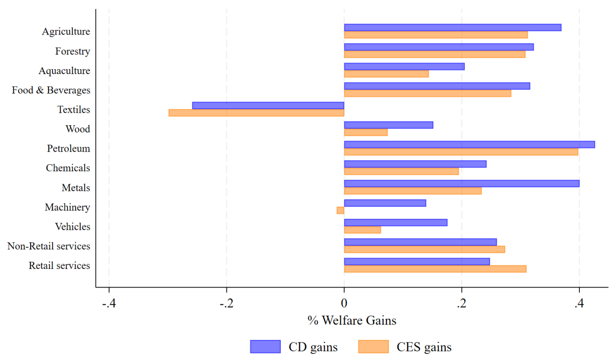
Figure V
Effects on Employment by sector



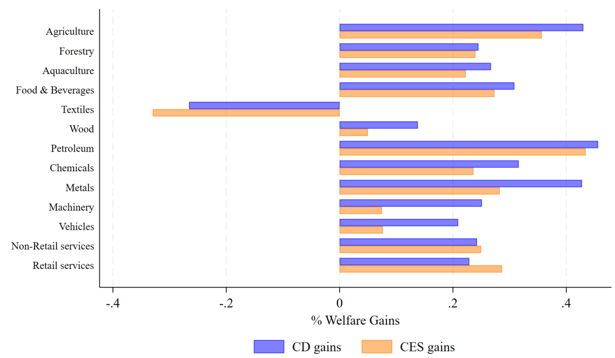
Notes: These figures plot the percentage change in total employment of the trade liberalization episode by industry from the model. Panel a shows the results for the aggregate category of sectors, panel b for the service sector, panel c for the manufacturing sector and panel d for the primary sector.

Figure VI

Welfare Gains from the Trade Liberalization by Sector



(a) Welfare gains: simple average

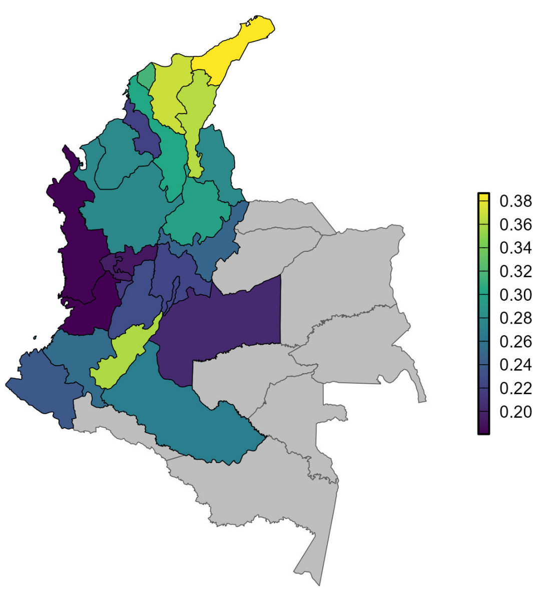


(b) Welfare gains: weighted average

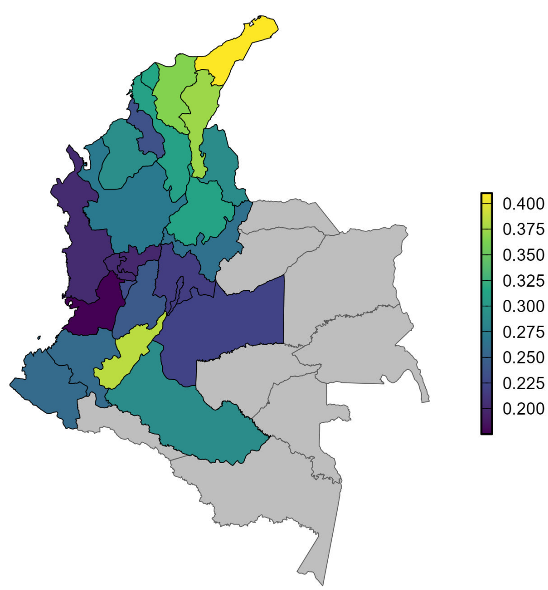
Notes: These figures plot the average change in welfare across states for each sector in the economy. Panel a plots the welfare gains using a simple average, while panel b computes a weighted average using as weights the initial sectoral employment.

Figure VII

Spatial Distribution of the Gains from Trade



(a) Cobb-Douglass production function

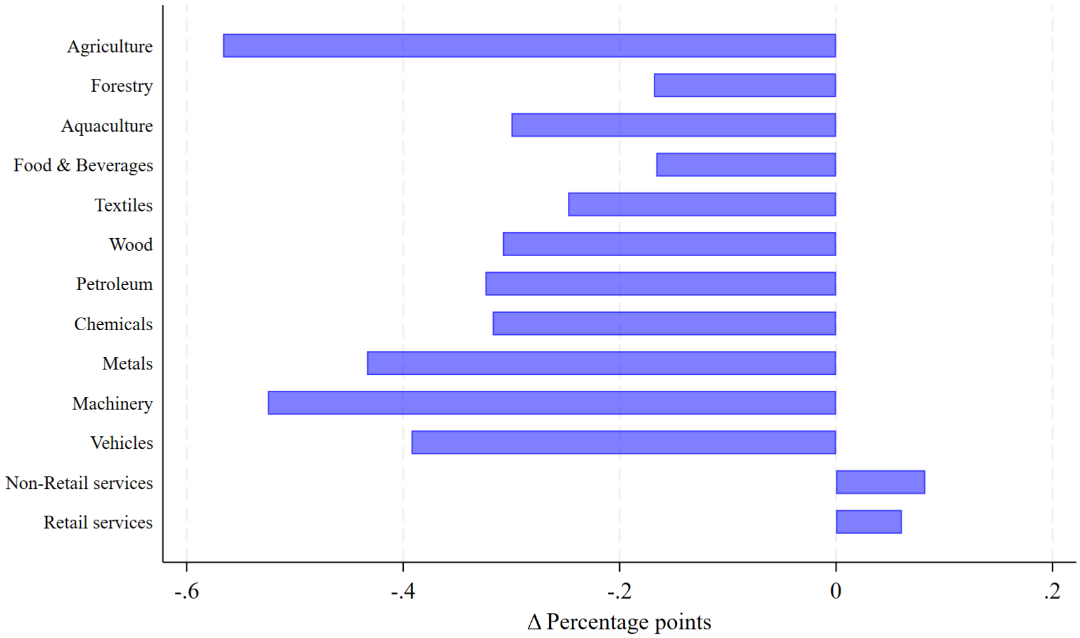


(b) CES production function

Notes: This figure plots a map of the average welfare gain across states in Colombia. Panel a plots the results for the Cobb-Douglass case and panel b for the CES case.

Figure VIII

Average Δ labor share by industry



Notes: This figure plots the average change in welfare across states for each sector in the economy. Panel a plots the welfare gains using a simple average, while panel b computes a weighted average using as weights the initial sectoral employment.

Table I
Tariff Reduction on Imports

	Log(Total Imports)		U.S. Imports (%)		Non-U.S. Imports (%)	
	(1)	(2)	(3)	(4)	(5)	(6)
A) All Imports						
Comp. Shock	-1.415***		-0.994***		0.280***	
	(0.208)		(0.205)		(0.066)	
Comp. $\text{Shock}_{t \in \{2010,2012\}}$		-1.346***		-0.620***		0.217**
		(0.280)		(0.238)		(0.092)
Comp. $\text{Shock}_{t \in \{2013,2018\}}$		-1.425***		-1.068***		0.288***
		(0.226)		(0.228)		(0.070)
Observations	69987	69987	79956	79956	79956	79956
B) Imported Inputs						
Comp. Shock	-1.428***		-0.848***		0.303***	
	(0.205)		(0.203)		(0.060)	
Comp. $\text{Shock}_{t \in \{2010,2012\}}$		-1.456***		-0.482**		0.210**
		(0.263)		(0.229)		(0.082)
Comp. $\text{Shock}_{t \in \{2013,2018\}}$		-1.424***		-0.929***		0.315***
		(0.223)		(0.229)		(0.065)
Observations	67125	67125	71496	71496	71496	71496
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table presents the results of estimating Equation 5.1 using imports as an outcome at the 10-digit product-by-year level. We are unable to compute the input shock at the product level due to the nonexistence of an input-output matrix at such level. Imported inputs correspond to the products imported by Colombian firms in 2008. Columns (1) and (2) use the log of total imports, columns (3) and (4) use the percentage of imports from the U.S, and columns (5) and (6) the percentage of non-U.S. imports. Specifications using logarithmic outcomes correspond to least squares estimates. Specifications using percentages as outcomes are estimated using poisson regression. Odd columns present the linear effect. Even columns split the effect before and after 2012 by interacting the import competition measure with a dummy variable that takes a value of one for 2011 and 2012, and a dummy variable that takes the value of one for years after 2012. Standard errors clustered at the product level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table II

Input and Competition Shocks on Wage Bill

	OLS			IV		
	(1)	(2)	(3)	(4)	(5)	(6)
A) All Sectors						
Input Shock	-1.276*	-2.107**	-1.673**	-4.073**	-4.368**	-4.677**
	(0.654)	(0.968)	(0.703)	(1.483)	(1.687)	(1.804)
Comp. Shock	2.995***	2.972***	2.989***	3.473**	3.460**	3.450**
	(0.899)	(0.854)	(0.839)	(1.366)	(1.369)	(1.377)
F-Stat First Stage				153.1	162.1	155.1
B) By Industry						
Input shock × 1(Agric.)	2.875***	2.302*	2.214*	-0.721	-0.805	-1.148
	(1.015)	(1.147)	(1.196)	(3.644)	(4.283)	(4.263)
Input shock × 1(Manuf.)	-0.605	-1.650	-1.571	1.861	0.535	-1.154
	(1.273)	(1.721)	(1.644)	(3.638)	(4.907)	(4.727)
Input shock × 1(Serv.)	-2.164*	-2.600*	-2.531*	-5.369***	-4.897***	-5.997***
	(1.091)	(1.506)	(1.274)	(1.405)	(1.425)	(1.496)
Comp. shock × 1(Agric.)	4.853***	4.608***	4.783***	6.520*	6.210	6.387
	(0.617)	(0.538)	(0.546)	(3.800)	(3.876)	(3.868)
Comp. shock × 1(Manuf.)	1.442***	1.583***	1.593***	0.069	0.649	0.699
	(0.421)	(0.465)	(0.477)	(1.155)	(1.417)	(1.319)
F-Stat First Stage				120.4	127.5	126.6
Observations	53,177	53,177	53,177	53,177	53,177	53,177
State-Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
State-Year FE	Yes			Yes		Yes
Year FE		Yes	Yes		Yes	
Baseline Controls			Yes			Yes

Notes: This table presents the results of estimating Equation 4.3 using the wage bill as outcome. Estimations performed in a panel at the industry-state-year level. Columns (1)-(3) are estimated using ordinary least squares, whereas columns (4)-(6) present IV estimates using the tariff initial values interacted with exchange rates 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, and the share of female workers in each state, all interacted with year fixed effects. Estimations are weighted by employment per industry and state 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 state level. *** p<0.01, ** p<0.05, * p<0.1

Table III

Welfare Gains: Trade Liberalization Shock

	Cobb-Douglas production function				CES production function				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
A) Welfare Gains-Weighted average	Mean	sd	Min	Max	Mean	sd	Min	Max	Obs
All industries	0.245	0.109	-0.800	1.355	0.245	0.108	-0.856	0.980	312
Primary sector	0.424	0.129	-0.033	1.113	0.353	0.101	-0.093	0.980	72
Manufacturing	0.201	0.271	-0.800	1.355	0.121	0.260	-0.856	0.782	192
Services	0.241	0.043	0.154	0.379	0.254	0.048	0.176	0.448	48
B) Welfare Gains-Simple average	Mean	sd	Min	Max	Mean	sd	Min	Max	Obs
All industries	0.231	0.242	-0.800	1.355	0.176	0.229	-0.856	0.980	312
Primary sector	0.299	0.180	-0.033	1.113	0.255	0.163	-0.093	0.980	72
Manufacturing	0.199	0.282	-0.800	1.355	0.117	0.256	-0.856	0.782	192
Services	0.254	0.056	0.154	0.379	0.292	0.061	0.176	0.448	48

Notes: This table reports the average welfare gains of the trade liberalization episode across industries and states in Colombia. Panel A reports the results using a weighted average in which the weights correspond to the initial employment, and panel B, the simple average. 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.

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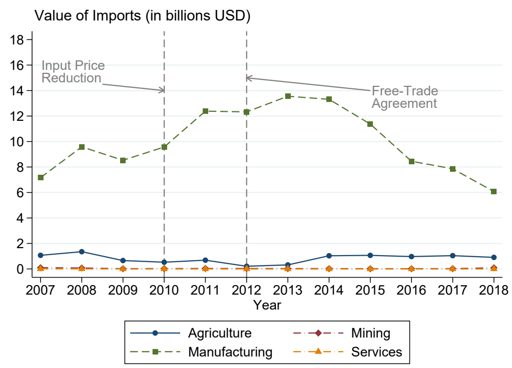
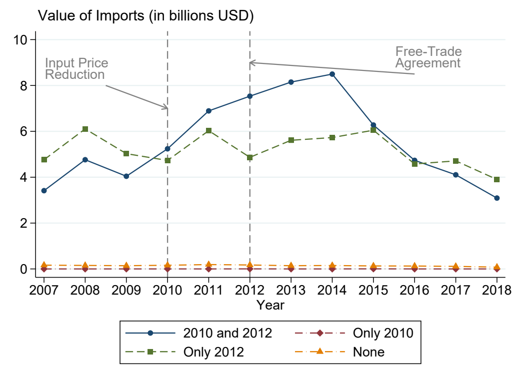
A. Appendix Figures and Tables

Appendix Figure A.1
Colombian Imports from the United States

(a) By Economic Sector



(b) By year of Tariff Reduction

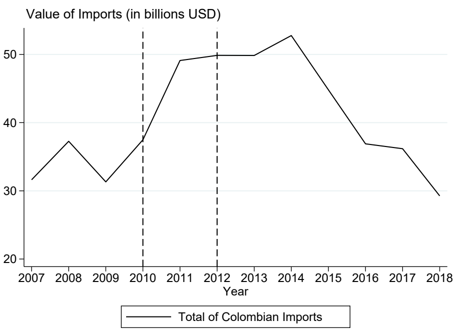


Notes: This graph plots the value of imports in billions USD. Panel A.1a plots the evolution of Colombian imports from the United States by industry. Panel A.1b plots the evolution of Colombian imports from the United States by the year in which the product's tariff was decreased. Vertical gray lines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

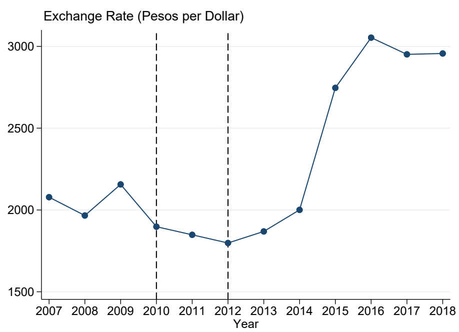
Appendix Figure A.2

Macroeconomic Environment

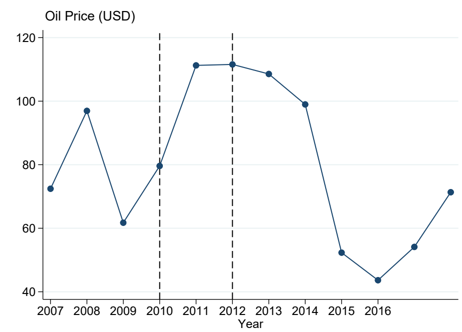
(a) Total Imports



(b) Exchange Rates

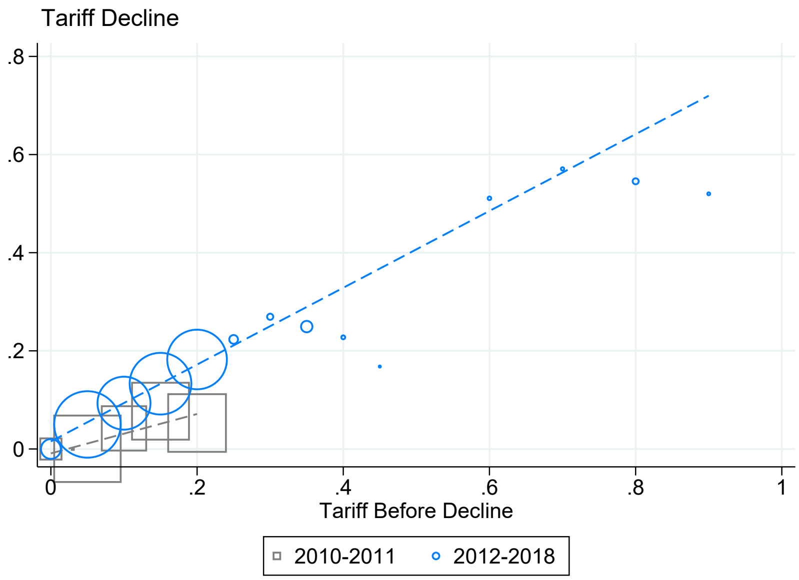


(c) Oil Prices



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
Tariff Reductions on Imports from the United States

(a) Products that Liberalized in 2010 and 2012

(b) Products that Liberalized only 2012

Notes: $N = 84,460$. These figures use log imports from the United States as outcome. Estimations performed in a panel at the product 10-digit-year level. Both estimations are performed jointly but presented separately. Excluded category corresponds to products that did not reduce tariffs. Plotted intervals correspond to the 95 percent confidence level, and standard errors clustered at the product level.

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

Appendix Table A.2

Descriptive Statistics Across Samples

	Count (1)	Mean (2)	S.D. (3)	Min. (4)	Max. (5)
A) Trade Data (10-Digit product)					
Comp. Shock	79,956	-0.05	0.06	-0.59	0.00
1(Ind. Decreased Tariffs)	79,956	0.98	0.15	0.00	1.00
1(Decreased in 2010 and 2012)	79,956	0.56	0.50	0.00	1.00
1(Decreased in 2012)	79,956	0.42	0.49	0.00	1.00
Log(value imports total)	69,987	13.25	2.73	-1.71	22.02
Log(value imports USA)	56,441	11.37	2.95	-2.53	22.02
Log(value imports AllOther)	68,286	12.99	2.73	-2.53	21.23
Perc. value imports USA	79,956	19.10	27.50	0.00	100.00
Perc. value imports AllOther	79,956	68.43	37.03	0.00	100.00
B) Employment Data (4-Digit Industry-state)					
Input Shock	66,759	-0.01	0.02	-0.14	0.00
Comp. Shock	66,759	-0.02	0.04	-0.18	0.00
Log(1+ q)	66,759	0.02	0.05	0.00	0.68
Log(1+ τ)	66,759	0.02	0.05	0.00	0.47
Log(Wagebill)	53,371	21.63	2.00	10.32	28.07
Log(Wagebill Low-Skilled)	47,997	21.19	1.91	8.22	27.49
Log(Wagebill High-Skilled)	42,996	21.10	1.90	10.32	28.00
Log(Wagebill Social Security)	61,125	18.86	2.36	0.69	28.08
1(Agriculture)	66,759	0.07	0.25	0.00	1.00
1(Manufacturing)	66,759	0.32	0.47	0.00	1.00
1(Services)	66,759	0.39	0.49	0.00	1.00
1(Retail)	66,759	0.22	0.41	0.00	1.00

Notes: This table presents descriptive statistics of the different samples used. Panel A) describes the panel at the product-year level. Panel B) describes the panel at the industry-state-year level. 1() stands for a dummy variable that takes the value of one if the condition inside parentheses is met.

Appendix Table A.3

Descriptive Statistics - Variables for model calibration

Industry	Count (1)	Mean (2)	S.D. (3)	Min. (4)	Max. (5)
A) Labor share $\phi_{t_0}^{nj}$					
Agriculture	72	0.652	0.091	0.237	0.760
Manufacturing	192	0.403	0.105	0.109	0.940
Services	48	0.575	0.025	0.515	0.608
All	312	0.487	0.144	0.109	0.940
B) Exposure to the input shock: $\vartheta = \sum_{i=1}^{N} \psi^{ij,nj}(1 - \pi^{ij,nj})$					
Agriculture	72	0.809	0.108	0.497	0.995
Manufacturing	192	0.913	0.060	0.734	1.000
Services	48	0.502	0.138	0.327	0.887
All	312	0.826	0.170	0.327	1.000

Notes: This table presents descriptive statistics of the variables that we compute to solve equation 6.2 to calibrate the elasticity of substitution between labor and intermediate inputs by 1-digit industries. Panel A reports the descriptive statistics for the labor share ϕ^{nj} and Panel B for the variable: $\vartheta = \sum_{i=1}^{N} \psi^{ij,nj}(1 - \pi^{ij,nj})$

Appendix Table A.4

Tariff Reduction on Imports using Inverse Hyperbolic Sine

	Total		*U.S. Imports*		*Non U.S. Imports*	
	(1)	(2)	(3)	(4)	(5)	(6)
A) All Imports						
Comp. Shock	-1.974***		-1.782***		-0.902*	
	(0.534)		(0.568)		(0.528)	
Comp. Shock$_{t\in\{2010,2012\}}$		-1.759***		-2.947***		-1.178*
		(0.582)		(0.759)		(0.624)
Comp. Shock$_{t\in\{2013,2018\}}$		-2.001***		-1.634***		-0.866
		(0.577)		(0.610)		(0.567)
Observations	79956	79956	79956	79956	79956	79956
B) Imported Inputs						
Comp. Shock	-1.728***		-1.251**		-0.868	
	(0.549)		(0.615)		(0.557)	
Comp. Shock$_{t\in\{2010,2012\}}$		-1.579***		-2.273***		-1.188**
		(0.539)		(0.797)		(0.590)
Comp. Shock$_{t\in\{2013,2018\}}$		-1.749***		-1.111*		-0.824
		(0.596)		(0.662)		(0.603)
Observations	71496	71496	71496	71496	71496	71496
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table presents the results of estimating Equation 5.1 using the inverse hyperbolic sine (IHS) transformation of imports as an outcome at the 10-digit product-by-year level. We are unable to compute the input shock at the product level due to the nonexistence of an input-output matrix at such level. Imported inputs correspond to the products imported by Colombian firms in 2008, which constitute 71,592 10-digit codes. Columns (1) and (2) use the IHS of total imports, columns (3) and (4) use the IHS of imports from the U.S, and columns (5) and (6) the IHS of non-U.S imports. Odd columns present the linear effect, whereas even columns split the effect before and after 2012 by interacting the import competition measure with a dummy variable that takes a value of one for 2011 and 2012, and a dummy variable that takes the value of one for years after 2012. Standard errors clustered at the product level. *** p<0.01, ** p<0.05, * p<0.1

Appendix Table A.5

Tariff Reductions on U.S. Imports by Type of Product and Economic Sector

	Capital		*Consumption*		*Raw Materials*	
	(1)	(2)	(3)	(4)	(5)	(6)
A) Overall Products by Purpose						
Comp. Shock	-0.798		-1.502**		-0.817	
	(0.486)		(0.591)		(0.511)	
Comp. Shock$_{t\in\{2010,2012\}}$		-1.158**		-4.270**		-0.563
		(0.565)		(1.660)		(0.611)
Comp. Shock$_{t\in\{2013,2018\}}$		-0.649		-1.465**		-0.881
		(0.589)		(0.594)		(0.579)
Observations	17,191	17,191	12,710	12,710	26,244	26,244
B) Products Imported by Agricultural Firms						
Comp. Shock	-0.559		0.631		-1.313	
	(0.698)		(1.281)		(1.015)	
Comp. Shock$_{t\in\{2010,2012\}}$		-1.015		-5.386**		-1.206
		(0.774)		(2.698)		(0.899)
Comp. Shock$_{t\in\{2013,2018\}}$		-0.382		0.779		-1.358
		(0.864)		(1.302)		(1.398)
Observations	5,191	5,191	2,033	2,033	3,642	3,642
C) Products Imported by Manufacturing Firms						
Comp. Shock	-0.967**		-0.755		-0.702	
	(0.490)		(0.646)		(0.525)	
Comp. Shock$_{t\in\{2010,2012\}}$		-0.958*		-4.058**		-0.519
		(0.545)		(1.690)		(0.629)
Comp. Shock$_{t\in\{2013,2018\}}$		-0.970		-0.731		-0.747
		(0.600)		(0.648)		(0.596)
Observations	15,417	15,417	10,658	10,658	24,013	24,013
D) Products Imported by Services Firms						
Comp. Shock	-0.892*		-1.356**		-0.593	
	(0.484)		(0.613)		(0.520)	
Comp. Shock$_{t\in\{2010,2012\}}$		-1.391**		-4.338***		-0.533
		(0.553)		(1.667)		(0.616)
Comp. Shock$_{t\in\{2013,2018\}}$		-0.688		-1.324**		-0.608
		(0.590)		(0.615)		(0.589)
Observations	16,695	16,695	12,293	12,293	24,484	24,484
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table presents the results of estimating Equation 5.1 using imports from the United States as an outcome at the 10-digit product-by-year level, and splitting the sample in multiple subgroups. Columns (1) and (2) focus on capital (that also includes construction) goods, columns (3) and (4) on consumption goods, and columns (5) and (6) on raw materials. Panel A includes all products. Panel B focuses on products imported in 2008 by firms in agriculture. Panel C focuses on products imported in 2008 by firms in manufacturing, and panel D focuses on products imported in 2008 by firms in services. We identify these products using information about the imported products by firm in 2008. Odd columns present the linear effect, whereas even columns split the effect before and after 2012 by interacting the import competition measure with a dummy variable that takes a value of one for 2011 and 2012, and a dummy variable that takes the value of one for years after 2012. Standard errors clustered at the product level. *** p<0.01, ** p<0.05, * p<0.1

Appendix Table A.6

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)
A) All Sectors												
Input Shock	0.860	1.972**	1.215	-2.215	0.215	-1.483	-0.813	-1.906**	-1.342*	-2.884**	-4.367**	-3.730**
	(1.103)	(0.833)	(0.963)	(2.246)	(1.484)	(2.020)	(0.623)	(0.859)	(0.667)	(1.272)	(1.702)	(1.653)
Comp. Shock	2.434**	2.185**	2.243**	1.630	1.399	1.415	2.610***	2.611***	2.626***	3.361**	3.379**	3.348**
	(1.081)	(0.897)	(0.964)	(0.953)	(0.891)	(0.931)	(0.782)	(0.740)	(0.720)	(1.329)	(1.342)	(1.339)
F-Stat First Stage				125.6	130.1	125.9				149.4	158	151.4
B) By Industry												
Input shock × 1(Agric.)	5.924***	6.051***	5.871***	2.475	3.722	3.356	2.071**	1.662	1.601	-0.792	-1.220	-1.335
	(0.596)	(0.491)	(0.446)	(6.291)	(6.348)	(6.204)	(0.950)	(1.020)	(1.081)	(3.559)	(4.144)	(4.129)
Input shock × 1(Manuf.)	1.837	4.017***	2.280*	5.723**	8.897**	5.573	-0.451	-2.142	-1.777	2.571	-0.957	-0.892
	(1.181)	(1.255)	(1.108)	(2.678)	(3.692)	(3.606)	(1.848)	(2.242)	(2.276)	(4.899)	(5.685)	(5.960)
Input shock × 1(Serv.)	-0.270	1.225	0.119	-4.205**	-1.504	-3.537*	-1.392	-2.221*	-1.932*	-3.659**	-4.590***	-4.556***
	(1.047)	(1.062)	(1.064)	(1.782)	(1.769)	(1.915)	(0.980)	(1.230)	(1.062)	(1.343)	(1.417)	(1.423)
Comp. shock × 1(Agric.)	4.494***	3.402***	3.896***	0.733	-0.340	-0.054	4.260***	3.996***	4.127***	6.549	6.319	6.369
	(0.624)	(0.495)	(0.647)	(3.096)	(2.398)	(2.399)	(0.635)	(0.498)	(0.523)	(3.932)	(3.980)	(3.999)
Comp. shock × 1(Manuf.)	1.053*	0.868	0.938*	-1.417	-1.500	-1.274	1.389**	1.610**	1.627**	0.285	1.032	0.987
	(0.598)	(0.519)	(0.496)	(1.329)	(1.486)	(1.418)	(0.577)	(0.714)	(0.712)	(1.289)	(1.618)	(1.548)
F-Stat First Stage				115.4	125.5	119.2				118.2	125.2	124.3
Observations	42,538	42,538	42,538	42,538	42,538	42,538	47,699	47,699	47,699	47,699	47,699	47,699
State-Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State-Year FE	Yes			Yes		Yes	Yes			Yes		Yes
Year FE		Yes	Yes		Yes			Yes	Yes		Yes	
Baseline Controls			Yes			Yes			Yes			Yes

Notes: 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-state-year level. Columns (1)-(3) are estimated using ordinary least squares, whereas columns (4)-(6) present IV estimates using the tariff initial values interacted with exchange rates 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, and the share of female workers in each state, all interacted with year fixed effects. Estimations are weighted by employment per industry and state 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 state level. *** p<0.01, ** p<0.05, * p<0.1

Appendix Table A.7

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)
A) All Sectors									
Input Shock$_k$	-0.643	-1.503	-0.859	-2.956*	-3.718**	-3.440**	-3.355	-4.758	-3.692
	(0.872)	(1.214)	(0.945)	(1.531)	(1.649)	(1.594)	(3.570)	(3.725)	(3.834)
Comp. Shock	2.762**	2.679**	2.719**	2.798**	2.755**	2.761**	3.066**	3.132**	3.055**
	(1.033)	(1.060)	(1.050)	(1.011)	(1.024)	(1.025)	(1.121)	(1.157)	(1.160)
F-Stat First Stage	69.14	71.19	69.30	68.08	62.58	65.06	43.53	45.43	44.65
B) By Industry									
Input shock × 1(Agric.)	0.333	-0.233	-0.349	2.271	1.803	1.550	4.211	4.697	5.572
	(2.430)	(2.622)	(2.639)	(3.205)	(3.377)	(3.507)	(18.451)	(19.781)	(18.916)
Input shock × 1(Manuf.)	2.749	2.135	2.763*	-7.925	-9.831	-9.708*	-2.353	-4.085	-3.633
	(1.718)	(1.714)	(1.577)	(5.128)	(6.303)	(5.511)	(2.553)	(3.302)	(2.815)
Input shock × 1(Serv.)	-1.384	-1.892	-1.603	-3.771**	-3.941**	-4.128**	-3.879	-4.777*	-4.284*
	(1.089)	(1.319)	(1.087)	(1.657)	(1.777)	(1.696)	(2.468)	(2.608)	(2.421)
Comp. shock × 1(Agric.)	7.483**	7.233**	7.373**	7.122**	6.858**	7.024**	7.447**	7.148**	7.225**
	(3.242)	(3.233)	(3.220)	(3.332)	(3.304)	(3.316)	(3.330)	(3.416)	(3.391)
Comp. shock × 1(Manuf.)	1.649**	1.593*	1.561**	2.252**	2.383**	2.298**	2.228**	2.429**	2.350**
	(0.795)	(0.789)	(0.754)	(1.037)	(1.106)	(1.014)	(0.971)	(1.043)	(0.935)
F-Stat First Stage	311.6	189.6	201.8	67.63	96.08	68.69	139.9	80.72	93.75
Observations	53,177	53,177	53,177	53,177	53,177	53,177	53,177	53,177	53,177
State-Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State-Year FE	Yes		Yes	Yes		Yes	Yes		Yes
Year FE		Yes			Yes			Yes	
Baseline Controls			Yes			Yes			Yes

Notes: 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-state-year level. Columns (1)-(3) are estimated using the input shock only for capital goods, columns (4)-(6) use the input shock only for consumption goods, and columns (7)-(9) 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, and the share of female workers in each state, all interacted with year fixed effects. Estimations are weighted by employment per industry and state 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 state level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

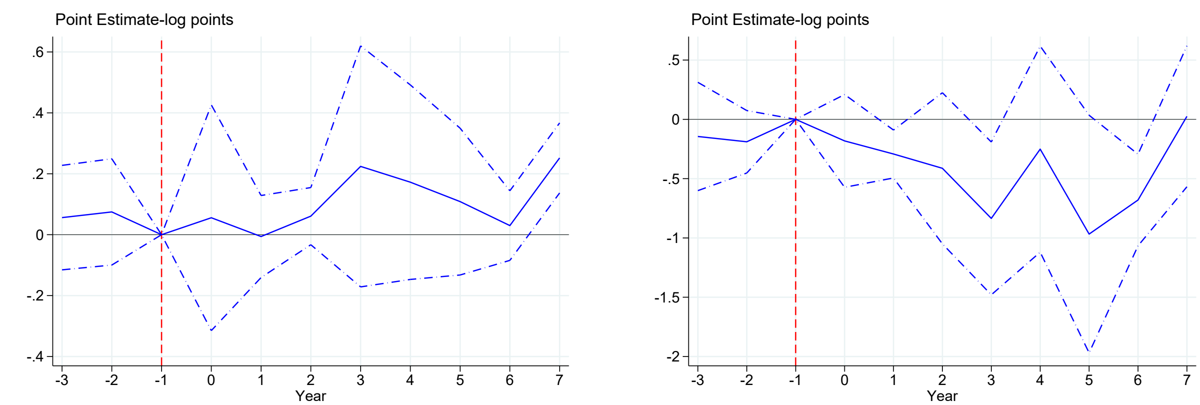
B. Robustness of Event Study

We complement our analysis using the bias-corrected estimator for inter-temporal treatment effects in de Chaisemartin and D'Haultfoeuille (2021) in Appendix Figure B.1, and estimate the event-study specification described in Equation (4.4) using different data sources (Appendix Figure B.2 and alternative estimation methods (Appendix Figure B.3). Furthermore, we present event study estimates by agriculture, manufacturing, and services in Appendix Figures B.4 and B.5.

Appendix Figure B.1

Competition and Inputs shocks Correcting for Heterogeneity

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

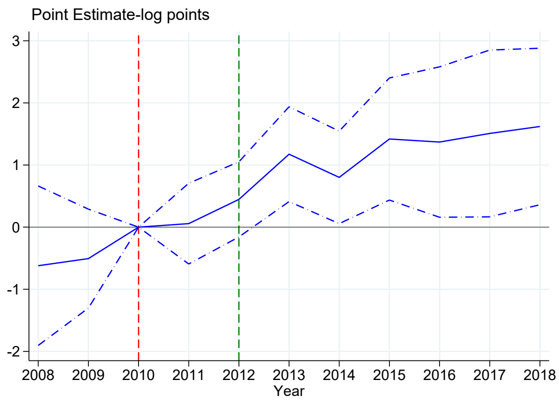


Notes: These figures plot the event study specification at the industry level for the competition shock. Plotted intervals correspond to the 95 percent confidence level.

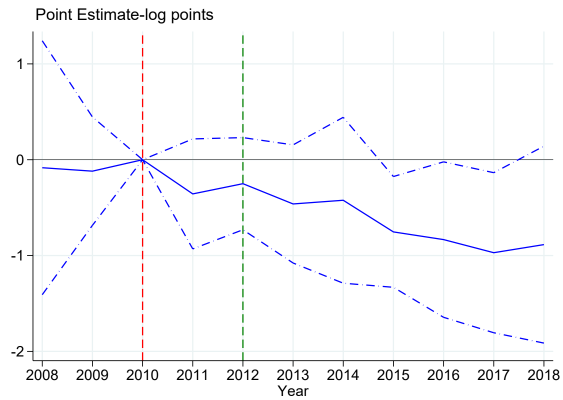
Appendix Figure B.2

Robustness of the Effect using Different Data Sources

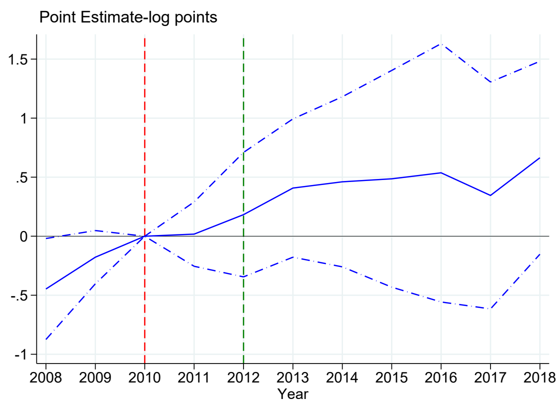
(a) Comp. Shock at the Industry-State-Year Level



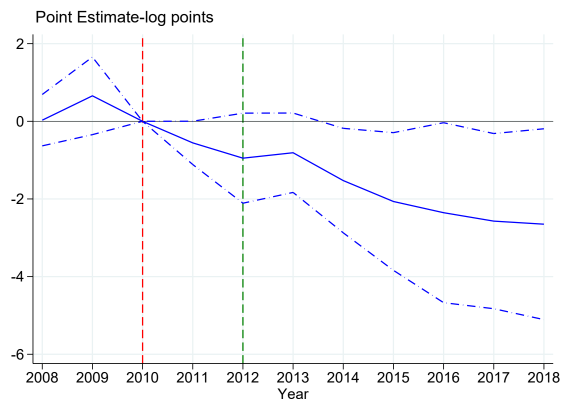
(b) Input Shock at the Industry-State-Year Level



(c) Comp. Shock Using Social Security Records



(d) Input Shock Using Social Security Records

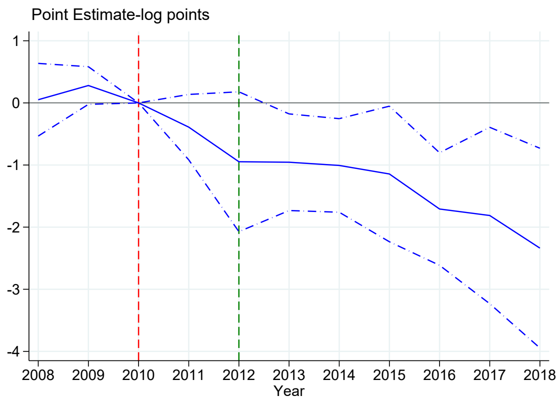


Notes: These figures plot the event study specification in Equation 4.4 for the competition and input shock. Point estimates obtained using the industry-state-year level are plotted in panel B.2a and B.2b. Point estimates obtained using the social security records are plotted in panel B.2c and B.2d. Plotted intervals correspond to the 95 percent confidence level.

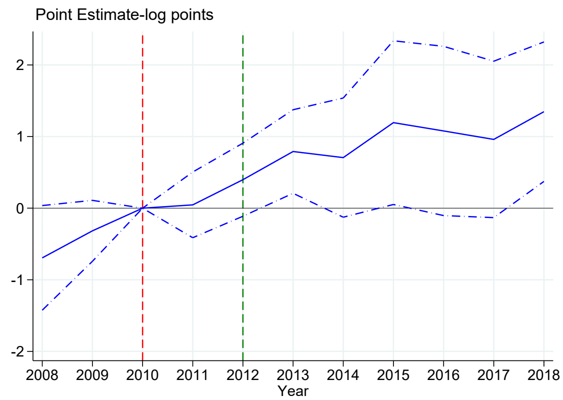
Appendix Figure B.3

Robustness of the Effects Using Poisson Regression

(a) Input Shock



(b) Competition Shock Using Poisson Regression

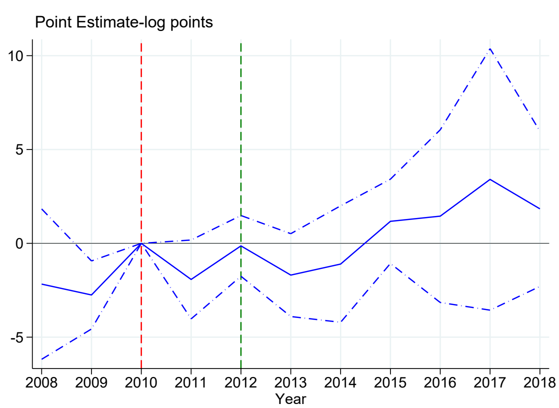


Notes: These figures plot the event study specification at the industry level for the competition shock. Estimation performed using Poisson regression. Plotted intervals correspond to the 95 percent confidence level.

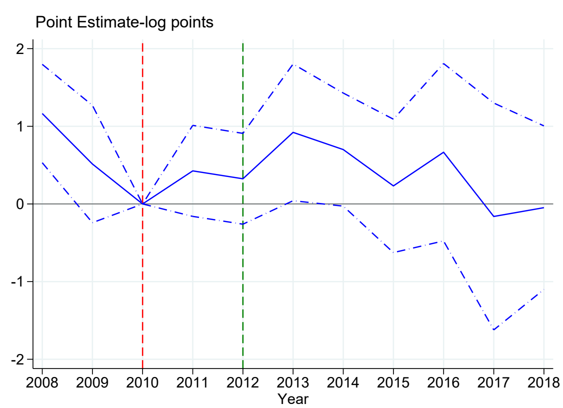
Appendix Figure B.4

Competition shock on Wage bill by Sector

(a) Agriculture



(b) Manufacturing

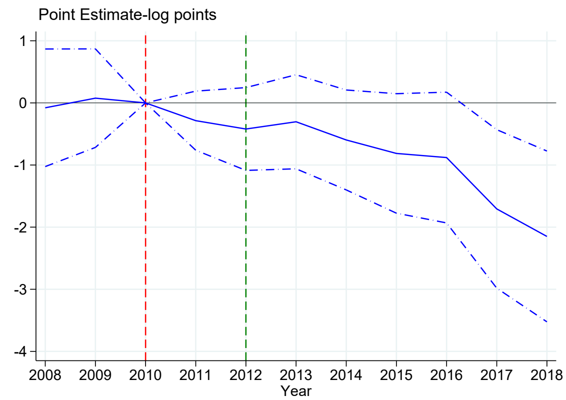


Notes: These figures plot the event study specification at the industry level for the competition shock. Plotted intervals correspond to the 95 percent confidence level.

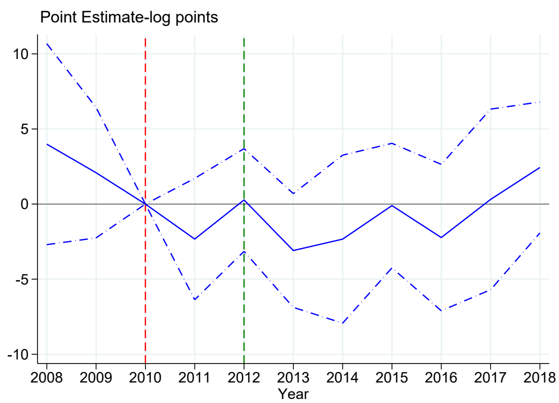
Appendix Figure B.5

Input shock on Wage Bill By Sector

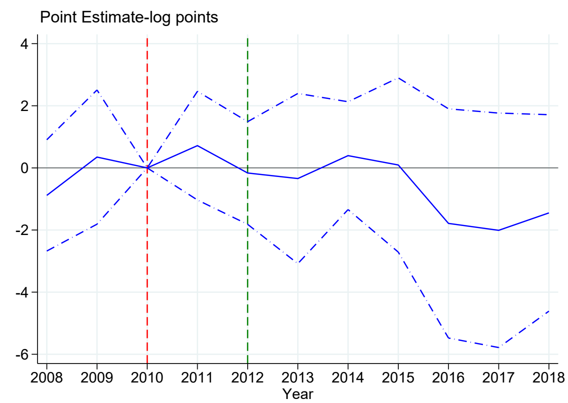
(a) Services



(b) Agriculture



(c) Manufacturing



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.

C. Robustness of Main Specification

Appendix Table C.1
Input and Competition Shocks on Wage Bill without Accounting by the Shares of Import and Sales

	OLS			IV		
	(1)	(2)	(3)	(4)	(5)	(6)
A) All Sectors						
DT$_i$*nput*2	-1.065***	-1.350***	-1.196***	-1.473***	-1.715**	-1.735**
	(0.248)	(0.435)	(0.288)	(0.519)	(0.661)	(0.633)
Comp. Shock	2.788***	2.810***	2.786***	3.260**	3.280**	3.271**
	(0.768)	(0.746)	(0.718)	(1.252)	(1.269)	(1.265)
F-Stat First Stage				246.1	242.8	263.3
B) By Industry						
Input shock × 1(Agric.)	1.190**	0.972	0.953	-0.391	-0.524	-0.623
	(0.545)	(0.637)	(0.650)	(1.801)	(2.079)	(2.077)
Input shock × 1(Manuf.)	-0.489	-0.947	-0.940	0.976	0.182	-0.208
	(0.444)	(0.620)	(0.575)	(1.429)	(1.907)	(1.826)
Input shock × 1(Serv.)	-1.406***	-1.531**	-1.530***	-1.868***	-1.847***	-2.108***
	(0.431)	(0.650)	(0.533)	(0.510)	(0.566)	(0.543)
Comp. shock × 1(Agric.)	4.272***	4.113***	4.204***	6.359*	6.119	6.273
	(0.541)	(0.453)	(0.478)	(3.675)	(3.784)	(3.779)
Comp. shock × 1(Manuf.)	1.268***	1.492***	1.478***	0.179	0.757	0.803
	(0.435)	(0.482)	(0.488)	(1.054)	(1.305)	(1.224)
F-Stat First Stage				195.4	184.1	192.8
Observations	53,177	53,177	53,177	53,177	53,177	53,177
State-Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
State-Year FE	Yes			Yes		Yes
Year FE		Yes	Yes		Yes	
Baseline Controls			Yes			Yes

Notes: 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-state-year level. Columns (1)-(3) are estimated using ordinary least squares, whereas columns (4)-(6) present IV estimates using the tariff initial values interacted with exchange rates 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, and the share of female workers in each state, all interacted with year fixed effects. Estimations are weighted by employment per industry and state 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 state level. *** p<0.01, ** p<0.05, * p<0.1

Appendix Table C.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	-1.636***	-0.637	-1.469**	-2.518*	-3.342***	-1.893	-2.091	-5.263***
	(0.575)	(0.922)	(0.624)	(1.413)	(1.213)	(1.321)	(1.293)	(1.970)
Comp. Shock	2.515***	1.622**	2.124***	1.202*	3.390***	1.246	3.029**	1.171
	(0.778)	(0.794)	(0.768)	(0.631)	(1.179)	(0.945)	(1.211)	(0.824)
F-Stat First Stage					64.42	64.17	64.14	64.55
B) By Industry								
Input shock × 1(Agric.)	1.950*	4.633	0.619	-0.576	-2.244	3.001	-2.318	-2.378
	(1.083)	(3.322)	(1.178)	(1.883)	(3.266)	(3.025)	(3.170)	(2.910)
Input shock × 1(Manuf.)	0.616	1.227	0.322	-0.163	5.955	7.645	5.985	1.472
	(1.022)	(1.330)	(1.059)	(1.338)	(4.619)	(6.454)	(4.048)	(6.064)
Input shock × 1(Serv.)	-1.669***	-0.880	-1.461**	-2.746*	-2.878**	-1.885	-1.640	-5.194**
	(0.595)	(0.899)	(0.646)	(1.439)	(1.114)	(1.303)	(1.237)	(2.076)
Comp. shock × 1(Agric.)	1.790	-2.609	2.327	-0.677	5.922	-4.871*	7.064*	-1.918
	(1.857)	(3.527)	(1.797)	(1.553)	(4.199)	(2.799)	(4.203)	(2.150)
Comp. shock × 1(Manuf.)	0.058	0.341	0.081	-0.445	-4.835	-5.501	-4.411	-3.814
	(0.818)	(0.894)	(0.882)	(0.505)	(3.825)	(5.349)	(3.358)	(5.131)
F-Stat First Stage					6.230	6.325	6.195	6.251
Observations	4,262	4,088	4,128	4,400	4,262	4,088	4,128	4,400
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: 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 exchange rates 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 C.3

Input and Competition Shocks on Wage Bill using Social Security Records

	OLS			IV		
	(1)	(2)	(3)	(4)	(5)	(6)
A) All Sectors						
Input Shock	-3.057	-1.713	-3.067	-5.619	-2.890	-5.138
	(2.547)	(2.235)	(2.288)	(5.670)	(4.536)	(4.889)
Comp. Shock	1.450	1.426	1.464	1.199	1.324	1.296
	(0.940)	(0.952)	(0.988)	(1.366)	(1.389)	(1.399)
F-Stat First Stage				158.3	162.9	159.7
B) By Industry						
Input shock × 1(Agric.)	0.623	0.423	0.209	1.022	2.268	1.503
	(1.786)	(1.579)	(1.515)	(4.495)	(3.818)	(3.803)
Input shock × 1(Manuf.)	1.292	3.516*	1.122	4.972	8.698	3.879
	(2.169)	(1.987)	(1.873)	(5.480)	(5.094)	(4.777)
Input shock × 1(Serv.)	-4.264	-2.529	-4.264*	-8.708	-5.034	-8.337
	(2.548)	(2.407)	(2.338)	(6.405)	(5.443)	(5.617)
Comp. shock × 1(Agric.)	2.567**	2.376*	2.692**	1.987	1.983	2.265
	(1.199)	(1.224)	(1.183)	(2.324)	(2.459)	(2.265)
Comp. shock × 1(Manuf.)	-0.667	-0.650	-0.654	-3.560	-3.263	-3.139
	(0.640)	(0.715)	(0.672)	(2.697)	(2.821)	(2.740)
F-Stat First Stage				124.7	130.6	130
Observations	61,076	61,076	61,076	61,076	61,076	61,076
State-Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
State-Year FE	Yes			Yes		Yes
Year FE		Yes	Yes		Yes	
Baseline Controls			Yes			Yes

Notes: 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-state-year level. Columns (1)-(3) are estimated using ordinary least squares, whereas columns (4)-(6) present IV estimates using the tariff initial values interacted with exchange rates 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, and the share of female workers in each state, all interacted with year fixed effects. Estimations are weighted by employment per industry and state 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 state level. *** p<0.01, ** p<0.05, * p<0.1

Appendix Table C.4

Input and Competition Shocks on Wage Bill (One-way clustering)

	OLS			IV		
	(1)	(2)	(3)	(4)	(5)	(6)
A) All Sectors						
Input Shock	-1.276**	-2.107***	-1.673***	-4.073***	-4.368***	-4.677***
	(0.566)	(0.652)	(0.594)	(1.290)	(1.270)	(1.282)
Comp. Shock	2.995***	2.972***	2.989***	3.473***	3.460***	3.450***
	(0.415)	(0.448)	(0.450)	(0.539)	(0.570)	(0.574)
F-Stat First Stage				387.1	767.9	487.2
B) By Industry						
Input shock × 1(Agric.)	2.875**	2.302	2.214	-0.721	-0.805	-1.148
	(1.349)	(1.448)	(1.456)	(2.538)	(2.557)	(2.471)
Input shock × 1(Manuf.)	-0.605	-1.650	-1.571	1.861	0.535	-1.154
	(0.960)	(1.059)	(1.092)	(2.463)	(2.674)	(2.761)
Input shock × 1(Serv.)	-2.164***	-2.600***	-2.531***	-5.369***	-4.897***	-5.997***
	(0.604)	(0.664)	(0.594)	(1.103)	(1.185)	(1.102)
Comp. shock × 1(Agric.)	4.853***	4.608***	4.783***	6.520***	6.210***	6.387***
	(0.999)	(1.086)	(1.095)	(1.512)	(1.622)	(1.625)
Comp. shock × 1(Manuf.)	1.442***	1.583***	1.593***	0.069	0.649	0.699
	(0.331)	(0.381)	(0.377)	(0.764)	(0.939)	(0.924)
F-Stat First Stage				356.7	357.8	382.6
Observations	53,177	53,177	53,177	53,177	53,177	53,177
State-Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
State-Year FE	Yes			Yes		Yes
Year FE		Yes	Yes		Yes	
Baseline Controls			Yes			Yes

Notes: This table presents the results of estimating Equation 4.3 using the wage bill as outcome. Estimations performed in a panel at the industry-state-year level. Columns (1)-(3) are estimated using ordinary least squares, whereas columns (4)-(6) present IV estimates using the tariff initial values interacted with exchange rates 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, and the share of female workers in each state, all interacted with year fixed effects. Estimations are weighted by employment per industry and state 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 one-way clustered at the industry-by-state level. *** p<0.01, ** p<0.05, * p<0.1

D. Data Construction for the Model

We collect different data sources to calibrate the model at the baseline, including regional Input-output matrices, WIOD, and social security records (see Section 4.1). Our observation unit corresponds to the state-sector cell. We aggregate the data to 26 regions, of which 24 are Colombian States and the last two are the US and the rest of the world, and 13 sectors (See Appendix D).

Using information from the regional IO tables, we construct bilateral trade flows, M_{ni,s,t_0} across the different locations in Colombian pesos, where n corresponds to the destination and i to the exporter country. Trade flows between the US and the rest of the world are based on World Input-Output Database (WIOD). We decompose the Colombian international trade flows (between the US 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.

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.[34]

The model is calibrated with the following 26 regions (24 Colombian States, the United States and the rest of the world) and 13 sectors:

[34]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 D.1

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

Appendix Table D.2

Sectors for the model

Sector Code	Sector	ISIC (Rev4)
01	Crop production and Animal Production	01
02	Forestry and logging	02
05	Fishing and aquaculture	05
15	Foods, beverages and tobacco products	15-16
18	Manufacture textiles, wearing apparel and leather	17-19
20	Wood, paper, printing, and recorded media	20-21
23	Mining, crude petroleum manufacture of coke and refined petroleum products	10-14, 23
24	Manufacture of non-metallic mineral products chemicals	24-26
27	Manufacture of basic and elaborated metal products except machinery	27
30	Manufacture of electronic, electrical equipment machinery. Repair and installation of machinery and equipment.	31
34	Vehicles, furniture, and other manufacturing	34-36
35	Non-retail or wholesale services	40-45, 60-95
36	Wholesale and retail trade, including trade . and repair of motor vehicles and motor cycles.	50-51

E. Trade Elasticities

Appendix Table E.3

Trade Elasticities - Industry

VARIABLES	(1) Aggregate	(2) 1-digit	(3) 2-digit
ln (1+t) x Crop Production			4.158**
			(1.724)
ln (1+t) x Animal Production			-0.857
			(8.366)
ln (1+t) x Forestry			5.582
			(6.994)
ln (1+t) x Fishing			18.982***
			(0.256)
ln (1+t) x Foods and bevarages			4.468***
			(0.789)
ln (1+t) x Tobacco			3.711
			(5.646)
ln (1+t) x Textiles			3.616***
			(1.156)
ln (1+t) x Wearing Apparel			1.742*
			(1.017)
ln (1+t) x Wood			2.297
			(1.790)
ln (1+t) x Petroleum			10.571
			(7.918)
ln (1+t) x Chemicals			2.938***
			(0.895)
ln (1+t) x Metal products			-0.333
			(1.190)
ln (1+t) x Office products			2.280*
			(1.211)
ln (1+t) x Vehicles			1.966
			(1.210)
ln (1+t) x Agriculture		4.614***	
		(1.639)	
ln (1+t) x Manufacturing		2.992***	
		(0.482)	
ln (1+t)	3.060***		
	(0.476)		
Observations	30,578	30,578	30,578
R-squared	0.777	0.777	0.777

Notes: This table reports the point estimates of the trade elasticities after estimating equation 6.1 comparing imports in Colombia between the US and the RoW after the FTA between Colombia and the US in 2012. The unit of of observation corresponds to a 4-digit industry -year cell. The first column reports the point estimate for the average trade elasticity. The second column for 1-digit industries, and the third column for 2-digit industries. Standard errors are clustered at the 4-digit sector level and reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Appendix Table E.4

Trade Elasticities - State-Industry

VARIABLES	(1) Aggregate	(2) 1-digit	(3) 2-digit
ln (1+t) x Crop Production			2.815***
			(0.913)
ln (1+t) x Animal Production			-10.887
			(9.775)
ln (1+t) x Forestry			5.169
			(4.998)
ln (1+t) x Fishing			18.996***
			(0.310)
ln (1+t) x Foods and bevarages			4.740***
			(1.014)
ln (1+t) x Tobacco			3.416***
			(0.229)
ln (1+t) x Textiles			2.682**
			(1.236)
ln (1+t) x Wearing Apparel			1.695
			(2.075)
ln (1+t) x Wood			3.109*
			(1.578)
ln (1+t) x Petroleum			10.879
			(6.547)
ln (1+t) x Chemicals			1.935***
			(0.563)
ln (1+t) x Metal products			0.345
			(0.727)
ln (1+t) x Office products			0.255
			(0.807)
ln (1+t) x Vehicles			2.018
			(1.673)
ln (1+t) x Agriculture		3.271***	
		(0.875)	
ln (1+t) x Manufacturing		2.509***	
		(0.447)	
ln (1+t)	2.531***		
	(0.445)		
Observations	108,743	108,743	108,743
R-squared	0.699	0.699	0.700

Notes: This table reports the point estimates of the trade elasticities after estimating equation 6.1 comparing imports in Colombia between the US and the RoW after the FTA between Colombia and the US in 2012. The unit of of observation corresponds to the state-4-digit industry - year cell. The first column reports the point estimate for the average trade elasticity. The second column for 1-digit industries, and the third column for 2-digit industries. Standard errors are clustered at the 4-digit sector level and reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.