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Maria Bas, Pamela Bombarda

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Maria Bas†

Pamela Bombarda‡

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Abstract

This work investigates the role of foreign technology embodied in imported inputs on labor allocation between informal and formal employment in Mexico. Using individual household data for Mexico (1993-2001), we exploit exogenous input tariff changes applied to United States (U.S.) products when Mexico enters the North American Free Trade Agreement (NAFTA) in 1994. The theoretical mechanisms considered are the foreign input cost reduction that increases revenues in the formal sector, and the foreign input-skilled biased channel. Within this framework, input-trade liberalization induces the reallocation of workers from informal to formal firms. Our empirical findings confirm these mechanisms: individuals working in manufacturing industries experiencing the average reduction in input tariffs (12 percentage points) are almost 4 percent more likely to work in formal rather than informal occupations. This effect is concentrated on high-skilled workers, further reinforcing the input-skilled biased complementarity channel.

JEL classification: F12, F16, O14, O17

Keywords: informal and formal employment, trade liberalization, household data.

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†University of Paris 1, Centre d'Economie de la Sorbonne (CES). maria.bas@univ-paris1.fr

‡CY Université, THEMA (UMR CNRS 8184), France. pamela.bombarda@cyu.fr

1 Introduction

During the late 80s and 90s developing countries have experienced several episodes of trade reform. The literature on trade liberalization effects on labor markets have focused mainly on the formal manufacturing sector (Amiti and Cameron, 2012, Chen et al., 2017, Fieler et al., 2018, Bas and Paunov, 2021a). However, in developing countries the share of the labor force employed in the informal sector ranges from 35 percent in Chile to 80 percent in Bolivia and Peru, with Mexico reaching 55 percent (Perry et al., 2007). Informal firms in those countries account for almost half of economic activity (La Porta and Shleifer, 2014). Despite the importance of the informal labor market in developing countries, there are few papers focusing on the effects of trade reforms on informal workers. These papers highlight two possible mechanisms through which trade liberalization might affect informal labor markets. The first mechanism works via foreign competition pressures in the formal sector that lead to an increase in informal employment (Goldberg and Pavcnik, 2003, Dix-Carneiro and Kovak, 2019, Ponczek and Ulyssea, 2022, Ben Yahmed and Bombarda, 2020). The second one is related to the expansion of market access for exporting firms in the formal sector that induced a reallocation of labor from informal to formal manufacturing sectors (McCaig and Pavcnik, 2018).

In this paper we focus on an unexplored mechanism through which trade liberalization also affects informal employment in developing countries: foreign technology embodied in imported inputs. We exploit tariffs reduction in Mexico during the 1990s, when the country joined NAFTA, to examine the effects of input-tariff cuts on the reallocation of workers from the informal to the formal sector. This paper shows that input-trade liberalization can contribute to a reallocation toward formal employment through two channels. The first channel involves the reduction of input tariffs, enabling formal firms in the manufacturing sector to lower their marginal costs while gaining access to foreign technology. This, in turn, boosts revenues, leading to an expansion in the number of firms and employment within the formal sector. The second channel involves the complementarity between foreign inputs and skilled labor. Several papers have shown that input tariff cuts allow firms in the formal sector to upgrade foreign technology and increase the demand for skilled labor (Chen et al., 2017, Fieler et al., 2018, Bas and Paunov, 2021b). In this work, we show that the complementarity channel has led to a reallocation of skilled workers from the informal to the formal sector. The main contribution of this paper to the existent literature on trade and informality lies in testing the unexplored mechanism of input-trade liberalization and

proposing a potential theoretical framework.

Our analysis is developed in two steps. First, we propose a simple theoretical framework which enables us to rationalize these two mechanisms through which input-trade liberalization affects employment in manufacturing sectors. The model builds on the extension of the Melitz (2003) framework proposed by Ulyssea (2018), where we add the possibility to source inputs from abroad. Firms with different productivity levels can produce in the formal or informal sector depending on their profitability. Firms producing in the formal sector have to pay a fixed labor regulation cost and variable taxes to hire formal registered workers. These formal firms can have access to foreign inputs that go through customs and must be registered. Firms in the informal sector can sidestep fixed and variable labor regulation costs, contingent upon the probability of detection, but face a limitation in accessing foreign inputs due to their unregistered status. Moreover, we assume that foreign inputs are complementary with skilled labor. Under these assumptions, the model predicts that input-tariff cuts reduce the relative unit costs of formal firms vis-à-vis informal ones. This reduces the cutoff threshold required to become a formal firm, and thereby increasing formal employment. In our framework, where foreign inputs are skilled-biased, the reallocation effect of input-trade liberalization will be more pronounced among skilled workers.

Then, we test the relationship between input-trade liberalization and reallocation of workers from informal to formal firms. We combine household level data from the Mexican labor force (National Urban Employment Survey, ENEU) and tariffs applied by Mexico to U.S. products over the period 1993-2001. From ENEU, we use information for wage workers, which are defined as those individuals reporting to have a fixed wage, salary or daily wage. ENEU survey also provides information about health insurance and social security coverage of household members. Following the literature (Maloney, 1999, Bosch and Maloney, 2010, Bosch et al., 2012 among others), we define informal employees as those individuals who do not have access to health insurance and social security coverage which are mandated benefits for legal labor contracts. Differently, we define formal wage workers as those individuals declaring to have access to benefits (social security coverage). To capture the effect of input-trade liberalization, we follow the methodology in Goldberg et al. (2010), and compute Mexican input tariffs applied to the U.S. at the 2-digit-SIC level. Due to tariffs data availability, in our benchmark regressions, we restrict the ENEU sample to those individuals in the manufacturing sector.

To capture the effect on wage workers reallocation from informal to formal, our identification

strategy relies on variation of input tariffs at the industry level over time. To establish the causal link between the availability of imported intermediate and the reallocation of labor from the informal to the formal manufacturing sector, we rely on trade reforms related to Mexico joining NAFTA in 1994. Among NAFTA members, Mexico was the country with the highest tariffs and experienced the largest cut during NAFTA. During the period under analysis (1993-2001), import tariffs on intermediate goods from the U.S. resulted in an average reduction of more than 12 percentage points, from more than 14 percent in 1993 to less than 1.7 percent in 2001. Over the same period, Mexico's imports of inputs from the United States were multiplied by 7. When analyzing the effect of trade policy, a key econometric aspect is that trade policy can result from economic conditions. Since Mexico adopted the existent preferential tariff within the NAFTA agreement, it seems unlikely that tariff changes between the U.S. and Mexico are driven by political pressures of Mexican firms. This makes it also unlikely that individuals have lobbied for reducing tariffs. However, to further reassure about this concern, we also provide some evidence that input-tariff changes were not related to initial industry characteristics. Then, since Mexico's tariffs reduction were occurring from the 80's, we try to address possible identification threats that may arise from pre-existing trends. Using pre-NAFTA data from ENEU (1987-1992), we show that input tariff reduction during the NAFTA period (1993-2001) are not affecting the reallocation of workers from informal to formal sector.

By leveraging this plausibly exogenous variation in input tariffs across 2-digit-SIC industries over time, we identify the causal effect of accessing cheaper foreign technology on the transition from informal to formal employment. Since our data does not allow us to follow individuals over time, we rely on pseudo-panel methods to estimate individual fixed effects models when only independent repeated cross-sectional data are available (Guillerm, 2017). All our estimations include pseudo individual fixed effects based on a detailed set of individual characteristics, such as year of birth, gender, municipality in which the individual lives, migration (internal and international), and years of education. We also include other fixed effects which may affect an individual's choices. For instance, to address unobserved time invariant characteristics at the sectoral level we use 4-digit industry fixed effect. Then, to capture other domestic policies at the state level, we add time-varying unobservable shocks (state-year fixed effect). To capture other unobservable shocks that may remain at the sectoral level, we also include 4-digit industry size trends as well as 2-digit industry-trends. Lastly, we complement the ENEU survey using CENSUS data, which enable us

to construct other time varying industry controls.

The results provide new evidence on the effects of input-tariff liberalization on informal labor markets in developing countries. Our main findings are as follows. First, individuals producing in industries with the largest falls in input tariffs experienced the greatest increase in their probability of being employed as a formal worker in the manufacturing sector. Specifically, our results show that workers in industries that faced average reductions in input tariffs, 12 percentage points, experienced more than 4 percentage points increase in the probability of being employed as formal workers relative to observationally equivalent workers in industries with lower tariff cuts. This effect is heterogeneous across workers with different skills, with the largest impact observed among those with more than 16 years of education. These high skilled workers experience more than 5 percentage points increase in the probability of being employed as formal workers relative to observationally equivalent workers in industries with lower tariff cuts. These results confirm that the channel through which input-trade liberalization induced the reallocation of workers from informal to formal jobs is related to the foreign inputs-skilled biased complementarity channel.

We also address other possible confounding factors that could drive our results. In fact, our results could also be explained by alternative explanations, such as the expansion of export opportunities of Mexican firms selling in the U.S. (market access channel), firm size, and location (i.e. border and maquiladoras). To capture the trade variable cost reduction for Mexican firms exporting to the U.S. in this period, we extend our baseline analysis to include the import tariff set by the U.S. to Mexican products. Our results show that the imported input channel is not picked up by the expansion of export opportunities. Next, we also explore the role of firm size in explaining the reallocation of workers from the informal to the formal sector. Our findings show that the heterogeneous effect of input-trade liberalization on formal employment is not driven by firm size. Furthermore, since NAFTA allowed Northern Mexico to become an export processing zone, we examine the heterogeneity of input tariff cuts by location (border) and maquiladoras factories. Our findings show that maquiladoras do not play a role on the allocation of workers between informal and formal status.

Finally, we carry out several robustness tests. First, as in Perry et al. (2007), and Dix-Carneiro et al. (2021), we rely on a broader definition of informality including both informal wage employment and self-employment. Second, we rely on a more precise pseudo individual fixed effect including the birthplace which, despite reducing the sample size due to missing information,

provides more precise information about time invariant individual characteristics. Third, we present a falsification test on the transition from informal labor market to self-employment and unemployment in manufacturing sectors. Lastly, we align with the recent and expanding literature on the local labor market effects of trade reforms and analyse whether input trade liberalization has differential effects on workers based on their geographical location. Our findings show that our results are robust and stable in all sensitivity tests.

The main contribution of our work to the literature that investigates the effects of globalization on informal employment in developing countries is to identify a new mechanism through which trade liberalization might affect the reallocation of workers from informal to formal employment. The literature has concentrated on the foreign competition channel through which trade liberalization has a negative impact on informal labor markets in developing countries. Dix-Carneiro and Kovak (2019) study the effects of Brazil's trade liberalization in 1990s on the margins of labor market adjustment. Their findings show that formally employed workers located in regions more exposed to foreign competition experienced a reduction in wages and in the probability of being employed in a formal job relative to those in less exposed regions. Ponczek and Ulyssea (2022) explore the effects on informality of output-trade liberalization in Brazil. Their results show that Brazilian regions more exposed to foreign competition observed higher informality and greater unemployment relatively to regions less exposed.[1] McCaig and Pavcnik (2018) highlights another mechanism through which a trade reform can have a positive effect on the reallocation of workers from the informal to the formal firms in Vietnam based on the expansion of export opportunities after the U.S.-Vietnam bilateral trade-agreement. In this work, we show a third channel through which trade liberalization affects informal employment in developing countries, which is by increasing the foreign inputs Mexican firms can have access to. Once we take into account the foreign competition and the market access mechanisms, our findings suggest that input-trade liberalization is the main channel that affects the reallocation of workers from informal to formal manufacturing employment in Mexico after the NAFTA agreement. We also show that our findings are heterogeneous across skills and larger for high-skilled workers providing evidence that the mechanism through which input-tariff cuts affect the probability an individual leaves the informal labor market is through foreign inputs-skills complementarity.[2]

[1] More recently, Dix-Carneiro et al. (2021) propose a general equilibrium model with labor market frictions and imperfectly enforced regulations. Using data from Brazil, their counterfactual simulations find that trade openness unambiguously decreases informality in the tradable sector.

[2] Our results are also in line with the findings in Waddle (2021).

This paper also contributes to the growing empirical literature on the role of input-trade liberalization, through the access to foreign technology embodied imported inputs, as a key determinant of economic growth in developing countries. The literature on the impacts of trade liberalization has documented positive effects of input tariff cuts on within-firm productivity (Amiti and Konings, 2021, Topalova and Khandelwal, 2011, Brandt et al., 2017, Bas and Paunov, 2021a). Our work is related to the literature that explores the effects of input-trade liberalization on the skill intensity of production and the skill premium in the formal manufacturing sector (Amiti and Cameron, 2012, Chen et al., 2017, Fieler et al., 2018, Bas and Paunov, 2021b). Bas and Paunov (2021b) provide causal evidence on the complementarity of high-quality imported inputs and skills in formal firms in the case of Ecuador. Relative to all these works, the main contribution of our work is to show that trade liberalization through the imported input channel can help developing countries to enhance economic growth through another channel by reducing informality and misallocation of resources as well as increasing fiscal capacity and thus provision of public goods.

The rest of the paper is organized as follows. Section 2 describes the main theoretical channels through which input-trade liberalization affects informal labor markets. Section 3 presents the empirical implications of the theoretical framework. Section 4 describes the trade reform in Mexico under the period of analysis. Section 5 presents the dataset as well as the measure of informality. Section 6 presents the identification strategy. Section 7 describe the main results and Section 8 controls for alternative explanations. Section 9 proposes additional sensitivity tests. Finally, the last Section concludes.

2 Theoretical Motivation

The aim of this section is to present a simple framework that rationalizes the main mechanisms through which input-trade liberalization affects formal and informal employment in the manufacturing sector.

In the economy there are a continuum of manufacturing firms with different productivity levels as in Melitz (2003) producing differentiated varieties of final goods under monopolistic competition. Firms rely on heterogeneous labor (skilled and unskilled labor) and intermediate inputs (domestic and foreign) to produce final goods. The model features two sectors: (1) the formal sector where firms must pay fixed labor regulation costs and variable taxes related to hire

formal workers and (2) an informal sector where firms are able to avoid paying labor regulation costs and taxes but they face a probability of detection by the government. Only firms in the formal sector can have access to imported intermediate goods that go through customs and must be registered. The main assumption is that imported inputs embody a more advanced skill-biased technology. Thereby, formal firms relying on imported inputs are then more skilled intensive than informal firms. Domestic intermediate inputs are produced under perfect competition and constant return to scale and its price is normalized to one. Consumer preferences are assumed to take the Constant Elasticity of Substitution (CES) utility function and they are described in the Theoretical Appendix.

We first focus on a version of the model with homogeneous labor to present the first channel through which input trade liberalization affects the reallocation of workers from informal to the formal sector based on the access to more efficient foreign inputs. Next, we extend the model to heterogeneous labor (skilled and unskilled) to present the second channel based on foreign inputs skilled-biased.

2.1 Production in the informal and formal sector with homogeneous labor

There is a continuum of firms, each producing a different range of final goods in manufacturing sector, in monopolistic competition with different levels of productivity (φ). Firms in the informal sector, indexed by i, produce final goods (q_i) using labor (l_i) and only domestic intermediate inputs ($x_{d,i}$) combined by a Cobb-Douglas production function. Domestic inputs are produced under perfect competition with labor. The wage is normalized to one. Informal firms have to pay a fixed production costs (f), but they are able to avoid paying labor regulation costs and taxes facing a probability of detection by the government. As in Ulyssea (2018), this expected cost takes the form of a production distortion denoted (τ_i).

Firms in the formal sector, indexed by f, have to pay a fixed labor regulation costs, f_r, and the fixed production costs, f. They have to pay also variable labor taxes costs (τ_f). Paying those fixed and variable labor taxes gives the firm the formal registered status that allows to have access to imported intermediate goods that go through customs and must be registered. The advantage to produce with foreign intermediate goods is that they are more efficient in the production process since they reduce marginal costs. Formal firms then produce final goods (q_f)

using labor (l_f), domestic ($x_{d,f}$) and imported intermediate inputs ($x_{m,f}$). Those intermediate goods are aggregated by a CES function. The production function of informal and formal firms is given by:

$$q_s(\varphi) = \varphi l_s^{\beta} x_s^{\eta} \quad \text{for} \quad s = \{i, f\} \tag{1}$$

where if the firm produces in the informal sector, $s = i$, then $x_i = x_{d,i}$, otherwise if $s = f$, $x_f = \left(x_{d,f}^{\gamma} + x_{m,f}^{\gamma}\right)^{\frac{1}{\gamma}}$.[3]

Firms in each sector (informal and formal) choose their price to maximize their profits subject to a demand curve with constant elasticity σ. The equilibrium price reflects a constant markup over marginal cost: $p_s(\varphi) = \frac{\sigma}{\sigma-1}\frac{c_s}{\varphi}\tau_s$, where τ_s corresponds to the variable taxes on labor paid by formal firms (τ_f) and the expected cost informal firms faced if they get caught in avoiding paying those labor regulation taxes (τ_i). The cost index c_s combines the wages (w) with the prices of intermediate goods. Since labor market is perfect competitive and labor is homogeneous and perfect mobile across sectors, the wages of formal and informal firms are equal ($w_i = w_f$) and the wages are normalized to one. Final good producers are price-takers in intermediate-input goods markets. The price of imported inputs takes into account the input tariff τ_m. Since the price of domestic intermediate goods is equal to the wage ($p_{xd} = w = 1$), the cost index for informal and formal firms can be expressed as a function of wages, the imported input efficiency parameter and foreign inputs and input tariffs: $c_i = w_i^{\beta} = 1$ and $c_f = \left(1 + (\tau_m)^{\frac{\gamma}{\gamma-1}}\right)^{\frac{\eta(\gamma-1)}{\gamma}}$. The ratio $\frac{c_f}{c_i}$ is determined by:

$$\frac{c_f}{c_i} = \left(1 + (\tau_m)^{\frac{\gamma}{\gamma-1}}\right)^{\frac{\eta(\gamma-1)}{\gamma}} \tag{2}$$

The relative unit cost equation $\frac{c_f}{c_i}$ is an increasing function of input tariffs. Partially differentiating the relative unit cost with respect to the input tariffs (τ_m), we find that $\partial\frac{c_f}{c_i}/\partial\tau_m > 0$ since $0 < \gamma < 1$. The lower the input tariffs the lower the relative unit costs of firms in the formal sector vis-a-vis firms in the informal sector. This result is explained by the fact that only firms in the formal sector have access to imported inputs. This is the first channel through which input-trade liberalization affects firms producing in the formal and informal sector. In this setting of heterogeneous firms, the reduction of marginal costs for formal firms results in an increase in

[3]The elasticity of substitution among intermediate goods is $\frac{1}{1-\gamma}$, and $0 < \gamma < 1$.

their revenues and thereby, in the number of firms and employment in the formal sector.

2.2 Production in the informal and formal sector with heterogeneous labor

This section extends the previous analysis to incorporate heterogeneous labor (skilled and unskilled labor) in order to present a second mechanism through which input-trade liberalization affects labor allocation of different skills between the formal and informal sector.

Firms in the informal sector produce final goods using both type of labor, skilled and unskilled, and only domestic intermediate inputs. Formal firms then produce final goods also using both type of labor and domestic and imported intermediate inputs. Unskilled (l_i) and skilled (h_i) labor are aggregated by a CES function. The elasticity of substitution between the two types of labor is $\theta = \frac{1}{1-\alpha}$. We assume that skilled and unskilled labor are imperfect substitutes, hence $0 < \alpha < 1$ and $1 \leq \theta \leq \infty$.

$$q_s(\varphi) = \varphi \left(a_h^{\alpha} h_s^{\alpha} + l_s^{\alpha}\right)^{\frac{\beta}{\alpha}} x_s^{\eta} \quad for \quad \mathrm{s} = \{i, f\} \tag{3}$$

As previously, $x_i = x_{d,i}$ if the firm produces in the informal sector and $x_f = \left(x_{d,f}^{\gamma} + x_{m,f}^{\gamma}\right)^{\frac{1}{\gamma}}$ if the firm produces in the formal sector. The coefficient a_h represents the complementary between imported intermediate inputs and skilled labor that translates in a skill-biased-foreign technology factor. The high value of this factor is only available to formal firms that can access foreign inputs since they are registered and pay the fixed labor regulation cost (f_r) and variable labor taxes costs (τ_f). Therefore, $a_h > 1$ if $s = f$, and $a_h = 1$ if $s = i$. The complementarity between imported inputs and skilled labor yields to a higher efficiency in the production process reducing formal firms' marginal costs. This complementarity assumption implies that formal firms are more skilled intensive than informal firms.

In this setting with heterogeneous labor, the cost index c_s combines the wages of unskilled (w_l) and skilled labor (w_h) with the prices of intermediate goods. The cost index for informal and formal firms can be expressed as a function of wages of both types of labor, the complementarity parameter between skilled labor and foreign inputs and input tariffs: $c_i = (w_l^{\frac{\alpha}{\alpha-1}} + w_h^{\frac{\alpha}{\alpha-1}})^{\frac{\beta(1-\alpha)}{\alpha}}$ and

$c_f = \left(w_l^{\frac{\alpha}{\alpha-1}} + \left(\frac{w_h}{a_h}\right)^{\frac{\alpha}{\alpha-1}} \right)^{\frac{\beta(1-\alpha)}{\alpha}} \left(1 + (\tau_m)^{\frac{\gamma}{\gamma-1}}\right)^{\frac{\eta(\gamma-1)}{\gamma}}$.[4] The ratio $\frac{c_f}{c_i}$ is determined by:

$$\frac{c_f}{c_i} = \left(\frac{\omega^{\frac{\alpha}{1-\alpha}} + 1}{\omega^{\frac{\alpha}{1-\alpha}} + (a_h)^{\frac{\alpha}{1-\alpha}}} \right)^{\frac{1-\alpha}{\alpha}} \left(1 + (\tau_m)^{\frac{\gamma}{\gamma-1}}\right)^{\frac{\eta(\gamma-1)}{\gamma}} \tag{4}$$

where $\omega = w_h/w_l$ is the wage of skilled labor relative to unskilled one. Partially differentiating equation (4). with respect to the input tariffs (τ_m), we find that $\partial \frac{c_f}{c_i}/\partial \tau_m > 0$ since $0 < \gamma < 1$, and $a_h > 1$. A reduction of input tariffs reduces the relative unit costs of formal firms relative to informal ones. This result is explained by two channels. First, as in the previous setting with homogeneous labor, only firms in the formal sector have access to imported inputs. Second, in the setting with heterogeneous labor, producing with foreign inputs induces a technical change that is biased towards skilled labor. Thereby, input tariff changes affect the relative demand of skilled labor in formal firms.

The differential effect of input-tariff changes on formal firms' revenues and profits is captured by the ratio of relative unit cost of formal to informal firms expressed in equation (4). Combining the demand and the price function, firms' revenues are given by

$$r_s(\varphi) = \left(\frac{P}{p_s(\varphi)}\right)^{\sigma-1} R = A(c_s\tau_s)^{1-\sigma}\varphi^{\sigma-1},$$

where R is the aggregate revenue, and $A = P^{\sigma-1}R\left(\frac{\sigma-1}{\sigma}\right)^{\sigma-1}$ is an index for market demand. Formal firms' revenues can be written as a function of revenues of informal firms $r_f(\varphi) = r_i\left(\frac{c_f}{c_i}\right)^{1-\sigma}$. Profits for both types of firms are given by $\pi_i(\varphi) = \frac{r_i(\varphi)}{\sigma} - f$ and $\pi_f(\varphi) = \frac{r_i(\varphi)\left(\frac{c_f}{c_i}\right)^{1-\sigma}}{\sigma} - f - f_r$. Formal firms have higher revenues and profits.

2.3 Formal and informal firms' decisions

Firms have to pay a sunk entry cost f_e to enter the market before they know what their productivity level will be. Entrants then derive their productivity φ from a known Pareto distribution function.[5] After observing its productivity draw, firms decide whether to stay and produce or to exit the market. Since there is a fixed production cost f, only those firms with enough profits to afford

[4] In this setting, we assume that intermediate goods are produced under perfect competition using one unit of unskilled labor and that the wage of unskilled labor is normalized to one.

[5] The Pareto distribution function is $g(\varphi) = k\frac{\varphi_{\min}^k}{(\varphi)^{k+1}}$ with $\varphi_{\min} > 0$ the lower bound of the support of the productivity distribution and a shape parameter k.

this cost can produce. The profits of the marginal firm that decides to stay and produce in the informal sector are equal to zero: $\pi_i(\varphi_i^*) = 0$. The value φ_i^* is the survival productivity cutoff to produce in the informal sector. This cutoff is determined by the following zero cutoff profit condition: $\frac{r_i(\varphi)}{\sigma} = f$. The survival productivity cutoff to produce in the informal sector is determined by $\varphi_i^{*\sigma-1} = f\ c_i^{\sigma-1}\frac{\sigma}{A}\tau_i^{*\sigma-1}$. Only firms with a productivity draw greater than the survival cutoff stay in the market and produce ($\varphi > \varphi_i^*$).

Firms can decide to produce in the formal sector by paying a labor regulation fixed cost and the variable labor taxes depending on their profitability. Producing in the formal sector allows firms to have access to foreign inputs that are complementary with skilled labor. The skilled-biased imported input complementarity reduces formal firms' marginal costs. The decision to produce in the formal sector is endogenously determined by the initial productivity draw. Firms with a more favorable productivity draw have a higher potential payoff from producing in the formal sector and hence are more likely to find incurring the fixed labor regulation cost worthwhile. Thereby, firms that produce in the formal sector are the most productive ones whose increase in revenues due to the use of foreign inputs (complementary with skilled labor) enables them to pay the fixed regulation cost. Being a formal firm allows to increase profitability through the complementarity channel between imported intermediate goods and skilled labor in the production process. The condition for the marginal firm to produce in the formal sector is given by $\pi_f(\varphi_f^*) = \pi_i(\varphi_i^*)$: $\frac{r_f(\varphi_f^*) - r_i(\varphi_f^*)}{\sigma} = f_r$.

The productivity cutoff to produce in the formal sector φ_f^* is the productivity level of the marginal firm that is able to afford the fixed labor regulation costs. Combining the zero cutoff profit condition for informal firms with the condition to produce in the formal sector, we obtain φ_f^* as an implicit function of φ_i^*:

$$\varphi_f^* = \varphi_i^* \left(\frac{f_r}{f}\right)^{\frac{1}{\sigma-1}} \left(\left(\frac{C_f}{C_i}\right)^{1-\sigma} - 1\right)^{\frac{1}{1-\sigma}} \tag{5}$$

where the relative cost between formal and informal firms, $\frac{C_f}{C_i}$, takes into account the relative unit costs ($\frac{c_f}{c_i}$) as well as the relative variable costs ($\frac{\tau_f}{\tau_i}$): $\frac{C_f}{C_i} = \frac{c_f}{c_i}\ \frac{\tau_f}{\tau_i}$. This relative cost is a function of input tariffs determined in equations (2) and (4). The sorting of firms by formal status depends on the relationship between fixed costs of production, of labor regulation costs, variable costs of labor and relative unit cost. If fixed labor regulation costs are lower than fixed production costs

all firms will produce in the formal sector.[6]

The aim of this theoretical framework is to analyse how changes in input tariffs affect firms' decision to produce in the formal sector. This question can be answered by investigating the impact of input-tariff changes on the productivity cutoff to produce in the formal sector φ_f^*. Equation (5) shows that input tariffs affect this productivity cutoff through a direct effect captured by the relative unit costs of formal relative to informal firms and through an indirect effect captured by the impact of input tariffs on the survival productivity cutoff to produce in the informal sector φ_i^*. In partial equilibrium, for a given φ_i^*, input tariffs cuts decrease the relative cost of formal firms and thereby, reduce the productivity cutoff to produce in the formal sector allowing more firms to afford paying the fixed labor regulation costs and increasing labor demand of the formal sector.

General equilibrium results are shown in Appendix A, where we also derive the industry equilibrium. The free entry condition and the zero cutoff profits condition determine the general equilibrium value of the productivity cutoff φ_i^*. In the next section we describe the main empirical implications of our model taking into account the general equilibrium effect of input tariff changes on the survival productivity cutoff to produce in the informal sector.

3 Empirical implications

In order to study the impact of input liberalization on the labor demand of formal and informal firms, we analyze the effect of changes in input tariffs on the probability of producing in the formal and informal sector.

Input trade liberalization increases the probability of being a formal firm producing with imported intermediate goods. Input tariff cuts imply a reduction of the relative costs of foreign inputs vis-a-vis domestic ones. The probability of producing in the formal sector is determined by the relationship between the two productivity cutoffs defined in equation (5): $\rho_f = \left(\varphi_f^*/\varphi_i^*\right)^{-k}$. This equation shows that the probability of producing in the formal sector is a function of fixed production costs, fixed labor regulation costs, input tariffs and the complementarity parameter. The probability of producing in the formal sector ρ_f is a decreasing function of input tariff: $\partial\rho_f/\partial\tau_m < 0$. Using equation (5), we can express this probability as a function of the relative unit cost of formal

[6]The ranking condition that ensures that $\varphi_f^* > \varphi_i^*$ is given by $f_r > f\left(\left(\frac{C_f}{C_i}\right)^{1-\sigma} - 1\right)$.

firms relative to informal ones that depends on input tariffs: $\rho_f = (f_f/f)^{\frac{-k}{\sigma-1}} \left((C_f/C_i)^{1-\sigma} - 1\right)^{\frac{-k}{1-\sigma}}$. From equation 2, we know that $\partial \frac{C_f}{C_i}/\partial \tau_m > 0$, thereby, $\partial \rho_f/\partial \tau_m < 0$, since $\sigma > 1$. In the simple setting with homogeneous labor, input tariff cuts increase the likelihood of firms to produce in the formal sector increasing labor demand in the formal sector.

Testable implication 1: *Input trade liberalization increases labor demand in the formal sector.*

In the extension of the model with heterogeneous labor, under the assumption that imported inputs are complementary with skilled labor, input-trade liberalization enhances the cost-advantage of skilled intensive firms producing in the formal sector. Thereby, input tariff cuts reduce the relative unit costs of producing in the formal sector, increasing profits of formal firms relative to informal firms creating incentives for firms in the informal sector to pay the fixed labor regulation costs. The increase in the number of formal firms increases the labor demand in the formal sector. Since formal firms produce with imported inputs that are skilled intensive, input tariffs reductions lead to a greater increase in the demand for skilled relative to unskilled labor in the formal sector. Moreover, most productive firms producing in the formal sector also expand thanks to input tariff reductions and increase their relative demand of skilled labor.

Testable implication 2: *Input trade liberalization increases the likelihood of an informal skilled worker to find a job in the formal sector.*

4 Trade liberalization in Mexico

The main feature of trade reform in Mexico was the substantial trade-integration process of the mid 1990s. In this section, we describe the different trade-policy instruments that were applied during the period under analysis 1993-2001.

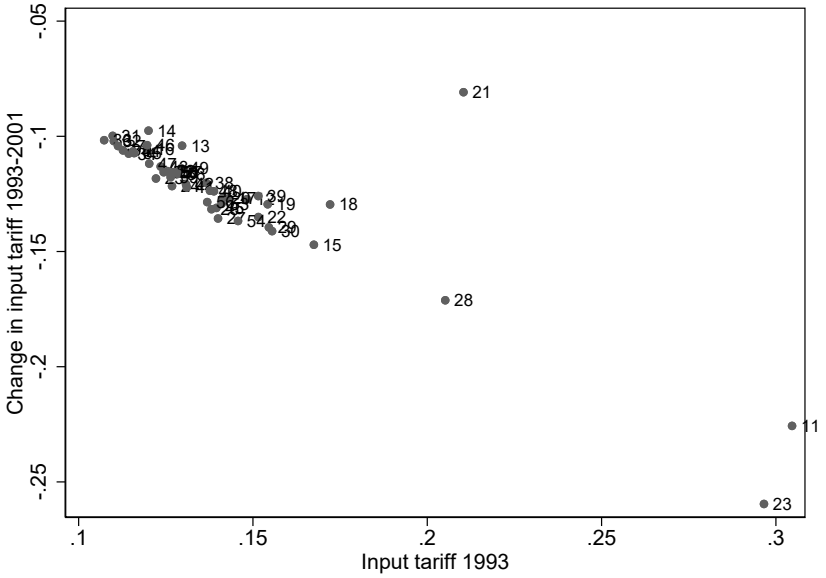
Mexico's trade policy during the 1970s and 1980s was characterized by a protectionist trade policy with an emphasis on import substitution regime. This trade regime was very restrictive, with high levels of nominal tariffs and import licenses in almost all sectors. In the 1990s Mexico started to move toward a liberalized trade regime. Mexico joined the NAFTA with the U.S. and Canada in 1994 and adopted the preferential tariff within NAFTA and the Most Favored Nation

(MFN) tariffs relative to the rest of the world. Among NAFTA members, Mexico was the country with the highest tariffs and experienced the largest cut after joining the NAFTA. Mexican import ad valorem tariffs on U.S. products at the 4-digit level come from Iacovone et al. (2015).[7] Import tariffs on U.S. imports between the initial year of the sample, 1993 in the pre-NAFTA period, and the last year of the sample, 2001, were substantially reduced. Mexico's average import tariff on U.S. products fell from more than 15 percent in 1993 to 1.5 percent in 1996.

To identify the impact of input-trade liberalization on the probability of an individual to find a formal job, we use input tariffs on U.S. imports at the 2-digit-SIC industry level. Input tariffs are computed following the methodology in Goldberg et al. (2010). Our constructed measure of intermediate good tariffs, shows an average reduction of more than 12 percentage points. Tariffs on intermediate input imported from U.S. declined from more than 14 percent in 1993 to less than 1.7 percent in 2001, with a wide variation in tariff changes across 2-digit industries. Importantly, the large disparity in industry level input tariffs at the beginning of the period diminished over time as high tariffs converged to a more uniform (low) level after accession of Mexico to the NAFTA. Figure 1 reflects this convergence in tariffs: industries with the highest initial 2 digit input tariffs, experienced the highest reduction over the period. Our identification strategy makes use of this sectoral discrepancy in input tariff reductions to capture the impact of trade liberalization on the transition from informal to formal employment.

[7] More details on Mexican tariffs data are provided in Section 5 and in Appendix B.

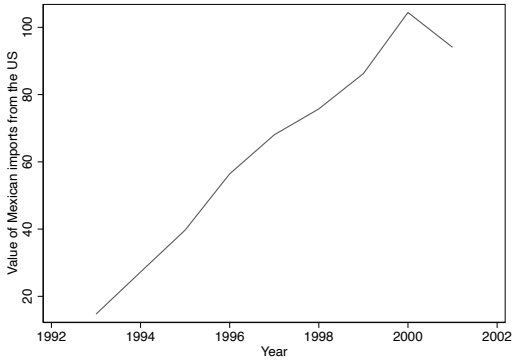
Figure 1: Input Tariff Changes and Pre-NAFTA Tariff Levels (2001-1993)



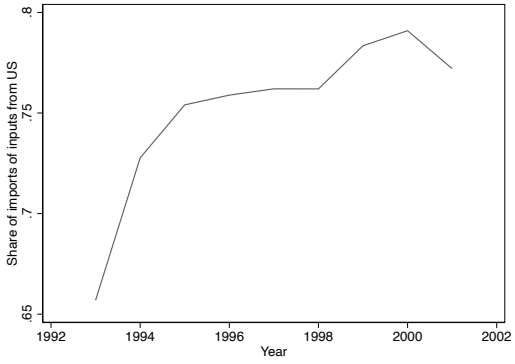
Source: Authors' calculation based on tariff data from Iacovone et al. (2015). 11 Meat and dairy products; 23 Tobacco and its products; 15 Coffee processing; 21 Bottled soft drinks; 28 Leather and leather products

These input tariff declines significantly affected the value of Mexican imports of inputs from the U.S. During the period 1993-2001, Mexico's total imports from the U.S. were expanding, with the highest expansion for imports of intermediate goods. Panel (a) in Figure 2 shows the growth of the value of total imports of Mexico from the U.S., while while panel (b) in Figure 2 presents intermediate input shares. The share of Mexican imports of intermediate goods over total imports from the U.S. increases from 65 percent in 1993 to almost 80 percent at the end of the period. Panel (c) shows that the faster increase occurred for high technology intermediate like electronic machinery and equipment.

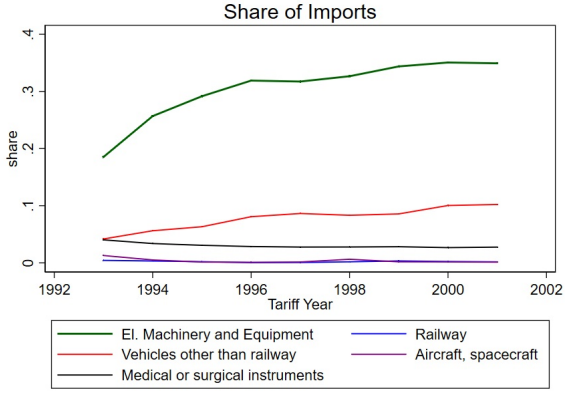
Figure 2: Mexican Imports from the U.S



(a) Total Imports



(b) Intermediate Imports



(c) Intermediate Imports

Source: Authors' calculations based on COMTRADE (WITS).

Along similar lines, Table 1 uses HS6 level data for tariffs and import flows (WITS, World Bank) to show the relationship between Mexican intermediate imports from U.S. and the corresponding import tariff applied by Mexico over the period 1993-2001. To define intermediate goods, we rely on the Broad Economic Categories (BEC) classification from United Nations. The estimates in column (2) suggest that the 12 percentage-point fall in input tariffs is estimated to increase average intermediate imports from the U.S. by 7.1 percent.

Table 1: Input tariff cuts and imports of intermediate goods from the U.S. (1993-2001)

Dependent variable:	(1) Intermediates and Capital	(2) Intermediates	(3) Parts and accessories
$\text{Tariff}_{p,t}$	-0.489***	-0.591***	-0.565***
	(0.154)	(0.172)	(0.179)
Product fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Observations	31,753	23,359	20,284
R-squared	0.773	0.763	0.738

Notes: This table presents OLS estimations at the HS6 and year level regressing import value of Mexico from the U.S. on HS6 import tariffs. We rely on the Broad Economic Categories (BEC) classification of intermediate and capital goods. Heteroskedasticity-robust standard errors clustered by 2 digit sector are reported in parentheses.

4.1 Exogeneity of input tariffs

Previous works on trade liberalization and firm performance address issues of potential endogeneity between changes in trade policy and industry performance, and verify that tariffs were set independently of industries' size and lobbying activities (Topalova and Khandelwal, 2011). In our context, we argue that it is unlikely that import tariff between the U.S./Canada and Mexico set during the trade agreement in 1994 are driven by political pressures of Mexican industries since when Mexico joined the NAFTA the Mexican government had to adopt the existent preferential tariff within the NAFTA agreement.

As a further test of the exogeneity of input tariffs, we follow the previous literature and examine the correlation of input tariff changes with initial industry performance. Tariff cuts after 1994 are set in the accession agreement; we therefore use data for 1993 in order to capture initial sectoral performances. We regress changes in input tariffs between 1993-2001 on a number of industry characteristics for the pre-NAFTA accession, 1993, such as the formal worker share, the size of the industry, and the average level of skilled labor. Our results presented in Table 2 show the absence of statistically correlation between Mexican's input tariff cuts and preexisting industry trends. We rely on this exogenous variation of input tariffs across Mexican industries to study the causal effect of input-trade liberalization on the reallocation of workers from informal to formal employment. Moreover, our estimations are robust to the inclusion of industry-trends that capture unobservable time-varying industry level shocks that might co-vary with input tariff changes.

Table 2: Changes in input tariffs and initial industry characteristics (1993-2001)

Dependent variable	Formal worker share$_{s,93}$	Size$_{s,93}$	Skilled labor$_{s,93}$
	(1)	(2)	(3)
Change input tariff$_{s,01-93}$	0.629	-1.021	3.869
	(0.852)	(2.917)	(4.618)
Observations	66	66	66
R-squared	0.009	0.000	0.016

Notes: Columns (1) to (3) regress the change in Mexican input tariffs on a measure of the share of formal employment in an industry, industry size, and level of education respectively. Heteroskedasticity-robust standard errors clustered by 2 digit sector are reported in parentheses.

5 Data and trends on the informal sector in Mexico

5.1 Mexican import tariffs

Mexican import ad-valorem tariffs on U.S. products at the 4-digit level follow CAE classification. Tariff data were originally available at the 8-digit Harmonized System (HS), and are matched to the Mexican CMAP classification as explained in Iacovone et al. (2015). We use a correspondence table to link tariff classification at the CMAP to ENEU industry-employment classification at the CAE level. Since CMAP classification is more disaggregated than the CAE classification, we take a simple average of CMAP tariffs to obtain Mexican import tariffs at the 4-digit of the CAE classification.

Using the above Mexican import tariffs at the 4-digit we build our measure of input tariffs. Specifically, intermediate input tariff changes are computed at the 2 digit industrial classification (SIC) of the Mexican 1980 Input-Output table for a total of 49 manufacturing input sectors.[8]

5.2 ENEU Survey

This work relies on households survey data on socio-economic characteristics from the National Urban Employment Survey (ENEU). This is a quarterly household labor force survey conducted

[8]Input tariff faced by final good producer in industry s is measured as a weighted average of the output tariffs at the 4-digit industry, τ_s, for every period,

$$\begin{aligned} \text{input tariff}_s &= (w_{s1}\tau_1 + w_{s2}\tau_2 + w_{s3}\tau_3 + \ldots + w_{sn}\tau_n) \\ &= \sum_i (w_{si}\tau_i), \end{aligned} \tag{6}$$

where the weight w_{si} is the share of input s in total inputs' cost of output i computed using Mexico 1980 Input-Output table at the 2 digit.

by the Mexican National Institute of Statistics (INEGI) in major metropolitan areas. The ENEU survey is representative of cities with over 100,000 inhabitants, and covers only urban areas. In 1993 the quarterly household interviews included 34 major metropolitan areas. Over time more urban areas were introduced in the sample to reach 44 cities by 2001. We choose to keep in our sample all metropolitan areas reported in each year over the period 1993-2001.

This survey provides information on household members' socio-economic characteristics traditionally found in employment surveys. The questionnaire is extensive in its coverage of participation in the labor market, wages, hours worked, industry affiliation at the 4-digit level classification actividades economicas (CAE) and location at the municipality level. The information reported in the survey takes the week prior to the week of the survey as a reference. This survey has been used by previous studies such as Robertson (2004), Verhoogen (2008), Bosch and Manacorda (2010) and Ben Yahmed and Bombarda (2020).

Our sample focus on individuals between 16 and 60 years of age. In our baseline estimations, we distinguish two types of employment: formal and informal wage employment. Wage workers are those individuals reporting to have a fixed wage, salary or daily wage. Then, to distinguish between formal and informal workers we consider social security coverage. Specifically, we define formal employment as those wage workers that have social security coverage. Descriptive statistics on formal and informal employment is provided in Table B.2 in the Appendix. Since the ENEU survey does not allow us to clearly distinguish between formal and informal self-employment, in our baseline estimations we exclude self-employment and only consider formal and informal wage workers. In a robustness test, we present results with an alternative definition of informal employment that includes both informal wage employment and self-employment.

Since ENEU is a survey and information on formality and informality statuses are self-reported, this could generate possible measurement error and under-reporting. Thus, it is reassuring that with the ENEU survey we can reproduce national statistics on informality. This replication improves when we treat self-employed workers as informal.[9] Other statistics on informality (Perry et al., 2007 and Gasparini and Tornarolli, 2009 among others) find that 55% of the labor force is informal. Using ENEU data, and including self employed in our informality measure, we find 48% are informal, in the pool of wage workers and self employed. Table B.2 provides in sample

[9]Self-employed individuals report being own-account workers (trabajador por su cuenta) as their main job. When including self employment in our measure of informality, we exclude those self employed that declares to be employer (patron). Self-employed individuals own very small businesses, and more than 80 percent of them have just one or no employees.

descriptive statistics. Finally, we complement the ENEU survey using Mexican CENSUS data to obtain information on employment at the CMAP level, to construct the share of employment at the CAE industry level.

5.3 Input trade liberalization and formal employment in Mexico

Figure 3 shows the evolution of formal employment in the manufacturing sector for industries that have the largest input tariff reductions (above the median) and for industries with the lowest input tariff cuts (below the median). The formal employment in the manufacturing sector has increased during the period of analysis for all industries. However, Figure 3 reveals that industries with the largest input tariff cuts have the greater increase in formal employment.

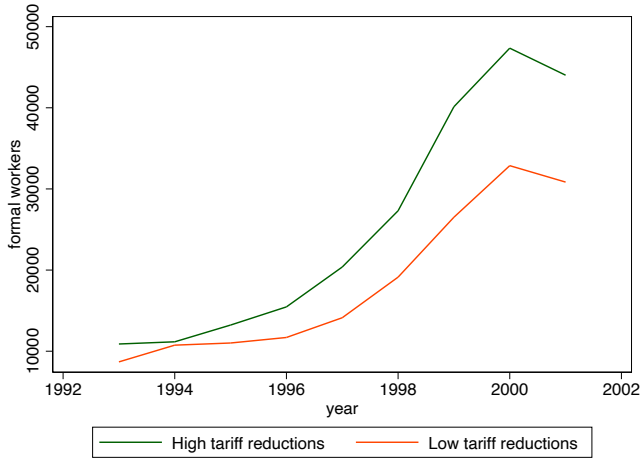


Figure 3: Employment Trends

6 Identification strategy

We investigate the relationship between input trade liberalization and the reallocation of labor from informal to the formal firms. Our identification strategy exploits the exogenous and heterogeneous reduction of input tariffs applied by Mexico to the United States across industries over time after Mexico joined the NAFTA in 1994. We estimate the following linear probability model on the sample of formal and informal workers in manufacturing industries to test the first empirical implication of our framework:

$$F_{isrt} = \alpha + \beta_1 \tau_{I,st} + \beta_2 \tau_{O,st} + \beta_3 Ind_{st} + \mathbf{X_{isrt}}\kappa + \alpha_i + \mu_s + \gamma_{ft} + \theta_{qt} + \epsilon_{isrt}, \tag{7}$$

where F_{isrt} is an indicator variable that takes the value one if individual i is employed as a formal worker in industry s, municipality r, at time t, and zero if the individual works as an informal employee. $\tau_{I,st}$ are the input tariffs at the 4-digit industry level set by Mexico to the United States. All our estimations control for the output tariffs set by Mexico to the United States at the 4-digit industry level ($\tau_{O,st}$), and industry characteristics (Ind_{st}) which includes average education level of the 4-digit industry, and 4-digit industry-size trends.[10] We also take into account differences in worker composition across employers and sectors that might change over time and that could also have an impact on the allocation of workers between the formal and informal firms by including individual worker characteristics. $\mathbf{X_{isrt}}$ are a set of individual characteristics as age square, couple, head of the household, the number of household members, the highest level of education in the household, and the share of household members holding a formal job.

ENEU household survey has the advantage of being representative at the city level and have information on informal employment in Mexico. However, since this survey is a repeated cross section, we need to rely on pseudo-panel methods to estimate individual fixed effects models when only independent repeated cross-sectional data are available (Guillerm, 2017). Thus, in all our estimations we include pseudo individual fixed effects, α_i. These pseudo individual fixed effects are based a detailed cohort effect composed of individual characteristics such as year of birth, gender, municipality, migration and years of education. We also control for time-invariant industry characteristics including a 4-digit industry fixed effects, μ_s and for unobservable time-variant regional characteristics including a region-year fixed effects (32 federal entities), γ_{ft}. Finally, we include in all estimations quarter-year fixed effects θ_{qt}. Standard errors are clustered at the 2-digit industry level.

Our empirical identification strategy identifies the coefficient on input tariffs by comparing the effects of exogenous input tariff cuts across industries over time on the probability of workers to find a formal job for workers with the same observable time variant and invariant characteristics located in the same regional labor markets and year.

6.1 Pre-trend test

In this section we address possible identification threats that may arise from pre-existing trends, and show that our results are not driven by pre-existing trends. Since Mexico's tariffs reduction

[10]The share of employment in the industry comes from the CENSUS data. To avoid endogeneity issues, we use the initial year, 1994, and then we interact it with time trends.

were occurring from the 80's, it seems crucial to propose a model that allows to check for anticipatory effects in reallocation from informal to formal (i.e. Angrist and Pischke, 2008). Thus, we combine ENEU employment data for the period before NAFTA, 1987-1992, with our tariffs measures over the period 1993-2001.

Note that our identification strategy is not a traditional difference-in-difference estimation as the treatment (i.e., the decrease in input tariffs) affects the treated group (workers in industries with larger input tariff cuts) over time. Therefore, in order to check for the existence of pre-trends in labor markets we estimate equation (7) for the periods before the treatment (input-tariff liberalization) and check if the input tariff changes between 1993 and 2001 are related to the period 1987-1992, which is before treated units (industries) actually become treated (affected by input trade reform). Results presented in Table 3 show that input tariff measures during the reform period (1993-2001) are not affecting the reallocation of workers from informal to formal sector in the pre-reform period (1987-1992).

Table 3: Pre-trend test

Dependent variable	Indicator for working in a formal firm			
	(1)	(2)	(3)	(4)
Input tariff(s,t)	-0.099	0.194	0.209	0.211
	(0.198)	(0.299)	(0.319)	(0.320)
Output tariff(s,t)		-0.173	-0.145	-0.139
		(0.110)	(0.115)	(0.114)
age^2			-0.001***	-0.001***
			(0.000)	(0.000)
couple			0.021***	0.019***
			(0.006)	(0.006)
Head of household			0.024***	0.034***
			(0.007)	(0.009)
Size of the family			-0.001	-0.005***
			(0.001)	(0.001)
Family members with a formal job				0.063***
				(0.015)
Family' highest level of educ				0.000
				(0.000)
4-digit sector FE	Yes	Yes	Yes	Yes
Pseudo individual FE	Yes	Yes	Yes	Yes
State-year FE	Yes	Yes	Yes	Yes
Quarter-year FE	Yes	Yes	Yes	Yes
Observations	231,165	231,165	231,165	231,165
R-squared	0.336	0.336	0.339	0.343

Notes: The dependent variable is an indicator for whether an individual is a formal wage worker, and it takes 0 if the individual is in informal wage employment. Pseudo individual FE include birth, gender, municipality, migration, and school. All regressions include additional worker characteristics (age square and highest level of education in the household), and sector characteristics. Heteroskedasticity-robust standard errors clustered by sector are reported in parentheses.

7 Input-trade liberalization effects on informality

7.1 Baseline results

This section discusses the estimation results for equation (7) by linear probability model (LPM). Results presented in column (1) of Table 4 show that workers employed in industries that faced greater input tariff cuts experienced larger increases in the probability of employment in the formal sector relative to workers producing in industries with smaller input tariff reductions. Column (2) controls for the foreign competition effect by including final goods tariffs applied by Mexico to the U.S. in the period under analysis. Our findings show that foreign competition did not play a

role on the reallocation of workers between formal and informal firms. Our coefficient of interest on input tariffs remains robust to the inclusion of output tariffs. Columns (3) and (4) include several observable worker characteristics that could also affect the allocation of workers between the formal and informal firms. Results show that being head of the household, being in couple or having a large share of family members with a formal job increases the likelihood of working in the formal sector, while the size of the family reduces this probability.

One of the challenges in the investigation of the relationship between input-tariff reductions and allocation of workers between formal and informal jobs is the potential omitted variable bias that could arise if there are industry-specific time-varying unobservable factors that covary with changes in input tariff across industries and independently affect the probability to be a formal wage worker. We take into account this issue by controlling for observable 4-digit industry characteristics varying over time. In column (5), we control for the skilled intensity of the industry by including the average level of education of the sector as well as for initial 4-digit industry size trend measured by number of workers and the share of establishments in the industry in the initial year.

Our findings are robust and stable to those controls and show that workers employed in industries with larger input tariff changes have a higher likelihood of being employed in the formal sector with respect to workers with similar observable characteristics employed in industries that faced lower input tariff cuts. In column (6), we go one step further and also control for 2-digit industry trends that allow to deal with the potential spurious correlation between input tariff changes across 4-digit industries and other contemporaneous industry-specific changes as other reforms or unobservable sectoral shocks. Our main findings about the effects of input tariff cuts on the probability of being employed as a formal wage worker are robust to the inclusion of industry trends.

The estimated coefficient in column (6) show that workers in industries that faced greater reductions in input tariffs, 12 percentage points, experienced 4.2 percentage points increase in the probability of being employed as formal workers relative to observationally equivalent workers in industries with lower tariff cuts. This evidence supports our first empirical implication that states that input-trade liberalization increases formal employment.

Table 4: The effects of input-trade liberalization on formal employment

Dependent variable	Indicator for working in a formal firm					
	(1)	(2)	(3)	(4)	(5)	(6)
Input tariff(s,t)	-0.472**	-0.566**	-0.483**	-0.474**	-0.420**	-0.356**
	(0.192)	(0.242)	(0.217)	(0.210)	(0.175)	(0.177)
Output tariff(s,t)		0.065	0.067	0.072	0.087	0.095
		(0.099)	(0.103)	(0.101)	(0.095)	(0.081)
age^2			-0.000***	-0.000***	-0.000***	-0.000***
			(0.000)	(0.000)	(0.000)	(0.000)
couple			0.020***	0.016***	0.016***	0.016***
			(0.006)	(0.006)	(0.006)	(0.006)
Head of household			0.035***	0.043***	0.043***	0.043***
			(0.010)	(0.011)	(0.011)	(0.011)
Size of the family			-0.000	-0.005***	-0.005***	-0.005***
			(0.001)	(0.001)	(0.001)	(0.001)
Family with a formal job				0.055***	0.055***	0.055***
				(0.013)	(0.013)	(0.013)
Family's highest level of educ				-0.000	-0.000	-0.000
				(0.000)	(0.000)	(0.000)
Average years of educ. industry					0.006***	0.006***
					(0.002)	(0.002)
4-digit industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Pseudo individual FE	Yes	Yes	Yes	Yes	Yes	Yes
State-year FE	Yes	Yes	Yes	Yes	Yes	Yes
Quarter-year FE	Yes	Yes	Yes	Yes	Yes	Yes
4-digit industry size trends	No	No	No	No	Yes	Yes
2-digit Industry trend	No	No	No	No	No	Yes
Observations	334,678	334,678	334,678	334,678	334,678	334,678
R-squared	0.460	0.460	0.464	0.467	0.468	0.468

Notes: The dependent variable is an indicator for whether an individual is a formal wage worker, and it takes 0 if the individual is in informal wage employment. Pseudo individual FE include birth, gender, municipality, migration, and school. All regressions include additional worker characteristics (age square and highest level of education in the household), and sector characteristics (average education). Adding CENSUS data from column 5 (4-digit industry size trends). Heteroskedasticity-robust standard errors clustered by sector are reported in parentheses.

7.2 The skilled-biased foreign input mechanism

This section test the second empirical implication of our framework through which input-trade liberalization affects the probability of a skilled informal worker to find a job in the formal sector. The literature has showed that imported inputs tend to be complementary to skilled labor in developing countries (Chen et al., 2017, Fieler et al., 2018, Bas and Paunov, 2021b among others). If foreign inputs are skilled biased, input tariff cuts increase the relative demand of skilled labor

of firms producing in the formal sector and might reduce informal employment of high-skilled workers.

To investigate the heterogeneous effects of input tariff cuts on the probability of formal employment depending on the level of education of workers, we include differential effects of input tariffs by workers' education level in our equation (7):

$$F_{isrt} = \alpha + \lambda_1 \tau_{I,st} \times High + \lambda_2 \tau_{I,st} \times Medium + \lambda_3 \tau_{I,st} \times Low + \lambda_4 \tau_{O,st} + \lambda_5 Ind_{st} + \lambda_6 X_{isrt} + \alpha_i + \mu_s + \gamma_{ft} + \theta_{qt} + \epsilon_{isrt}, \quad (8)$$

where $High$ corresponds to an indicator variable equal to one when the individual has more than 16 years of education; $Medium$ between 15 and 5; and Low less than 5 years of education. The interaction terms between input tariffs and these indicator variables, $\tau_{I,st} \times High$; $\tau_{I,st} \times Medium$, and $\tau_{I,st} \times Low$, measure the heterogeneous effect of input tariffs on the probability that an individual gets a formal job depending on workers' education level.

Table 5 presents the results. Estimates confirm that the effect of input-trade liberalization on the likelihood of becoming a formal wage worker is heterogeneous across workers with different skills. The coefficients in column (5) of Table 5 are comparable with those in column (6) of Table 4 that shows that an industry that experienced the average reduction in input-tariffs of 12 percentage points increases by 4.2 percent points the probability of working in a formal employment relative to an industry facing no reduction in input-tariffs. Column (5) in Table 5 shows that this probability increases to 5.2 percentage points for workers with more than 16 years of education.[11] A Wald test reveals that the equality between coefficients of input tariffs across skills is rejected. These findings suggest that foreign inputs-skilled biased mechanism is the channel through which input trade liberalization induced the reallocation of workers from informal to formal firms.

[11] As shown in Table B.2, high educated workers correspond to 15 percent of our estimating sample.

Table 5: The effects of input trade liberalization on formal employment depending on the skills

Dependent variable	Indicator for working in a formal firm				
	(1)	(2)	(3)	(4)	(5)
Input tariff(s,t) × High Skill	-0.363**	-0.471**	-0.466**	-0.468**	-0.437**
	(0.173)	(0.202)	(0.202)	(0.199)	(0.170)
Input tariff(s,t) × Medium Skill	-0.433**	-0.541**	-0.392*	-0.385*	-0.354*
	(0.214)	(0.247)	(0.216)	(0.211)	(0.180)
Input tariff(s,t) × Low Skill	-0.228	-0.336	-0.345	-0.339	-0.312*
	(0.162)	(0.201)	(0.218)	(0.213)	(0.182)
Output tariff(s,t)		0.076	0.078	0.082	0.095
		(0.088)	(0.088)	(0.087)	(0.081)
age^2			-0.000***	-0.000***	-0.000***
			(0.000)	(0.000)	(0.000)
couple			0.020***	0.016***	0.016***
			(0.006)	(0.006)	(0.006)
Head of household			0.035***	0.042***	0.043***
			(0.010)	(0.011)	(0.011)
Size of the family			-0.000	-0.005***	-0.005***
			(0.001)	(0.001)	(0.001)
Family members with a formal job				0.055***	0.055***
				(0.013)	(0.013)
Highest level of educ in the family				-0.000	-0.000
				(0.000)	(0.000)
Family' highest level of educ					0.005***
					(0.002)
4-digit sector FE	Yes	Yes	Yes	Yes	Yes
Pseudo individual FE	Yes	Yes	Yes	Yes	Yes
State-year FE	Yes	Yes	Yes	Yes	Yes
Quarter-year FE	Yes	Yes	Yes	Yes	Yes
2-digit industry trend	Yes	Yes	Yes	Yes	Yes
4-digit industry size trends	No	No	No	No	Yes
Observations	334,678	334,678	334,678	334,678	334,678
R-squared	0.460	0.460	0.464	0.468	0.468

Notes: The dependent variable is an indicator for whether an individual is a formal wage worker. Pseudo individual FE include birth, gender, municipality, migration, and school. All regressions include additional worker characteristics (age square and highest level of education in the household), and sector characteristics. CENSUS data are used in column 5 (4-digit industry size trends). Heteroskedasticity-robust standard errors clustered by sector are reported in parentheses.

8 Controlling for alternative explanations

This section presents a set of sensitivity estimations that test for alternative explanations that can explain the reallocation of workers from informal to formal employment in Mexico in the 1990s.

The first one is the reduction of trade variable costs faced by Mexican exporters when they sell their goods in the U.S. market. The second explanation relies on the heterogeneous effect of the reform depending on firm size. The last one explores the role of maquiladoras during input-trade liberalization.

8.1 Market access

Expansion of export opportunities due to foreign demand shocks might also increase the labor demand of more productive firms producing in the formal sector and induce a reallocation of workers from informal to the formal sector. McCaig and Pavcnik (2018) study this channel relying on households survey data from Vietnam and changes in U.S. tariffs on Vietnamese exports in the context of the 2001 U.S.-Vietnam Bilateral Trade Agreement. They show that this export shock induced allocation of labor across the informal microenterprise and formal sectors.

Our previous results could also be explained by the expansion of foreign market access for Mexican firms selling in the United States due to changes in import tariff set by the United States to Mexico. We test for this alternative explanation by including in the previous estimations the export tariffs faced by Mexican firms when exporting to the U.S.[12] As described in section 4, Mexico was the country among the NAFTA members with the highest import tariffs and the one that experienced the greatest tariff cuts after joining the NAFTA, while the import tariff set by the U.S. to Mexico experienced lower reduction. During the period under analysis, the import tariff set by Mexico to the United States was reduced by 15 percentage points and the import tariff set by the United States to Mexico was only reduced by 1.6 percentage points. Table 6 presents the results. Export tariff have a negative but not significant sign. Our results on input trade liberalization remain stable and robust suggesting that they do not pick up the effects of market access.

[12]U.S. import tariff data are from Feenstra, Romalis, and Schott (2002).

Table 6: The role of market access

Dependent variable	Indicator for working in a formal firm			
	(1)	(2)	(3)	(4)
Input tariff(s,t)	-0.564**	-0.417**	-0.357**	
	(0.245)	(0.177)	(0.177)	
Input tariff(s,t) × High Skill				-0.437**
				(0.170)
Input tariff(s,t) × Medium Skill				-0.354*
				(0.180)
Input tariff(s,t) × Low Skill				-0.312*
				(0.182)
Output tariff(s,t)	0.075	0.095	0.101	0.101
	(0.094)	(0.093)	(0.080)	(0.080)
Export tariff(s,t)	-0.127	-0.117	-0.094	-0.094
	(0.105)	(0.084)	(0.085)	(0.085)
age^2		-0.000***	-0.000***	-0.000***
		(0.000)	(0.000)	(0.000)
couple		0.016***	0.016***	0.016***
		(0.006)	(0.006)	(0.006)
Head of household		0.043***	0.043***	0.043***
		(0.011)	(0.011)	(0.011)
Size of the family		-0.005***	-0.005***	-0.005***
		(0.001)	(0.001)	(0.001)
Family members with a formal job		0.055***	0.055***	0.055***
		(0.013)	(0.013)	(0.013)
Family' highest level of educ		-0.000	-0.000	-0.000
		(0.000)	(0.000)	(0.000)
Average years of educ. industry		0.006***	0.006***	0.005***
		(0.002)	(0.002)	(0.002)
4-digit sector FE	Yes	Yes	Yes	Yes
Pseudo individual FE	Yes	Yes	Yes	Yes
State-year FE	Yes	Yes	Yes	Yes
Quarter-year FE	Yes	Yes	Yes	Yes
4-digit industry size trends	No	Yes	Yes	Yes
2-digit industry trend	No	No	Yes	Yes
Observations	334,678	334,678	334,678	334,678
R-squared	0.460	0.468	0.468	0.468

Notes: The dependent variable is an indicator for whether an individual is a formal wage worker, and it takes 0 if the individual is in informal wage employment. Pseudo individual FE include birth, gender, municipality, migration, and school. All regressions include additional worker characteristics (age square and highest level of education in the household), and sector characteristics (average education). Adding CENSUS data from column 2 (4-digit industry size trends). Heteroskedasticity-robust standard errors clustered by sector are reported in parentheses.

8.2 Controlling for firm size

This section explores if the heterogeneous effect of input trade liberalization on formal employment depending on skill is driven by the size of the firm the individual is employed. More skilled intensive firms tend to be larger relative to less skilled intensive firms since larger firms have more revenues to afford workers with a higher level of qualification.

First, we test the effect of input trade liberalization on the probability of being a formal wage worker conditional on firm size. To control for firm size, we exploit the information in ENEU survey, which asks the firm size where each individual works. We compute five firm-size categories: 1) firms with 2 to 5 employees, 2) firms with 6 to 10 employees, 3) firms with 11 to 50 employees, 4) firms with 51 to 250 employees, and finally 5) firms with more than 250 employees. Results are presented in columns (1) to (3) of Table 7. As expected workers in larger firms have a higher likelihood of being employed as formal wage workers. Next, we investigate if the previous findings on the heterogeneous effect of input tariff cuts depending on workers skills are driven by differences in firm size. Thus, we extend equation (8) to include an interaction term between input tariff and firm size in column (5). This interaction term is not significant suggesting no differential effect of input trade liberalization on the allocation of workers from informal to formal status depending on firm size. Moreover, our previous findings on the differential impact depending on the level of education of workers presented in column (5) show that the effect of input trade liberalization is only significant for high and medium skill workers. These results confirm that our results do not pick up either differences in firm size nor differences in the effect of input tariff cuts according to the size of the firm.

Table 7: Controlling for firm size

Dependent variable	Indicator for working in a formal firm				
	(1)	(2)	(3)	(4)	(5)
Input tariff(s,t)	-0.541**	-0.422**	-0.357**		
	(0.221)	(0.161)	(0.161)		
Input tariff(s,t) × High Skill				-0.413**	-0.498*
				(0.165)	(0.253)
Input tariff(s,t) × Medium Skill				-0.363**	-0.445*
				(0.160)	(0.240)
Input tariff(s,t) × Low Skill				-0.301*	-0.379
				(0.171)	(0.250)
Firm size(t)	0.001***	0.001***	0.001***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Input tariff(s,t) x Firm size(t)					0.001
					(0.001)
Output tariff(s,t)	0.113	0.133*	0.139**	0.140**	0.128**
	(0.080)	(0.071)	(0.062)	(0.063)	(0.059)
Export tariff(s,t)		-0.082	-0.057	-0.057	-0.087
		(0.080)	(0.076)	(0.076)	(0.091)
age^2		-0.000***	-0.000***	-0.000***	-0.000***
		(0.000)	(0.000)	(0.000)	(0.000)
couple		0.014***	0.014***	0.014***	0.014***
		(0.005)	(0.005)	(0.005)	(0.005)
Head of household		0.037***	0.037***	0.037***	0.037***
		(0.009)	(0.009)	(0.009)	(0.009)
Size of the family		-0.004***	-0.004***	-0.004***	-0.004***
		(0.001)	(0.001)	(0.001)	(0.001)
Family members with a formal job		0.048***	0.048***	0.048***	0.048***
		(0.011)	(0.011)	(0.011)	(0.011)
Family' highest level of educ		-0.000	-0.000	-0.000	-0.000
		(0.000)	(0.000)	(0.000)	(0.000)
Average years of educ. industry		0.005***	0.005***	0.005***	0.004**
		(0.002)	(0.001)	(0.001)	(0.002)
4-digit sector FE	Yes	Yes	Yes	Yes	Yes
Pseudo individual FE	Yes	Yes	Yes	Yes	Yes
State-year FE	Yes	Yes	Yes	Yes	Yes
Quarter-year FE	Yes	Yes	Yes	Yes	Yes
4-digit industry size trends	No	Yes	Yes	Yes	Yes
2-digit industry trend	No	No	Yes	Yes	Yes
OObservations	334,162	334,162	334,162	334,162	334,162
R-squared	0.498	0.503	0.503	0.503	0.503

Notes: The dependent variable is an indicator for whether an individual is a formal wage worker. Pseudo individual FE include birth, gender, municipality, migration, and school. All regressions include additional worker characteristics (age square and highest level of education in the household), and sector characteristics (average education). Adding CENSUS data from column 2 (4-digit industry size trends). Heteroskedasticity-robust standard errors clustered by sector are reported in parentheses.

8.3 Controlling for the role of maquiladoras

NAFTA allowed Northern Mexico to became an export processing zone. Thus, US multinational firms could set affiliates in Mexico to produce cheaply. In fact, US multinational firms could use maquiladoras factories to import intermediates and produce (assemble) a good more cheaply than in the US and paying less import duties. These plants might benefit more from input U.S. tariff cuts than Mexican firms.

This section presents robustness checks that control for the role of maquiladoras in two different ways. First, since these maquiladoras are located near the United States-Mexico border, we rely on the location of workers and test if the effect of input trade liberalization on the probability of employment as a formal wage workers is driven by the location of workers near the U.S.- Mexico border. Then, we construct an alternative variable to capture maquiladoras, which relies on the following question in the ENEU survey "the person for which you work is a maquilador or a contractor?". Results are presented in Table 8 and show that maquiladoras do not play a role on the effects of input trade liberalisation on the allocation of workers between the informal and formal wage working status. Thus, when controlling for the role of maquiladoras, our findings remain robust and stable.

Table 8: Controlling for the role of maquiladoras

Dependent variable	Indicator for working in a formal firm			
	(1)	(2)	(3)	(4)
Input tariff(s,t)	-0.397*		-0.325*	
	(0.206)		(0.177)	
Input tariff(s,t) x Border	0.272	0.273		
	(0.241)	(0.240)		
Input tariff(s,t) x Maquiladora			-0.363	-0.368
			(0.703)	(0.704)
Maquiladora			-0.410***	-0.409***
			(0.039)	(0.039)
Input tariff(s,t) × High Skill		-0.480**		-0.405**
		(0.199)		(0.170)
Input tariff(s,t) × Medium Skill		-0.394*		-0.321*
		(0.208)		(0.180)
Input tariff(s,t) × Low Skill		-0.354		-0.285
		(0.213)		(0.182)
Output tariff(s,t)	0.098	0.098	0.084	0.084
	(0.080)	(0.080)	(0.078)	(0.078)
Export tariff(s,t)	-0.103	-0.103	-0.097	-0.097
	(0.086)	(0.086)	(0.086)	(0.086)
age^2	-0.000***	-0.000***	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
couple	0.016***	0.016***	0.016***	0.016***
	(0.006)	(0.006)	(0.005)	(0.005)
Head of household	0.042***	0.043***	0.042***	0.042***
	(0.011)	(0.011)	(0.011)	(0.011)
Size of the family	-0.005***	-0.005***	-0.005***	-0.005***
	(0.001)	(0.001)	(0.001)	(0.001)
Family members with a formal job	0.055***	0.055***	0.055***	0.055***
	(0.013)	(0.013)	(0.013)	(0.013)
Family' highest level of educ	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Average years of educ. industry	0.005***	0.005***	0.005***	0.005***
	(0.002)	(0.002)	(0.002)	(0.002)
4-digit sector FE	Yes	Yes	Yes	Yes
Pseudo individual FE	Yes	Yes	Yes	Yes
State-year FE	Yes	Yes	Yes	Yes
Quarter-year FE	Yes	Yes	Yes	Yes
4-digit industry size trends	Yes	Yes	Yes	Yes
2-digit industry trend	Yes	Yes	Yes	Yes
Observations	334,678	334,678	334,678	334,678
R-squared	0.468	0.468	0.470	0.470

Notes: The dependent variable is an indicator for whether an individual is a formal wage worker. Pseudo individual FE include birth, gender, municipality, migration, and school. All regressions include additional worker characteristics (age square and highest level of education in the household), sector characteristics (average education), and CENSUS controls. Heteroskedasticity-robust standard errors clustered by sector are reported in parentheses.

9 Other robustness tests

This final section presents a series of additional robustness tests. First, we use an alternative definition of informal employment that includes both informal wage employment and self-employment. Second, we rely on a more precise pseudo individual fixed effect including information on birthplace. Finally, we present a falsification test on the transition from informal labor market to self-employment and unemployment in manufacturing sectors.

9.1 Alternative definition of informality

Following the literature (Perry et al., 2007, Dix-Carneiro et al., 2021 among others), we rely on a broader definition of informality in manufacturing sectors. This measure includes both individuals holding informal wage jobs and individuals declaring to be self-employment. In the ENEU survey, self-employed individuals are identified as those reporting as main activity to be own-account workers (trabajador por su cuenta). Notice that we exclude those self employed that declare to be employers (patron). Self-employed individuals considered in our sample own very small businesses, and more than 80 percent of them have just one or no employees. Table C.1 in the Appendix presents results accounting for this broader measure of informality. These findings show that including self-employed in our measure of informality does not alter the results. On the contrary, it increases the magnitude of the effect of input trade liberalization on skilled workers.

9.2 Alternative pseudo individual fixed effect

In this section, we exploit an additional information of the ENEU household survey, the birthplace of the individual. This information is used in the construction of the pseudo individual fixed effects, which now becomes a more precise measure of time invariant individual characteristics. However, since this information is not available for all individuals used in our manufacturing sample, this means reducing our sample size by 20 percent. Results presented in Table C.2 in the Appendix show that our baseline results are robust to this sensitivity test.

9.3 Accounting for other dimensions

In this section, we present a falsification test in which we take into account two other dimensions of the labor market within manufacturing sectors: self-employment and unemployment. Specifi-

cally, the indicator variable F_{isrt} in equation (7) will take a zeros if the individual works as self employment or as unemployed. By excluding informal wage workers from the zeros this exercise should verify whether transition is occurring from informal to formal wage workers.

Results are presented in Table C.3 in the Appendix. In all columns, the coefficient on input tariff is no longer significant. This suggests that the transition to formal employment induced by input tariff cuts is not driven by changes in employment status from self-employed or unemployed. Notice that results also hold when proposing a falsification test where we only consider transition from unemployment to formality, i.e. when we remove the self-employed from the zeros in line with Table C.1.

10 The role of local labor markets

This section presents evidence on the effects of input-trade liberalization at the regional level. A recent and growing literature on the local labor market effects of trade reforms highlights that trade liberalization, through foreign competition, affects differently workers depending on their geographical location. This variability arises due to the distinct industrial compositions of different regions (see, for instance, Topalova, 2005, McCaig, 2011, Kovak, 2013, Autor et al., 2013, Hakobyan and McLaren, 2016, Dix-Carneiro and Kovak, 2017, and Dix-Carneiro and Kovak, 2019). These works take into account the industrial distribution of labor in each region in order to evaluate the local market effects of trade liberalization across regions with different patterns of industrial specialization.

In order to take into account differences in the impacts of trade across geographic regions, we follow the existing literature and calculate a weighted average of input tariffs at the municipality level. These weights are based on the industrial distribution of labor in each municipality at the beginning of the period. Following Kovak, 2013, we construct a weighted average of input tariff only considering tradable industries active in each municipality using as weights employment shares at the municipality-industry level. We rely on constant weights based on the employment structure of each municipality, using the first year in which the municipality enters the survey in order to avoid endogeneity concerns that might arise from changes over time in the industry mix

within a municipality. The weighted average municipality input tariff is computes as follows:

$$\text{Input tariff}_{mt} = \sum_i (w_{mit_0} \times \tau_{it}), \quad \text{with} \quad w_{mit_0} = \frac{Emp_{mit_0}}{Emp_{mt_0}} \tag{9}$$

where t_0 indicates the initial year in which the municipality enters the survey, Emp_{mit_0} denotes employment in municipality m and industry i, and Emp_{mt_0} is total employment in municipality m.[13] Differently from our previous input tariff measure, the municipality tariff in equation (9) varies across municipalities and over time.

To estimate the effects of regional tariff changes on the probability of formal employment, we modify equation 7 by including the input tariffs at the municipality level, as in equation (9). Additionally, we account for time-varying observable characteristics at the municipality level, such as the average education level, and replace region-year fixed effects with municipality fixed effects.[14] The identification strategy differs from the baseline estimation since it exploits the variation in industry mixes among municipalities which allows for differential effect of liberalization across Mexican municipalities. More precisely, the local labor markets approach involves comparing the probability of individuals obtaining formal employment in municipalities experiencing substantial tariff reductions to observationally equivalent individuals in municipalities undergoing less significant tariff cuts.

The results are presented in Appendix C, Table C.4 and highlight the adjustment in local labor market in terms of formality status over the period 1993-2001. The number of observations is now significantly greater compared to previous estimations which only focused on industry-level tariffs for tradable sectors. The regional tariff used in the local labor markets approach enables the inclusion of all workers in the sample, encompassing both tradable and non-tradable industries. Our results show that local labor markets whose workers are concentrated in industries facing higher input tariffs cuts have a larger probability of finding a job in the formal sector relative to local labor markets whose workers are concentrated in industries with smaller input tariff reductions. Our findings (column 4) suggest that workers located in municipalities facing the average reduction in regional tariff, 2.8%, experience a 1.5 percent point increase in the probability of being employed as formal worker relative to observationally equivalent individuals in regions less affected. Estimates in the last column of Table C.4 show that this result is driven by high-skilled

[13] Emp_{mit_0} and Emp_{mt_0} are computed using information from the survey.

[14] Note that it is not feasible to incorporate output tariffs at the municipality level in the same estimation due to a high correlation of 0.9 between input and output tariffs at the municipality-year level.

workers. Workers with higher level of education located in municipalities facing a 2.8 percentage points reduction of input tariffs, experience a 2.6 percent points increase in the probability of being employed as formal workers, relative to observationally equivalent individuals in regions less affected. The effect is not significant for workers with lower level of education.[15]

11 Conclusion

We present new evidence on the role of input-trade liberalization on allocation of workers between informal and formal jobs. We rely on individual household data for Mexico for the period 1993-2001 when Mexico joined the NAFTA trade agreement with the U.S. and Canada. This trade agreement presents an interesting framework to explore the effects of input tariff applied by Mexico to the U.S. on informal labor markets. When Mexico enters the NAFTA agreement in 1994, it applies largest import tariff cuts relative to the other members. During the 1993-2001 period, Mexican import tariff on intermediate goods applied to the U.S. decreased by 12 percentage points and the share of imports of intermediate goods from the United States increased by more than 10 percentage points in this period.

Our findings suggest that input-trade liberalization increases the probability that a worker in the informal sector finds a job in a formal manufacturing firm. Our theoretical framework suggests that the channel through which input tariff cuts induce the allocation from informal to formal employment is related to the complementarity between foreign inputs and skilled labor. Input-trade liberalization enables more productive firms in the formal sector to adopt skilled-biased foreign technology, thereby increasing the demand for skilled workers and prompting the reallocation of highly educated workers from the informal sector to formal firms.

By investigating an unexplored channel through which trade integration might positively affect the reallocation toward formal employment, this work complement the important debate about the effects of trade reforms in developing countries. In Mexico, access to better technologies, induced by trade liberalization, generates a movement from informal to formal employment. Given the prevalence of informality in Mexico, as well as in other low income countries, further exploration of the interaction between this type of market imperfection and openness seem to be an important area of research.

[15]The results presented in Table C.4 remain consistent even when constructing the local tariff at the level of the federal states.

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Appendices

A Theoretical Derivation

Preferences. The representative household allocates consumption from among the range of differentiated varieties of final goods ω . Consumer preferences are assumed to take the Constant Elasticity of Substitution (CES) utility function: $U = \left[\int_{\omega\in\Omega} q(\omega)^{\frac{\sigma-1}{\sigma}} d\omega\right]^{\frac{\sigma}{\sigma-1}}$, where $\sigma > 1$ is the elasticity of substitution between two varieties and Ω the set of available varieties. The optimal demand function for each differentiated variety is given by: $q(\omega) = Q\left[\frac{p(\omega)}{P}\right]^{-\sigma}$, where $Q \equiv U$ is the aggregate consumption of available varieties, P the price index and $p(\omega)$ the price set by a firm. $R = PQ$, aggregate revenue. The price index dual to the CES utility function is $P = \left[\int_{\omega\in\Omega} p(\omega)^{1-\sigma} d\omega\right]^{\frac{1}{1-\sigma}}$.

Industry equilibrium in the downstream sector. The free entry condition below represents a relationship between the average profits and the informal sector productivity cutoff level, where the average profits are an increasing function of this cutoff. In equilibrium entry is unrestricted and the net value of entry is equal to zero. Once firms pay the sunk entry costs, entrants then draw their productivity from a known Pareto distribution function, $G(\varphi) = 1 - \left(\frac{\varphi_{min}}{\varphi}\right)^k \equiv Pr(\varphi \geq \varphi_i)$, where $k \geq 1$ is the shape parameter. Any entering firm with $\varphi < \varphi_i$ will immediately exit.

The FE condition is given by:

$$\widetilde{\pi} = \frac{\delta f_e}{1 - G(\varphi_i^*)} = \left(\frac{\varphi_i^*}{\varphi_{min}}\right)^k \delta f_e. \tag{A.1}$$

where $1 - G(\varphi_i)$ represents the ex ante probability of successful entry. Under the zero cutoff profit condition, average profits, $\pi_i(\widetilde{\varphi_i})$ and $\pi_f(\widetilde{\varphi_f})$, are a decreasing function of the respective cutoff:

$$\widetilde{\pi} = \rho_i \pi_i(\widetilde{\varphi_i}) + \rho_f \pi_f(\widetilde{\varphi_f}), \tag{A.2}$$

where $\widetilde{\varphi_i}$ and $\widetilde{\varphi_f}$ correspond to the average productivity levels of firms producing in the informal and formal sector, which depend on the productivity cutoff levels. The ex-ante probability of producing in the formal, ρ_f, and informal, ρ_i, sectors is given by $\rho_f = \frac{1-G(\varphi_f^*)}{1-G(\varphi_i^*)} = \left(\frac{\varphi_f^*}{\varphi_i^*}\right)^{-k}$, and $\rho_i = 1 - G(\varphi_i)$, respectively.

The free entry and zero cutoff profit conditions jointly determine the equilibrium cutoff level (φ_i^*). Using the Pareto distribution of productivity draws, we can solve for the average productivity for informal and formal firms, $\widetilde{\varphi_i}$ and $\widetilde{\varphi_f}$. Then using the formal firm productivity cutoff defined in equation (5), yields:

$$\varphi_i^{*k} = \frac{\sigma-1}{k-(\sigma-1)}\left[\frac{f \; + \left[\left(\frac{c_f}{c_i}\right)^{1-\sigma}-1\right]^{\frac{k}{\sigma-1}}\left(\frac{f_r}{f}\right)^{\frac{-k}{\sigma-1}}\left(\frac{\tau_f}{\tau_i}\right)^{-k} f_r}{\delta f_e}\right]\varphi_{\min}^{k}. \tag{A.3}$$

This cutoff, φ_i^*, then determines the formal firms productivity cutoff level φ_f^* defined in equation (5). This productivity cutoff is an increasing function of input tariff (τ_m). Keeping in mind that $\frac{c_f}{c_i}$ is an increasing function of τ_m, we take the partial derivative of the productivity cutoff for formal firms (φ_f^*) determined in equation (5) with respect to τ_m:[16]

$$\frac{\partial \varphi_f^*}{\partial \tau_m} = \frac{\varphi_f^*}{\varphi_i^*}\left[\frac{\partial \varphi_i^*}{\partial \tau_m} + \frac{\partial \frac{c_f}{c_i}}{\partial \tau_m}\frac{\varphi_i^*}{\left[\left(\frac{c_f}{c_i}\right)^{1-\sigma}-1\right]\left(\frac{c_f}{c_i}\right)^{\sigma}}\right] \tag{A.4}$$

Next, we partially differentiate equation (A.3) φ_i^* with respect to τ_m, to obtain $\frac{\partial \varphi_i^*}{\partial \tau_m}$:

$$\frac{\partial \varphi_i^*}{\partial \tau_m} = (-1)\left(\varphi_i^{*k}\right)^{\frac{1}{k}-1}\frac{\partial \frac{c_f}{c_i}}{\partial \tau_m}\frac{\left[\left(\frac{c_f}{c_i}\right)^{1-\sigma}-1\right]^{\frac{k}{\sigma-1}-1}\left(\frac{\tau_f}{\tau_i}\right)^{-k}\left(\frac{f_r}{f}\right)^{\frac{-k}{\sigma-1}} f_r}{\delta f_e}\left(\frac{c_f}{c_i}\right)^{-\sigma}\varphi_{\min}^{k}\left(\frac{\sigma-1}{k-(\sigma-1)}\right) < 0 \tag{A.5}$$

The inequality in (A.5) works since $\frac{\partial \frac{c_f}{c_i}}{\partial \tau_m} > 0$, $\left(\frac{c_f}{c_i}\right)^{1-\sigma} > 1$ and $\frac{\sigma-1}{k-(\sigma-1)} > 0$. Plugging equation (A.5) into equation (A.4), a sufficient condition for $\frac{\partial \varphi_f^*}{\partial \tau_m} > 0$ is:

$$\varphi_i^{*k} > \frac{\sigma-1}{k-(\sigma-1)}\left[\left[\left(\frac{c_f}{c_i}\right)^{1-\sigma}-1\right]^{\frac{k}{\sigma-1}}\left(\frac{f_r}{f}\right)^{\frac{-k}{\sigma-1}}\left(\frac{\tau_f}{\tau_i}\right)^{-k}\frac{f_r}{\delta f_e}\right]\varphi_{\min}^{k} \tag{A.6}$$

To prove that this condition holds, we plug in equation (A.6) the survival productivity cutoff φ_i^*, as determined in equation (A.3). This shows that equation (A.6) holds when:

$$f > 0. \tag{A.7}$$

[16]Partially differentiating equation (5) with respect to the input tariffs, τ_m, we find that $\partial \frac{c_f}{c_i}/\partial \tau_m > 0$ since $0 < \alpha < 1$, and $a_h > 1$.

B Descriptive Statistics

Table B.1: Summary Statistics

Panel A: Summary Statistics on ENEU data

Variable	Observations	Number per year			
	1993-2001	Mean	Std. dev.	Min	Max
Municipality	5563509	179.36	22.32	131	202
States	5563509	15.96	9.35	32	32
Industry (4-digit)	5563509	350.83	3.05	346	357

Panel B: Summary Statistics Tariffs

	1993-2001	Mean	Std. dev.	Min	Max
Input Tariff	362,850	0.052	0.044	0.004	0.305
Output Tariff	362,850	0.050	.058	0	0.5

Notes: Calculation based on the ENEU data for the period 1993-2001. Column (1) in Panel A displays the overall number of observations over the whole period. Columns (2) to (5) displays the mean, standard deviation, minimum and maximum number of municipality/industry per year. Approximately 500,000 individuals per year in the selected age group. 3,696,802 wage workers individuals over 1993-2001 period (304,461 in 1993). We use data for wage workers with non missing Mexico and US tariff information, which leaves us with 362,850 observations (Panel B). Approximately 90,000 individuals per year in the selected age group (with tariffs info), of which 70,000 are wage workers.

Table B.2: Descriptive Statistics (1993)

	Total Full (mean/sd)	Total in-sample (mean/sd)	Formal in-sample (mean/sd)	Informal in-sample (mean/sd)
Age	32.44	30.70	30.51	27.46
	(11.27)	(10.83)	(10.07)	(10.55)
Years of schooling	9.16	8.99	9.29	8.67
	(5.17)	(4.80)	(4.71)	(4.75)
Live in couple	0.57	0.57	0.58	0.43
	(0.49)	(0.49)	(0.49)	(0.50)
Number of children	1.78	1.36	0.99	1.13
	(2.27)	(1.97)	(1.60)	(1.93)
Share of workers with				
... more than 16 years of edu	0.19	0.15	0.16	0.13
... between 5 and 16 years of edu	0.63	0.70	0.71	0.71
... less than 5 years of edu	0.17	0.15	0.12	0.16
Work less than 35 hours a week	0.17	0.09	0.04	0.13
between 35 and 48 hours a week	0.49	0.60	0.76	0.60
more than 48 hours a week	0.21	0.18	0.17	0.24
Work in a firm				
... with 5 or less people	0.41	0.21	0.03	0.44
... with 6 to 50 people	0.18	0.21	0.18	0.35
... with 51 to 250 people	0.07	0.13	0.17	0.08
... with more than 250 people	0.34	0.44	0.62	0.13
Formal	0.68	0.83		
Informal	0.32	0.17		
N	505,569	39,423	23,319	4,684

Notes: Calculation based on the ENEU survey for 1993. Formality and informality measures only consider wage workers. Column 1 reports statistics for all individual in ENEU in 1993. Average informality rate over the period raises to 45% if self-employed individual (excluding employer) is also treated as an informal worker. Column 2 focuses on in sample wage worker individuals (with tariffs information). Columns 3 and 4 show individual characteristics by formality status for wage workers. Standard deviation is reported in parenthesis.

C Additional Robustness Checks

Table C.1: Accounting for self employed

Dependent variable	Indicator for working in a formal firm				
	(1)	(2)	(3)	(4)	(5)
Input tariff(s,t)	-0.348*				
	(0.187)				
Input tariff(s,t) × High Skill		-0.459**	-0.507**	-0.438**	-0.513**
		(0.178)	(0.219)	(0.175)	(0.201)
Input tariff(s,t) × Medium Skill		-0.346*	-0.439**	-0.325*	-0.398*
		(0.187)	(0.210)	(0.184)	(0.210)
Input tariff(s,t) × Low Skill		-0.285	-0.350	-0.266	-0.337
		(0.207)	(0.234)	(0.202)	(0.233)
Output tariff(s,t)	0.025	0.026	0.079	0.020	0.028
	(0.087)	(0.087)	(0.048)	(0.082)	(0.082)
Export tariff(s,t)			-0.067	-0.083	-0.091
			(0.104)	(0.161)	(0.162)
Firm size(t)			0.001***		
			(0.000)		
Input tariff(s,t) x Maquiladora				-0.720	
				(0.779)	
Maquiladora				-0.299***	
				(0.053)	
Input tariff(s,t) x Border					0.329
					(0.257)
4-digit industry size trends	Yes	Yes	Yes	Yes	Yes
4-digit sector FE	Yes	Yes	Yes	Yes	Yes
2-digit industry trend	Yes	Yes	Yes	Yes	Yes
Pseudo individual FE	Yes	Yes	Yes	Yes	Yes
State-year FE	Yes	Yes	Yes	Yes	Yes
Quarter-year FE	Yes	Yes	Yes	Yes	Yes
Pseudo birth FE	Yes	Yes	Yes	Yes	Yes
Observations	366,859	366,859	366,334	366,859	366,859
R-squared	0.543	0.543	0.593	0.544	0.543

Notes: The dependent variable is an indicator for whether an individual is a formal wage worker. Pseudo individual FE include birth, gender, municipality, migration, and school. All regressions include additional worker characteristics (age square and highest level of education in the household), sector characteristics (average education), and CENSUS controls. Heteroskedasticity-robust standard errors clustered by sector are reported in parentheses.

Table C.2: Alternative pseudo individual fixed effect

Dependent variable	Indicator for working in a formal firm				
	(1)	(2)	(3)	(4)	(5)
Input tariff(s,t)	-0.500**	-0.497**	-0.333*		
	(0.228)	(0.228)	(0.190)		
Input tariff(s,t) × High Skill				-0.447**	-0.427**
				(0.211)	(0.181)
Input tariff(s,t) × Medium Skill				-0.349	-0.329*
				(0.228)	(0.196)
Input tariff(s,t) × Low Skill				-0.298	-0.281
				(0.223)	(0.189)
Output tariff(s,t)	0.091	0.102	0.133	0.117	0.133
	(0.109)	(0.104)	(0.089)	(0.097)	(0.089)
Export tariff(s,t)		-0.137	-0.116	-0.134	-0.116
		(0.112)	(0.096)	(0.103)	(0.096)
age^2			-0.000***	-0.001***	-0.001***
			(0.000)	(0.000)	(0.000)
couple			0.018***	0.018***	0.018***
			(0.006)	(0.006)	(0.006)
Head of household			0.043***	0.043***	0.043***
			(0.011)	(0.011)	(0.011)
Size of the family			-0.005***	-0.005***	-0.005***
			(0.001)	(0.001)	(0.001)
Family members with a formal job			0.055***	0.055***	0.055***
			(0.013)	(0.013)	(0.013)
Family ' highest level of educ			0.000	-0.000	-0.000
			(0.000)	(0.000)	(0.000)
Average years of educ. industry			0.005***		0.005***
			(0.002)		(0.002)
4-digit sector FE	Yes	Yes	Yes	Yes	Yes
Pseudo individual FE	Yes	Yes	Yes	Yes	Yes
State-year FE	Yes	Yes	Yes	Yes	Yes
Quarter-year FE	Yes	Yes	Yes	Yes	Yes
4-digit industry size trends	No	No	Yes	No	Yes
2-digit industry trend	No	No	Yes	Yes	Yes
Observations	307,405	307,405	307,405	307,405	307,405
R-squared	0.499	0.499	0.506	0.506	0.506

Notes: The dependent variable is an indicator for whether an individual is a formal wage worker. Pseudo individual FE include birth, gender, municipality, migration, and school. All regressions include additional worker characteristics (age square and highest level of education in the household), and sector characteristics (average education). 4-digit industry size trends are constructed from CENSUS data. Heteroskedasticity-robust standard errors clustered by sector are reported in parentheses.

Table C.3: Falsification test: considering self-employment and unemployment

Dependent variable	Indicator for working in a formal firm			
	(1)	(2)	(3)	(4)
Input tariff(s,t)	-0.206	-0.078	-0.046	
	(0.240)	(0.206)	(0.180)	
Input tariff(s,t) × High Skill				-0.105
				(0.195)
Input tariff(s,t) × Medium Skill				-0.040
				(0.175)
Input tariff(s,t) × Low Skill				-0.028
				(0.196)
Output tariff(s,t)	-0.164	-0.150	-0.104	-0.104
	(0.145)	(0.118)	(0.116)	(0.115)
Export tariff(s,t)		0.057	0.089	0.090
		(0.166)	(0.138)	(0.139)
age^2			-0.000***	-0.000***
			(0.000)	(0.000)
couple			-0.063***	-0.063***
			(0.012)	(0.012)
Head of household			0.083***	0.083***
			(0.006)	(0.006)
Size of the family			0.002	0.002
			(0.002)	(0.002)
Family members with a formal job			0.036***	0.036***
			(0.009)	(0.009)
Family' highest level of educ			-0.002***	-0.002***
			(0.000)	(0.000)
Average years of educ. industry			0.004	0.004
			(0.003)	(0.003)
4-digit sector FE	Yes	Yes	Yes	Yes
Pseudo individual FE	Yes	Yes	Yes	Yes
State-year FE	Yes	Yes	Yes	Yes
Quarter-year FE	Yes	Yes	Yes	Yes
2-digit industry trend	Yes	Yes	Yes	Yes
4-digit industry size trends	No	No	Yes	Yes
Observations	327,482	327,482	327,482	327,482
R-squared	0.414	0.414	0.421	0.421

Notes: The dependent variable is an indicator for whether an individual is a formal wage worker, and it takes a zero if the individual is self-employment or unemployed. Pseudo individual FE include birth, gender, municipality, migration, and school. All regressions include additional worker characteristics (age square and highest level of education in the household), and sector characteristics (average education). 4-digit industry size trends are constructed from CENSUS data. Heteroskedasticity-robust standard errors clustered by sector are reported in parentheses.

Table C.4: Local labor markets

Dependent variable	Indicator for working in a formal firm				
	(1)	(2)	(3)	(4)	(5)
Input tariff(m,t)	-0.909***	-0.732**	-0.578**	-0.534*	
	(0.299)	(0.304)	(0.285)	(0.291)	
Input tariff(m,t) × High Skill					-0.925***
					(0.346)
Input tariff(m,t) × Medium Skill					-0.471
					(0.289)
Input tariff(m,t) × Low Skill					-0.442
					(0.303)
age^2		-0.000***	-0.000***	-0.000***	-0.000***
		(0.000)	(0.000)	(0.000)	(0.000)
couple		0.027***	0.018***	0.018***	0.018***
		(0.001)	(0.001)	(0.001)	(0.001)
Head of household		0.042***	0.057***	0.057***	0.057***
		(0.001)	(0.001)	(0.001)	(0.001)
Size of the family		-0.002***	-0.009***	-0.009***	-0.009***
		(0.000)	(0.000)	(0.000)	(0.000)
Family members with a formal job			0.091***	0.091***	0.091***
			(0.002)	(0.002)	(0.002)
Family' highest level of educ			-0.000***	-0.000***	-0.000***
			(0.000)	(0.000)	(0.000)
Average years of educ. industry	0.001	0.001	0.001	0.001	0.001
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Average years of educ. municipality				0.011***	0.011***
				(0.002)	(0.002)
4-digit sector FE	Yes	Yes	Yes	Yes	Yes
Pseudo individual FE	Yes	Yes	Yes	Yes	Yes
Municipality FE	Yes	Yes	Yes	Yes	Yes
Quarter-year FE	Yes	Yes	Yes	Yes	Yes
Observations	3,691,251	3,691,251	3,691,251	3,619,582	3,619,582
R-squared	0.350	0.354	0.360	0.361	0.361

Notes: The dependent variable is an indicator for whether an individual is a formal wage worker. Pseudo individual FE include birth, gender, migration, and school. All regressions include additional worker characteristics (age square and highest level of education in the household), sector characteristics (average education) and municipality characteristics (average education). Heteroskedasticity-robust standard errors clustered by municipality and year are reported in parentheses.