Highlights

Trade Liberalization and Labor Monopsony: Evidence from Chinese Firms[⋆]

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- After joining the WTO, labor markdowns fell more in labor markets exposed to larger input tariff reductions.
- This relative decline in labor markdowns is more pronounced for skill-intensive firms compared with non-skill-intensive firms.
- Firms that have a large skilled labor market share also see their markdowns decrease more in regions with large contemporaneous college expansion reforms.
- Lower labor markdowns due to input trade liberalization offset China's aggregate labor share decline by almost one-half percentage point in the early 2000s.

Trade Liberalization and Labor Monopsony: Evidence from Chinese Firms

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Abstract

We document that larger input tariff reductions were associated with lower labor markdowns in China, especially for skill-intensive firms. Guided by a stylized model of equilibrium labor market power, we leverage differences in the aggregate labor supply dynamics across labor markets—such as regional variations in China's contemporaneous college expansion reforms—to that show trade-induced labor markdown decreased more in labor markets with more labor supply growth. Our estimates suggest that lower labor markdowns due to input trade liberalization offset China's aggregate labor share decline by almost one-half percentage point in the early 2000s.

Keywords: input trade liberalization, labor market power, skill intensity, China.

JEL: E2, F1, J2, J3, J42.

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1. Introduction

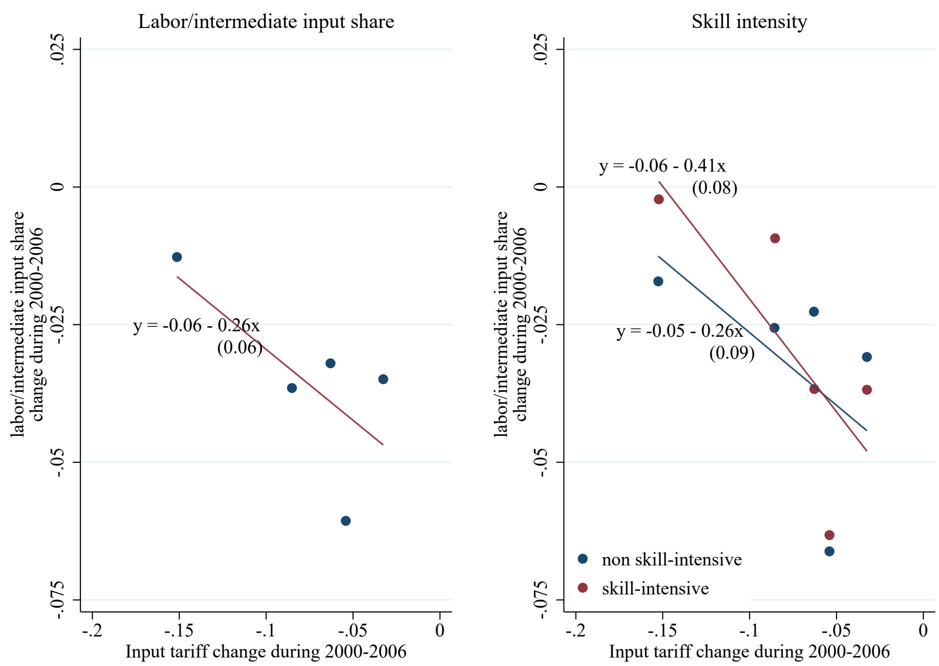
Rising inequality, labor's declining share of income, and growing protectionism have led to renewed interest in the implications of trade policy for labor markets. While trade reforms can improve consumer welfare, their labor market implications can be uneven, especially when worker reallocation is not frictionless. The literature shows that when trade tariffs fall, industries and locations more exposed to rising import competition can experience lower employment and lower wages relative to less exposed locations (e.g., Davidson and Matusz, 2004; Autor, Dorn and Hanson, 2013; Dix-Carneiro, 2014; Kondo, 2018). Similarly, the labor market effects of trade liberalization have been found to be heterogeneous effects across occupations (e.g., Ebenstein et al., 2014) or by worker skill (e.g., Goldberg and Pavcnik, 2007; Topalova, 2010). Even though labor monopsony power has become a key theme in understanding growing inequality and labor markets (e.g., Rinz, 2018; Hershbein, Macaluso and Yeh, 2022; Berger, Herkenhoff and Mongey, 2022), the literature on international trade and labor markets has typically abstracted from it.[1] In this paper, we study how input trade liberalization affects firms' market power in labor markets, how firms' skill intensity shapes this effect, and the role of labor market differences in aggregate labor supply elasticity.

We use China's unprecedented trade liberalization in the early 2000s to examine the response of firms' labor monopsony power to trade policies. China is a particularly relevant case for multiple reasons. First, it has the largest labor force in the world, twice as large as the combined labor forces of the U.S. and E.U. It is also the largest economy in the world in PPP (purchasing power parity) terms and one of the world's largest importers and exporters. Second, labor's share in China is quite low, standing at approximately 40 percent of value-added in manufacturing in 2001 and has declined since. The nature of China's

[1]The trade literature has traditionally focused more on the monopoly power of firms in their product markets rather than their monopsony power in domestic labor markets. See de Loecker et al. (2016), Fan et al. (2018), and Edmond, Midrigan and Xu (2015), for example, on firm markup strategies in India and China and the competitive effects of trade liberalization.

labor market flexibility is disputed, as the well-known Hukou registration system restricts internal migration across regions. Finally, China's substantial college expansion reforms since the late 1990s provide a quasi-natural experiment to test the mechanism at work for skill heterogeneity in labor market power.

Figure 1: Changes in factor shares and input tariff reductions



Notes: The solid line in the left panel of Figure 1 represents fitted values from regressing changes in the ratio of labor expenditure and intermediate input expenditure on changes in input tariffs using all (non-binned) observations. The regression is shown on the graph, where the value in the bracket is the robust standard error of the coefficient. The dots represent a scatter plot that partitions the data into five quintiles. The right panel of Figure 1 reproduces the same exercise for skill-intensive and non-skill-intensive firms separately. A firm is considered skill-intensive if its fraction of college-educated employees is higher than the average fraction of college-educated employees across all firms in the same 2-digit industry.

To motivate our analysis, we regress changes in a proxy for labor market power–the ratio of labor expenditure and intermediate input expenditure–on changes in input tariffs across industries. The two panels in Figure 1 show the predicted changes in expenditure shares against input tariff reductions using a simple linear fit. In the left panel, we note that input tariff reductions significantly increase the share of expenditures on labor input. The right panel suggests that this increase in labor expenditure shares is larger for skill-intensive firms.

Formally, we estimate firms' monopsony power in labor markets by measuring "labor markdowns," the wedge between the value of the marginal product of labor and the wage that is above and beyond what is explained by a markup in the output market. We utilize the estimation methods proposed by Brooks et al. (2021*b*) to distinguish between an output markup and a labor markdown. We use various approaches, such as the methods of de Loecker and Warzynski (2012), to estimate markups.[2] Using a panel dataset on manufacturing firms, we estimate that sizeable labor markdowns in Chinese manufacturing.

First, we turn to a stylized model of input tariff liberalization and labor monopsony power to analytically characterize how labor markdowns endogenously respond to trade liberalization and the role of skill intensity. Our model highlights how changes in labor markdowns are an industry equilibrium phenomenon that depends crucially on the aggregate labor supply dynamics: As intermediate input tariffs fall, firms also demand more labor, but this increased labor demand pushes up labor market power if the aggregate labor supply remains unchanged change. Therefore, the model predicts that a key determinant of markdown changes is how aggregate labor supply expands to offset firms' increased labor demand.

Before investigating this aggregate labor supply channel, we exploit variations in the exposure to input tariff reductions across industries in China to document two main empirical findings establishing the impact of the input trade liberalization on firm labor market power in China. First, after joining the WTO, labor markdowns fell more in labor markets exposed to larger input tariff reductions. Second, this relative decline in labor markdowns is more pronounced for skill-intensive firms compared with non-skill-intensive firms. We conduct a number of robustness tests to account for potentially endogenous tariff changes and exporter-specific year-to-year variations. We show that our results are robust to alternative markdown

[2] Assuming that firms are price-takers in the market for materials, the gap between the value of the marginal product of materials and its price is equal to the output markup. Labor markdowns can then be measured by comparing the ratio of the value of the marginal product of labor to wages with the ratio of the value of the marginal product of materials to its price. See Appendix B for estimation details.

measures and a variety of regression specifications.

We then present three pieces of evidence supporting this key insight from our simple theory. First, we confirm that labor markdowns fall more in labor markets in which the aggregate labor expands during trade reform. Second, utilizing college expansion as an exogenous regional shocks to the supply of skilled labor in China, we find that skill-intensive firms in industries that were exposed to larger expansion of skilled labor have a larger decrease in labor markdowns. Finally, firms that have a large skilled labor market share also see their markdowns decrease more in regions with large contemporaneous college expansion reforms.

Related Literature Our paper broadly relates to three strands of literature: the literature on trade and labor market outcomes, the literature on monopsony power in labor markets, and the literature on trade liberalization and product markups.

The trade literature has extensively evaluated the effects of trade liberalization on wages, employment, and inequality (Davidson and Matusz, 2004; Amiti and Davis, 2012; Topalova, 2010; Goldberg and Pavcnik, 2007). Recently, the dramatic rise of China's importance in international trade has motivated a vibrant literature on the labor market effects of trade-induced foreign competition (Autor, Dorn and Hanson, 2013; Pierce and Schott, 2016; Kondo, 2018; Caliendo, Dvorkin and Parro, 2019). In contrast to the literature, we allow for labor market power. This departure allows us to isolate one potentially important determinant of both measured wages and employment: the effects of trade on labor markdowns. Our findings suggest that labor monopsony power can influence the skill premium, as trade-induced markdowns vary with skill intensity. Our work also emphasizes to role of labor market heterogeneity in labor supply elasticity.

A growing number of papers investigate labor monopsony, mainly in developed countries such as the United States (Card et al., 2018; Gouin-Bonenfant, 2022; Lamadon, Mogstad and Setzler, 2022; Berger, Herkenhoff and Mongey, 2022; Hershbein, Macaluso and Yeh, 2022; Macedoni, 2022; Pham, 2023). We borrow our labor markdown estimation from Brooks et al. (2021*a*) and Brooks et al. (2021*b*), who also study on labor markdowns in India and China. This paper contributes to this literature by looking at the impact of trade liberalization on firms' labor monopsony power. In this regard, our paper complements existing findings in Pham (2023) and Dobbelaere and Wiersma (2020), who also document lower labor markdowns following trade liberalization in China. Our contributions consist of new findings on the role of firm skill intensity, new evidence on the labor supply elasticity channel, and macroeconomic implications for the labor share and the skill premium. In contrast to the findings in China, Felix (2022) finds that output trade liberalization in Brazil *increased* labor markdowns, using a structural approach and trade-induced changes in concentration to estimate economy-wide labor supply elasticity parameters.

Our paper also relates to the literature on the competitive effects of trade liberalization. Edmond, Midrigan and Xu (2015) and Arkolakis et al. (2019) provide theoretical and quantitative insights into the effects of trade in the presence of variable markups. More recent studies estimate the impact of trade liberalization on firm markup (e.g., de Loecker et al. (2016) for India, and Fan et al. (2018) for China). We estimate labor markdowns as the ratio of the labor-based markup and materials-based markup. We show that the trade-induced fall in labor markdowns that we document are not systematically due to higher product markups. Specifically, we find that trade-induced labor markdowns fall more for skill-intensive firms, but their product markups do not change more.

The remainder of this paper is organized as follows. In Section 2, we introduce a simple model of equilibrium labor markdowns following input tariff liberalization. Section 3 describes the firm-level data, our markup estimation methods, and our findings on the impact of tariff reductions on labor markdowns as well as the role of skill intensity and spatial variations in labor supply adjustments. In Section 4, we investigate the implications of our findings for the aggregate labor share and for the wage premium at skill-intensive firms. Section 5 concludes.

2. A Simple Model of Markdowns and Input Tariffs

We now provide a simple model of endogenous markdowns following input tariff liberalization. We aim to derive analytically, in a minimal model, the effects of input tariff liberalization on labor markdowns. The model is therefore deliberately stylized and focused on deriving potential mechanisms behind the motivating facts above. The model is also consistent with the more general accounting framework used to estimate markups and labor markdowns in the data. Detailed model derivations are in Appendix C.

Environment

We consider an economy in which firms are price-takers in the market for intermediate inputs but can exercise labor market power in their local labor market, indexed by $k \in \mathcal{K}$. A labor market k is populated by a mass L_k of workers who elastically supply labor to the discrete set $\mathcal{I}_k = \{1, \ldots, N_k\}$ of firms operating locally.

First, we present the key assumptions we make to solve each firm's input choice problem. We then focus, for tractability, on a symmetric equilibrium concept to derive closed-form solutions for the impact of trade liberalization on labor markdowns and highlight the role of skill-intensity and the degree of local labor supply adjustments.

Assumption 1 (Cobb-Douglas production function)**.** *The production function satisfies $y_i = z_i F(\ell, m) = z_i \ell^{\lambda} m^{\mu}$ with $\lambda > 0$, $\mu > 0$. The implied output elasticities with respect to labor and materials satisfy $\theta_\ell(\ell, m) = \lambda$ and $\theta_m(\ell, m) = \mu$.*

Assumption 2 (Constant inverse demand elasticity)**.** *The inverse demand function satisfies $p(y_i) = A y_i^{-\sigma^{-1}}$ with $\sigma > 1$ and $A > 0$. The inverse product demand elasticity faced by the firm is therefore given by $-\sigma_i^{-1}(y_i) = -\sigma^{-1}$.*

Assumption 3 (Wage function)**.** *Given other firms' labor demands* $\{\ell_j : j \neq i\}$*, the wage function for a given firm* i *demanding* ℓ_i *units of labor in labor market* k *satisfies*

$$w_{i,k}(\ell_i, \cdot) = \left[\frac{\ell_i^{\varphi}}{\mathcal{L}_{-i}^{\varphi} + \ell_i^{\varphi}}\right]^{\frac{\eta}{\varphi}} \left(\mathcal{L}_{-i}^{\varphi} + \ell_i^{\varphi}\right)^{\frac{\nu}{\varphi}},$$

where $\mathcal{L}_{-i}^{\varphi} \triangleq \sum_{j\neq i, j\in\mathcal{I}_k} \ell_j^{\varphi}$.

The inverse labor supply elasticity faced by firm i is

$$\varepsilon_{i,k}^{-1}(\ell_i) \equiv \frac{\partial \log w_{i,k}(\ell_i)}{\partial \log \ell_i} = \eta + (\nu - \eta)\frac{\ell_i^{\varphi}}{\mathcal{L}_{-i}^{\varphi} + \ell_i^{\varphi}}. \tag{1}$$

For instance, in the common iso-elastic case; that is, $(\nu - \eta = 0)$, the firm-level inverse labor supply elasticity $\varepsilon_{i,k}^{-1}(\ell_i)$ is constant, and the labor markdown $(1 + \varepsilon_{i,k}^{-1}(\ell_i))$ does not vary with tariffs. Also, the cross-firm labor supply elasticity φ may be location-specific. In fact, we derive such labor supply function in an environment with labor supply choice across a continuum of locations in Appendix D.[3]

Firm Problem

The problem of a firm i located in location k, given the inverse demand function $p(y_i; \cdot)$, the choices of other firms $\{\ell_j\}_{j\neq i}$, and intermediate input prices $r_k \equiv (1 + \tau_k)\tilde{r}$ is

$$\max_{\ell_i, m_i} \quad p(y_i; \cdot)y_i - w_{i,k}(\ell_i; \cdot)\ell_i - r_k m_i \tag{2}$$
$$\text{s.t. } y_i = z_i F(\ell_i, m_i)$$

[3] A standard result in the literature is that that the firm's inverse labor supply elasticity is correlated with its labor market share. This formulation implies the same correlation: here $\varepsilon_{i,k}^{-1}(\ell_i) = \eta + (\nu - \eta)\tilde{s}_{i,k}^{-1}$, where $\tilde{s}_{i,k}^{\frac{\varphi}{1+\eta}} = (w_{i,k}\ell_{i,k})^{\frac{\varphi}{1+\eta}} / \sum_{j\in\mathcal{I}_k} (w_{j,k}\ell_{j,k})^{\frac{\varphi}{1+\eta}}$ is correlated with firm i's labor market share.

where τ_k denotes tariffs and $\tilde{r}$ is the world price for intermediate input materials.[4]

While the firm is price-taking in the market for intermediate inputs m, it can exercise labor market power when hiring labor ℓ in its labor market k; that is, $\frac{\partial w_{i,k}}{\partial \ell_i} \neq 0$, where $w_{i,k}$ denotes the wage in i's labor market k.[5]

Lemma 1 (Labor market power as labor wedge)**.** *The firm optimality conditions imply the standard formulation that labor market power, in the sense of positive firm-level inverse labor supply elasticities ($\varepsilon_{i,k}^{-1}(\ell_i) > 0$), acts as a wedge distorting the allocation of labor relative to the competitive market allocation:*

$$\frac{F_{\ell_i}(\cdot)}{F_{m_i}(\cdot)} = \frac{\lambda}{\mu} = \frac{w_{i,k}(\ell_i)}{r_k}\left[1 + \varepsilon_{i,k}^{-1}(\ell_i)\right]. \tag{3}$$

Following the literature, we define labor markdowns as the labor-based markup divided by the materials-based markup, an input for which we assume the firm is a price-taker.

Lemma 2 (Labor markdowns)**.** *The labor markdown–the ratio of the labor-based markup and the materials-based markup– for firm i equals*

$$\left[1 + \varepsilon_{i,k}^{-1}(\ell_i)\right]. \tag{4}$$

This lemma naturally follows from the fact that the labor-based markup satisfies

$$\frac{z_i F_{\ell_i}(\cdot)}{w_{i,k}(\ell_i)} p(y_i) = \left[1 + \varepsilon_{i,k}^{-1}(\ell_i)\right]\left[1 - \sigma_i^{-1}(y_i)\right]^{-1} = \left[1 + \varepsilon_{i,k}^{-1}(\ell_i)\right]\left(1 - \sigma^{-1}\right)^{-1} \tag{5}$$

[4]In the model, a firm's location refers to the labor market in which it competes for workers, which can be industry- and location- specific. We therefore allow tariffs τ_k to vary by location. More generally, domestic trade frictions may further affect the input tariffs faced by the firms in a given labor market.

[5]We build a model to explain specifically the relationship between input tariff liberalization and labor markdowns. We can easily extend the model to include output tariffs. We focus on input tariff liberalization because we view it as a shock to relative input prices as opposed to a final demand shock. While both shocks change the relative demand for both inputs, we think the shock to local relative input prices is better suited for isolating changes in local labor market power.

and the materials-based markup satisfies

$$\frac{z_i F_{m_i}(\cdot)}{r_k} p(y_i) = \left[1 - \sigma_i^{-1}(y_i)\right]^{-1} = \left(1 - \sigma^{-1}\right)^{-1}. \tag{6}$$

Optimal Labor Demand

Substituting for the optimal materials choice, the firm's problem can be re-written as the labor choice problem below

$$\max_{\ell_i} \quad B(r_k) \times \left[\tilde{z}_i \times \ell_i^{\tilde{\lambda}}\right]^{\frac{1}{1-\tilde{\mu}}} - w_{i,k}(\ell_i; \cdot)\ell_i \tag{7}$$

where $B(r_k) \triangleq (1 - \tilde{\mu}) \left[\tilde{\mu}/r_k\right]^{\frac{\tilde{\mu}}{1-\tilde{\mu}}} \left[A\right]^{\frac{1}{1-\tilde{\mu}}}$, $\tilde{z}_i \triangleq z_i^{1-\sigma^{-1}}$, $\tilde{\mu} \triangleq \left[1 - \sigma^{-1}\right] \mu$, and $\tilde{\lambda} \triangleq \left[1 - \sigma^{-1}\right] \lambda$.

The first-order conditions with respect to ℓ_i imply that the equilibrium labor allocations $\{\ell_i\}_i$ across firms jointly satisfy a system of equations such that

$$\frac{\tilde{\lambda}}{1 - \tilde{\mu}} B(r_k) \times \left[\tilde{z}_i \times \ell_i^{\tilde{\lambda}}\right]^{\frac{1}{1-\tilde{\mu}}} \times \frac{1}{w_{i,k}(\ell_i; \cdot)\ell_i} = 1 + \varepsilon_{i,k}^{-1}(\ell_i) \quad \forall\, i. \tag{8}$$

Theorem 3 (Optimal labor demand)**.** *The optimal labor demanded by firm i, given other firms' strategies $\mathcal{L}_{-i}$ and given intermediate input prices $r_k \equiv (1 + \tau_k)\tilde{r}$, solves*

$$\left(1 + \eta + (\nu - \eta)\frac{\ell_i^{\varphi}}{\mathcal{L}_{-i}^{\varphi} + \ell_i^{\varphi}}\right)\left(\frac{\ell_i^{\varphi}}{\mathcal{L}_{-i}^{\varphi} + \ell_i^{\varphi}}\right)^{\frac{-(\nu-\eta)}{\varphi}} \ell_i^{(1+\nu) - \frac{\tilde{\lambda}}{1-\tilde{\mu}}} = \frac{\tilde{\lambda}}{1 - \tilde{\mu}} B(r_k) \left[\tilde{z}_i\right]^{\frac{1}{1-\tilde{\mu}}}. \tag{9}$$

The optimal labor demand equation implicitly defines the firm's labor demand as a function of the other firms' strategies $\mathcal{L}_{-i}$ and the material price $r_k \equiv (1 + \tau_k)\tilde{r}$. The dependence on other firms' decisions highlights that markdowns are jointly determined as a labor market equilibrium outcome.

For the remainder of the paper, we focus on symmetric equilibria where all local firms are homogeneous and choose the same allocations. Though stylized, the symmetry restriction allows us to derive intuitive closed-form results.[6]

Corollary 4 (Symmetric Local Equilibrium and Entry)**.** *In a symmetric equilibrium (that is, $z_i = z_k$ and $\ell_i = \ell_k$ $\forall i \in N_k$), given materials prices r_k and aggregate labor L_k, the number of firms N_k satisfies*

$$\left(N_k\right)^{\frac{(\nu-\eta)}{\varphi}} \left(1+\eta+(\nu-\eta)\frac{1}{N_k}\right)\left(\frac{L_k}{N_k}\right)^{(1+\nu)-\frac{\tilde{\lambda}}{1-\tilde{\mu}}} = \frac{\tilde{\lambda}}{1-\tilde{\mu}}\left[\tilde{z}\right]^{\frac{1}{1-\tilde{\mu}}} B(r_k)$$

with $\ell_k = \frac{L_k}{N_k}$. Furthermore, the labor markdown is $\left[1+\varepsilon_k^{-1}\left(\ell_k\right)\right] = 1+\eta+\frac{(\nu-\eta)}{N_k}$.

With symmetric firms, if the labor supply does not expand, fewer firms would operate in response to increased labor demand arising from lower input prices r_k and labor market power will rise.

Having taken the local labor supply of workers L_k as given in order to characterize the firm solution and local equilibrium, the next assumption governs how tariff-induced wage changes affect the local labor supply.

Assumption 4 (Aggregate labor supply elasticity)**.** *Input tariff changes affect equilibrium labor supply through wages such that*

$$\frac{\partial \log L_k}{\partial \log((1+\tau_k)\tilde{r})} = \frac{\partial \log L_k}{\partial \log w_k} \times \frac{\partial \log w_k}{\partial \log((1+\tau_k)\tilde{r})} \triangleq -\kappa \leq 0.$$

Discussion of Assumption 4: This assumption is a reduced-form way of capturing the elasticity of labor supply across labor markets when intermediate input tariffs change. In a full model with labor market choice across locations, this elasticity would be endogenous to optimal labor allocations through labor markets clearing within and across locations. In the case of a continuum of locations shown in Appendix D, the elasticity of local labor to the local wage index is a constant, but the transmission of tariff reductions into local

[6] More generally, in the heterogeneous-firms case, the change in the aggregate labor demand will feature both the extensive and the intensive margins of the firms that operate in equilibrium and their size.

wages is endogenous. Note also, that in Appendix D, the households' labor supply elasticity parameter may vary across labor markets.[7] As a result, the implied values for the aggregate labor supply elasticity κ may vary across local labor markets. This is an important source of heterogeneity for our empirical strategy.

This assumption therefore captures how local labor force dynamics can offset standard selection and entry mechanisms that typically lead to higher labor market power when the mass of workers does not change. We formalize this finding in the theorem below.

First, we note that taking derivatives $\frac{\partial}{\partial \log r_k}$ on the equilibrium conditions, we get

$$\frac{\partial \log N_k}{\partial \log r_k} = \frac{\left(\frac{\tilde{\mu}}{1-\tilde{\mu}}\right) - \left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \nu\right)\kappa}{\left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \frac{\varphi-1}{\varphi}\nu + \frac{\eta}{\varphi}\right) + \left[\left(\frac{1+\eta}{\nu-\eta}\right) N_k + 1\right]^{-1}}$$

by applying the chain rule and substituting for the aggregate labor supply elasticity term.[8] The labor supply elasticity under symmetry implies $\log N_k = -\log(\varepsilon_k^{-1} - \eta) + \log(\nu - \eta)$. Therefore,

$$\frac{\partial \log(\varepsilon_k^{-1} - \eta)}{\partial \log r_k} = -\frac{\left(\frac{\tilde{\mu}}{1-\tilde{\mu}}\right) - \left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \nu\right)\kappa}{\left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \frac{\varphi-1}{\varphi}\nu + \frac{\eta}{\varphi}\right) + \left[\left(\frac{1+\eta}{\nu-\eta}\right) N_k + 1\right]^{-1}}. \tag{10}$$

[7] In the random utility framework, workers draw idiosyncratic preference shocks across labor markets that may differ in switching costs, local amenities, or local wages. Artuç, Chaudhuri and McLaren (2010), Dix-Carneiro (2014), Redding (2016), and Caliendo, Dvorkin and Parro (2019) use random utility discrete choice models to investigate the labor market effects of trade reforms. With more discrete options, such quantitative models also have more degrees of freedom to fit observed choice probabilities across options. Berger, Herkenhoff and Mongey (2022) allow for strategic firm behavior within and across discrete locations, in the oligopolistic approach of Atkeson and Burstein (2008), to study firm labor monopsony power. The assumption of a continuum of locations in our extension (see Appendix D) allows us analytically to maintain oligopsonistic firm behavior locally, *within* but not *across* labor markets—thanks to insights from Malmberg (2013) and Malmberg and Hössjer (2018) who characterize the infinite limit case of random discrete choice problems. Specifically, Berger, Herkenhoff and Mongey (2022) (see Appendix B in their paper) build on these findings to motivate a more convenient constant-elasticity-of-substitution (CES) formulation of the labor supply choice *across* labor markets.

[8] Technically, the equilibrium number of firms N_k needs to be an integer. We consider the equilibrium condition on the real line for the purpose of our variational analysis.

Theorem 5 (Intermediate input prices and labor market power)**.** *Labor markdowns* $(1+\varepsilon_k^{-1})$ *decline (and the equilibrium number* N_k *of firms increases) with lower intermediate input prices iff*

$$\left(\frac{\tilde{\mu}}{1-\tilde{\mu}}\right) - \left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \nu\right)\kappa < 0 \Longleftrightarrow \kappa > \frac{\left(\frac{\tilde{\mu}}{1-\tilde{\mu}}\right)}{\left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \nu\right)}. \tag{11}$$

This theorem summarizes a key insight from our simple model: While the firm-level labor supply elasticity shapes the firm's labor market power, its equilibrium labor markdown response to a change in input tariffs critically depends on the aggregate labor supply elasticity also. We test this insight empirically using spatial variation in local labor supply dynamics.

Before turning to the evidence supporting this mechanism, we also characterize the role of skill intensity in the effect of input trade liberalization on markdowns. We explore the role of skill intensity in the context of our model by applying $\frac{\partial}{\partial\tilde{\lambda}}$ to $\frac{\partial \log N_k}{\partial \log r_k}$.

We then obtain, after some transformations,[9]

$$\begin{aligned}\frac{\partial^2 \log N_k}{\partial \log r_k\,\partial\tilde{\lambda}} = &\frac{\left(\frac{1}{1-\tilde{\mu}}\right)\left\{\left(\frac{\tilde{\mu}}{1-\tilde{\mu}}\right) - \kappa\left(\frac{\nu-\eta}{\varphi}\right) + \kappa\left[\left(\frac{1+\eta}{\nu-\eta}\right)N_k + 1\right]^{-1}\right\}}{\left\{\left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \frac{\varphi-1}{\varphi}\nu + \frac{\eta}{\varphi}\right) + \left[\left(\frac{1+\eta}{\nu-\eta}\right)N_k + 1\right]^{-1}\right\}^2}\\ &+ \frac{\left(\frac{1+\eta}{\nu-\eta}\right)\left[\left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \nu\right)\kappa - \left(\frac{\tilde{\mu}}{1-\tilde{\mu}}\right)\right]\left[\left(\frac{1+\eta}{\nu-\eta}\right)N_k + 1\right]^{-2}}{\left\{\left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \frac{\varphi-1}{\varphi}\nu + \frac{\eta}{\varphi}\right) + \left[\left(\frac{1+\eta}{\nu-\eta}\right)N_k + 1\right]^{-1}\right\}^2}\\ &\times \frac{\left(\frac{1}{1-\tilde{\mu}}\right)N_k\left(\log\frac{L_k}{N_k} + \frac{1-\tilde{\mu}}{\tilde{\lambda}}\right)}{\left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \frac{\varphi-1}{\varphi}\nu + \frac{\eta}{\varphi}\right) + \left[\left(\frac{1+\eta}{\nu-\eta}\right)N_k + 1\right]^{-1}}.\end{aligned}$$

[9] Since $N_k \geq 1$ and $\nu > \eta > 0$, $\kappa\left[\left(\frac{1+\eta}{\nu-\eta}\right)N_k + 1\right]^{-1} \in \left(0, \kappa\frac{\nu-\eta}{1+\nu}\right]$, which implies

$$\left(\frac{\tilde{\mu}}{1-\tilde{\mu}}\right) - \kappa\left(\frac{\nu-\eta}{\varphi}\right) + \kappa\left[\left(\frac{1+\eta}{\nu-\eta}\right)N_k + 1\right]^{-1} > \left(\frac{\tilde{\mu}}{1-\tilde{\mu}}\right) - \kappa\left(\frac{\nu-\eta}{\varphi}\right).$$

The equation above allows us to characterize whether the cross-derivative is positive: that is, whether, an input tariff reduction leads to a larger labor markdown reduction when the skill intensity is higher.

Theorem 6 (Labor intensity, input tariffs, and equilibrium number of firms)**.** *Skill intensity amplifies the increase in the number of firms and, equivalently, the associated reduction in markdowns arising from a decline in input prices; that is,*

$$\frac{\partial \log N_k}{\partial \log r_k} < 0 \quad \text{and} \quad \frac{\partial^2 \log N_k}{\partial \log r_k \, \partial \tilde{\lambda}} > 0,$$

when

$$\kappa \in \left(\frac{\frac{\tilde{\mu}}{1-\tilde{\mu}}}{\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \nu}, \frac{\frac{\tilde{\mu}}{1-\tilde{\mu}}}{\frac{\nu-\eta}{\varphi}} \right). \tag{12}$$

Note that Theorem 6 imposes restrictions on the labor supply elasticity for this amplification result to be true.[10] Overall, our theorems show how endogenous markdowns respond to tariff reductions, albeit in a stylized environment. Our results emphasize the key role played by the local aggregate labor supply elasticity: changes in labor demand combined with reallocation in labor supply across labor markets both matter. The mechanics are simple enough that we think a version of our "possibility" of pro-competitive result may hold in a more general setup. These results motivate us to consider heterogeneous local labor supply elasticities when investigating equilibrium labor markdown dynamics after tariff reductions.

In the next section, we document the effects of input tariffs reductions on labor markdowns along with the role of skill intensity before exploring suggestive evidence on the labor supply mechanisms highlighted in Theorems 5 and 6. Specifically, we estimate firm-level markdowns and leverage both exogenous variations in input tariff changes and the contemporaneous reforms which drastically increase college admissions in China.

[10]The condition in Theorem 6 requires $1 + \left(1 - \frac{1}{\varphi}\right)\nu + \frac{\eta}{\varphi} > \frac{\tilde{\lambda}}{1-\tilde{\mu}}$. This necessary condition guarantees the existence of κ and is always true, since $1 + \left(1 - \frac{1}{\varphi}\right)\nu + \frac{\eta}{\varphi} > 1 > \frac{\tilde{\lambda}}{1-\tilde{\mu}}$.

3. Empirical Strategy and Findings

3.1. Data and Measurements

The main dataset used in the analysis is the firm-level production data from the Annual Survey of Chinese Industrial Enterprises (CIE). The CIE data are collected by the National Bureau of Statistics of China, and they cover all state-owned enterprises (SOEs), and non-state-owned enterprises with annual sales of at least 5 million RMB (approximately $760,000 in 2020). Between 2000 and 2006, the number of firms in the CIE data grew from approximately 162,000 to 300,000, making our sample unbalanced panel. We focus only on the manufacturing sector and 4-digit manufacturing industries.

The tariff data come from the World Trade Organization (WTO) website. The liberalization episode involves both time and industry variations. The liberalization was sudden, involving a sharp and sudden cut in tariff rates in 2001. Tariffs went from being high and variable across industries to being low and less variable. Moreover, preexisting regional differences in industrial composition led to regional variation in the impact on labor markets.[11] We map the tariff data at the 8-digit harmonized system (HS) product level into a 3-digit input/output (IO) industry classification based on the HS codes and the China's 2002 IO table. Our 3-digit output tariffs are just the simple average of all tariffs for products whose 8-digit HS map into a given 3-digit IO industry code. Following Amiti and Konings (2007), we compute 3-digit input tariffs as an input-cost weighted average of output tariffs:

$$\tau_{it}^{\text{input}} = \sum_{k} \alpha_{ki} \tau_{kt}^{\text{output}},$$

where $\tau_{kt}^{\text{output}}$ is the 3-digit output tariffs imposed on industry k at time t, and α_{ki} is the percentage of industry i's total costs that were expended on products supplied by industry

[11]The liberalization also disproportionately impacted industries that initially had high tariffs. Specifically, industries with initially high tariffs experienced greater tariff reductions when China joined the WTO.

k as intermediate inputs for industry i. Finally, we map IO 3-digit tariffs into the 4-digit Chinese Industrial Classification (CIC) code system so that we can merge it with our firm-level production data.

Recall that labor markdown can be written as the ratio of the labor-based markup and the materials-based markup. Moreover, we can derive markups from factor payment shares and output elasticities. Combining these two results, we estimate labor markdowns using the following equation:

$$\text{Labor markdown} = \frac{\theta_{l_i}}{\alpha_{l_i}} \cdot \frac{\alpha_{m_i}}{\theta_{m_i}}$$

where α_{l_i} and α_{m_i} represent labor and materials payment shares for firm i. θ_{l_i} and θ_{m_i} represent output elasticities from firm i's production function with respect to materials and labor. We compute values of labor and materials payment shares directly from the data. To estimate output elasticity with respect to materials, we apply the methods of de Loecker and Warzynski (2012) and estimate firms' production functions. Following Brooks et al. (2021*b*), we set the output elasticity with respect to labor to be a constant and estimate the value of the constant using an auxiliary regression between labor markdowns and firms' labor market shares. Details on our labor markdown estimation steps are in Appendix B.[12]

[12]The benefit of using the auxiliary regression between firms' labor markdowns and their labor market shares is that we will only attribute the part of firms' labor markdowns that comove with their labor market shares to monopsony power. This is consistent with our theory and the rest of the literature: a firm's labor market power is correlated with their labor market share (see the discussion of Equation 1 on the firm's residual labor supply elasticity).

Table 1: Summary statistics

	Mean	Median	SD
Markup (baseline)	1.27	1.24	0.19
Markup (alter-CD)	1.12	1.10	0.16
Markup (alter-CRS)	1.13	1.12	0.16
Markdown (baseline)	1.03	0.61	1.22
Markdown (alter-CD)	1.03	0.61	1.21
Markdown (alter-CRS)	1.02	0.64	1.12
Capital per firm (real value, 000s RMB)	305	46	3193
Materials per firm (real value, 000s RMB)	634	154	4888
Output per firm (real value, 000s RMB)	861	217	6454
Workers per firm	299	125	1026
No. of firm-year Obs		868342	

Notes: Market shares are computed using 4-digit industries. Capital, materials, and output are in thousands of RMB (in real value). The table winsorizes the 3 percent in both sides of the markup/markdown estimates of each 2-digit industry in each year. Markup (baseline) is estimated following the methods of de Loecker and Warzynski (2012). Markup (alter-CD) is estimated assuming a Cobb-Douglas production technology. Markup (alter-CRS) is estimating assuming that the production function is constant returns to scale. Markdown (alter-CD) is computed using markup (alter-CD), and markdown (alter-CRS) is computed using markup (alter-CRS).

Table 1 gives the summary statistics for the important measures in our data. The average values for markups range from 1.12 to 1.27, and the markdowns averaged approximately 3 percent across different measures. Notice that there is substantial variation in the measures of markdowns, and the markdown distributions are strongly skewed to the left. Since many of the results are robust to different measures of markups and markdowns, in text, we present only the results using the baseline measure and we leave those using the alternative measures to the appendix.

3.2. Results

In this section, we report our empirical findings on the impact of input trade liberalization on labor markdowns. We find that input tariff reductions are associated with lower labor markdowns across Chinese manufacturing firms. Moreover, firms that are more skill-intensive also reduce labor markdowns more following input tariff reductions. Our main findings are robust to alternative markdown measurements and a variety of alternative specifications, including long difference estimations and difference-in-difference estimations.

3.2.1. Trade Liberalization and Labor Markdowns

To document the effect of trade liberalization on labor markdowns, we adopt the following regression specification:

$$log(\mu_{ist}) = \alpha_1 \text{tariff}_{st} + \mathbf{X}_{ist}\beta + \delta_t + \delta_s + \delta_i + \epsilon_{ist}, \tag{13}$$

where $log(\mu_{ist})$ denotes the logarithm of firm-level markdowns by firm i in year t, and tariff_{st} denotes the input or output tariff at time t in a 4-digit CIC industry s. The vector of controls, $\mathbf{X}_{ist}$, contains firm-level characteristics that could potentially influence the dynamics of markups and markdowns. These controls include the logarithm of total output, the size of employment, the capital-labor ratio, and total labor payments. We also control for the time fixed effect (δ_t), the 2-digit CIC sector/industry fixed effect (δ_s), and the firm fixed effect (δ_i). Throughout the analysis, we cluster the standard errors at the industry-year pair to account for the potential correlation between errors within each industry over time.

Table 2: The effect of tariffs on markdowns: Baseline results.

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variable = log(markdown)					
	Sample period: 2000–2006					
Input tariff	0.144***		0.125***	0.222***		0.246***
	(0.033)		(0.037)	(0.042)		(0.047)
Output tariff		0.057***	0.023		0.038**	-0.025
		(0.013)	(0.015)		(0.016)	(0.019)
lagged log(markup)				0.042***	0.041***	0.042***
				(0.008)	(0.008)	(0.008)
Observations	774,159	774,159	774,159	408,703	408,703	408,703
Adjusted R-squared	0.977	0.977	0.977	0.979	0.979	0.979

Notes: All regressions include the time fixed effect, the 2-digit CIC sector/industry fixed effect, and the firm fixed effect. The regressions also control for firm-level characteristics including total output, size of employment, capital-labor ratio, and total labor payments. These variables enter the regression in logarithms. Robust standard errors clustered at the industry-year pair are in parentheses. Significance: ***: 1%, **: 5%, *: 10%.

Table 2 shows that larger tariff reductions are associated with significantly lower markdowns across firms in China. Column 1 suggests that a reduction of tariffs from 30 percent to 10 percent has led to a decrease in markdowns by approximately 3 ($=20 \times 0.144$) percent, all else equal. Column 2 looks at the effect of output tariffs and the estimate on output tariffs is also positive and statistically significant. Column 3 includes both input tariffs and output tariffs in the regression. The estimated coefficient on output tariffs loses statistical significance once input tariffs are controlled for, suggesting that the effect of trade liberalization on labor markdowns works primarily through input tariff reductions. Columns 4 to 6 show that the result is not driven by changes in the distortion within the output market. Recall that the markdown is measured as the ratio of two markups: the labor-based markup and the materials-based markup, with the latter reflecting the distortion in the output market.

Therefore, an increase in the output market distortion would mechanically cause a decrease in our measured markdown. Columns 4 to 6 add one-period lagged log markups as an additional control in the regression. Input tariff reductions continue to be associated with lower markdowns after including lagged markups.[13]

One may be concerned that trade liberalization affects not just labor market power but also the monopsony power in raw materials. An increase in materials market monopsony power, after trade liberalization–say due to more potential sellers, would bias upward our results. We therefore look at the robustness of the results across firms exposed to different degree of concentration in the market for materials. In the Appendix, in Table A.13, we interact the input tariffs with firms' share of imported inputs or the concentration of imported input market. We find no evidence that higher pre-reform firm share in the market for imported materials explains the decline in labor markdowns after trade liberalization. Table A.13 shows that the newly added interaction terms have no significant effect on the dynamics of labor markdowns, even though they are negative.

Table 3 suggests that the effect of trade liberalization is driven mainly by long-term changes in tariffs and labor markdowns. In Table 3, we estimate time-difference regressions with lags ranging from one year to five years. This approach allows us to control for latent heterogeneity in the panel data, and further reduces omitted variable bias concerns. We find that the one-year and two-year changes in input tariffs are not significantly associated with markdown changes over the same period. In contrast, lower input tariffs significantly decrease labor markdowns using three-to-five-year difference estimators.

The results above show that Chinese manufacturing firms exposed to larger input tariffs reductions had significantly lowers labor markdowns in their labor markets.

[13] Controlling for contemporaneous markups in the regression is problematic because markup also responds to changes in tariffs (see the discussion of "bad controls" in Angrist and Pischke, 2009.) In the following analyses, we stop presenting the results with only output tariffs since Table 2 suggests that the effect of trade liberalization on markdowns is driven mainly by input tariff variations.

Table 3: The effect of tariffs on markdowns: Difference estimator.

	(1)	(2)	(3)	(4)	(5)
	Dependent variable = Δlog(markdown)				
	Sample period: 2000–2006				
	1-year	2-year	3-year	4-year	5-year
Δ Input tariff	0.032	0.051	0.122***	0.131**	0.107*
	(0.028)	(0.038)	(0.044)	(0.051)	(0.060)
Δ Output tariff	0.023**	0.020	0.025	0.021	0.031
	(0.011)	(0.018)	(0.020)	(0.024)	(0.031)
Observations	511,072	300,720	198,498	120,570	68,119
Adjusted R-squared	0.897	0.906	0.911	0.914	0.917

Notes: All regressions include the time fixed effect, the 2-digit CIC sector/industry fixed effect, the firm fixed effect, and firm-level characteristics (total output, size of employment, capital-labor ratio, and total labor payments). The regression also controls for one-period-lagged markup. The firm-level characteristics and markup enter the regression in logarithms. Robust standard errors clustered at the industry-year pair are in parentheses. Significance: ***: 1%, **: 5%, *: 10%.

3.2.2. Role of Skill Intensity

The literature suggests that trade liberalization increases the wage gap between high-skill and low-skill workers (Attanasio, Goldberg and Pavcnik, 2004; Verhoogen, 2008; Chen, Yu and Yu, 2017; Han, Liu and Zhang, 2012), implying that trade-induced markdown changes may also contribute to income inequality. In this subsection, we test whether the impact of trade liberalization on markdowns differs across a firm's skill intensity. The regression specification we use is as follows:

$$log(\mu_{ist}) = \alpha_1 \text{tariff}_{st} + \alpha_2 \text{tariff}_{st} \times \mathbb{1}\{\text{skill intensive}\}_i + \mathbf{X}_{ist}\beta + \delta_t + \delta_s + \delta_i + \epsilon_{ist}, \quad (14)$$

where $\mathbb{1}\{\text{skill intensive}\}_i$ is a variable indicating whether firm i is skill intensive. The indicator of skill-intensive firms is based on the fraction of employees who completed college. $\mathbb{1}\{\text{skill intensive}\}_i$ is equal to 1 if the fraction of college-educated employees at firm i is higher than the average fraction of college-educated employees across all firms in the same 2-digit industry.[14] The markdown at skill-intensive firms may have evolve differently compared with that of non-skill-intensive firms. We allow for this by interacting the skill-intensive firm indicator with time fixed effects and including these interaction terms as additional controls.

Table 4 shows the results from examining the potentially heterogeneous effects of trade liberalization on markdowns across a firm's skill intensity. Columns 1 and 2 regress markdowns on tariffs and the interaction term of tariffs with the skill-intensive indicator. We find that the estimated coefficients on the interaction terms are significantly positive. It suggests that compared to non-skill-intensive firms, skill-intensive firms reduce markdowns significantly more after trade liberalization. Columns 3 and 4 add one-period lagged log markups as an additional control in the regression. We find that the estimated coefficient on the interaction term is still significantly positive. Altogether, these results show that the reduction of labor markdowns caused by input trade liberalization is significantly larger for skill-intensive firms.[15]

[14] The information about employees' education level is available only in the 2004 CIE data. Therefore, our measure of a firm's skill intensity is time-invariant. This also precludes us from having a time-varying measure of the skill premium at the firm level.

[15] We conduct robustness tests on the results in Table 4, using alternative cutoffs for skill-intensive firms. We consider a firm skill-intensive if the fraction of college-educated employees at the firm is higher than the 60th percentile or the 70th percentile of the distribution of the fraction of college-educated employees across all firms with the same 2-digit industry code. Our results are not sensitive to the cutoff used.

Table 4: Effect of trade liberalization on markdowns and skill intensity.

	(1)	(2)	(3)	(4)
	Dependent Variable = log(markdown)			
	Sample period: 2000–2006			
Input tariff	0.127***	0.112***	0.156***	0.178***
	(0.035)	(0.040)	(0.048)	(0.054)
Input tariff$\times \mathbb{1}\{$skill intensive$\}$	0.073**	0.076**	0.134***	0.130***
	(0.032)	(0.032)	(0.044)	(0.044)
Output tariff		0.017		-0.021
		(0.016)		(0.021)
lagged log(markup)			0.025***	0.025***
			(0.008)	(0.008)
Observations	662,147	662,147	360,531	360,531
Adjusted R-squared	0.978	0.978	0.979	0.979

Notes: This table presents the estimates from Equation (14). All regressions include the time fixed effect, the 2-digit CIC sector/industry fixed effect, and the firm fixed effect. The regressions also control for firm-level characteristics including total output, size of employment, capital-labor ratio, and total labor payments. These variables enter the regression in logarithms. Robust standard errors clustered at the industry-year pair are in parentheses. Significance: ***: 1%, **: 5%, *: 10%.

We also find that the role of skill intensity on trade-induced lower markdowns is not present for product markups. This exercise is particularly useful, since it further suggests that the markdown effects we are documenting are not driven simply by changes in markups in the output market. Specifically, we estimate Equations (13) and (14), replacing markdowns with markups as the dependent variable in the regressions.

Table 5: Effect of trade liberalization on markups and skill intensity.

	(1)	(2)	(3)	(4)
	Dependent variable = log(markup)			
	Sample period: 2000–2006			
Input tariff	-0.121***	-0.119***	-0.125***	-0.126***
	(0.021)	(0.024)	(0.023)	(0.027)
Input tariff $\times\mathbb{1}\{\text{skill intensive}\}$			-0.013	-0.013
			(0.021)	(0.022)
Output tariff		-0.002		0.000
		(0.011)		(0.012)
Observations	774,159	774,159	662,147	662,147
Adjusted R-squared	0.578	0.578	0.574	0.574

Notes: This table presents the estimates from Equation (13) and (14), replacing markdowns with markups as the dependent variable. All regressions control for the time fixed effect, the 2-digit CIC sector/industry fixed effect, the firm fixed effect, and firm-level characteristics (total output, size of employment, capital-labor ratio, and total labor payments). Columns 3 and 4 also include the interaction terms between the indicator for skill-intensive firms and time dummies. Robust standard errors clustered at the industry-year pair are in parentheses. Significance: ***: 1%, **: 5%, *: 10%.

The results are reported in Table 5. Columns 1 and 2 show the effect of trade liberalization on product markups. The results suggest that input trade liberalization is associated with higher product markups. Columns 3 and 4 test the role of skill intensity by including the interaction term of tariffs and the skill-intensive indicator in the regression. Skill intensity does not play a significant role in explaining the variation in trade-induced product markups, in contrast to trade-induced labor markdowns. In none of the regressions are the estimated coefficients on the interaction term between tariffs and skill intensity indicator significantly different from zero. Overall, this result suggests that while skill-intensive firms experience a greater decline in markdowns during input trade liberalization, the increase in product markups they experience is no greater than that of non-skill-intensive firms.

3.2.3. Robustness

We study the robustness of the baseline results to alternative specifications or measures of markdowns, as well as additional controls, and report those results in Appendix A.

China's Hukou System Reform – One policy that affects China around the same time is the reform of China's Hukou system 1997–2002, which relaxed internal migration restrictions especially for skilled workers. As this reform increases the number of available workers in the local labor markets, it is possible that the reform has also reduced labor monopsony power. We test the robustness of our results to the impact of Hukou reform using two different kinds of regressions. First, we construct measures of migration costs following Tombe and Zhu (2019) and include migration cost between all province-industry pairs as an additional control in the regression.[16] Table A.1 and Table A.2 show that higher migration costs predict larger markdowns, but controlling for migration costs does not impact our results for trade liberalization. Second, we divide the sample into two groups based on the inflow of migrants in each province during 2000–2010. We find that the impact of tariffs on labor markdowns is not statistically different between the two subsamples, suggesting that migration flows are not driving the relationship between tariffs and markdowns (see Table A.3 and Table A.4).

Potential Endogeneity with Tariff Changes – To account for potentially endogenous tariff changes, we consider an alternative specification that explores the fact that trade liberalization disproportionately impacted industries that initially had high tariffs. In the regression, we replace contemporaneous tariff rates with the industry's initial tariff level and its interaction with a post-WTO dummy. This approach alleviates the endogeneity concern because

[16] Tombe and Zhu (2019) show that the migration flow between two places can be written as a function of real wage differences and migration costs. Using migration patterns and real income level for each of China's provinces, Tombe and Zhu (2019) estimate the migration costs for agricultural and non-agricultural workers between all province-sector pairs. We construct measures of migration costs for all province and 4-digit industry pairs based on the estimates from Tombe and Zhu (2019). Specifically, we use the paper's estimates of between-province migration costs for non-agricultural workers and multiply them by each province's distribution of employment across industries in 2000 to estimate province-industry specific migration costs. The assumption underlying our migration cost estimation is that the migration patterns between all province-industry pairs will mimic the distribution of employment across industries and provinces.

it is unlikely that the Chinese government predicted the future changes of various industries and used that information to negotiate tariff reductions upon entering the WTO. This alternative regression points to the same conclusion as our baseline specification. We find that industries experiencing greater input tariff reductions upon WTO accession showed a larger markdown decline relative to the industries experiencing less input tariff reductions. We also continue to find that the effect of input trade liberalization on labor markdowns is larger for skill-intensive firms (see Tables A.5 and A.6, respectively).

Alternative Markdown Measures – We also consider using different approaches to measuring markups in the construction of markdowns. As described in Section 3.1, one approach estimates markups using the gross profit margin, and the other approach estimates the markups under the assumption that the production function is Cobb-Douglas. All the regressions using different estimates of markdowns give qualitatively similar and comparable results and confirm our main findings on the impact of input tariff reduction on labor markdowns (see Table A.7) and the role of skill intensity (see Table A.8).

Exporting Status – We noted that the markdowns of exporting firms perhaps had a differential time patterns compared with those of non-exporting firms. We allow for this by creating a dummy for exporters and including its interaction with year dummies as additional controls in the regressions. For some years, these exporter-specific time patterns are significant, but our results for the effect of tariffs on markdowns and the role of skill intensity do not qualitatively alter (see Tables A.9 and A.10).

Province-Specific Time Patterns – Finally, we add province-time dummies as controls to allow year-to-year variation to differ at the province level. The results, shown in Tables A.11 and A.12, are virtually the same as the main findings in Section 3.2.1 and 3.2.2.

3.3. Exploring a Potential Labor Supply Mechanism

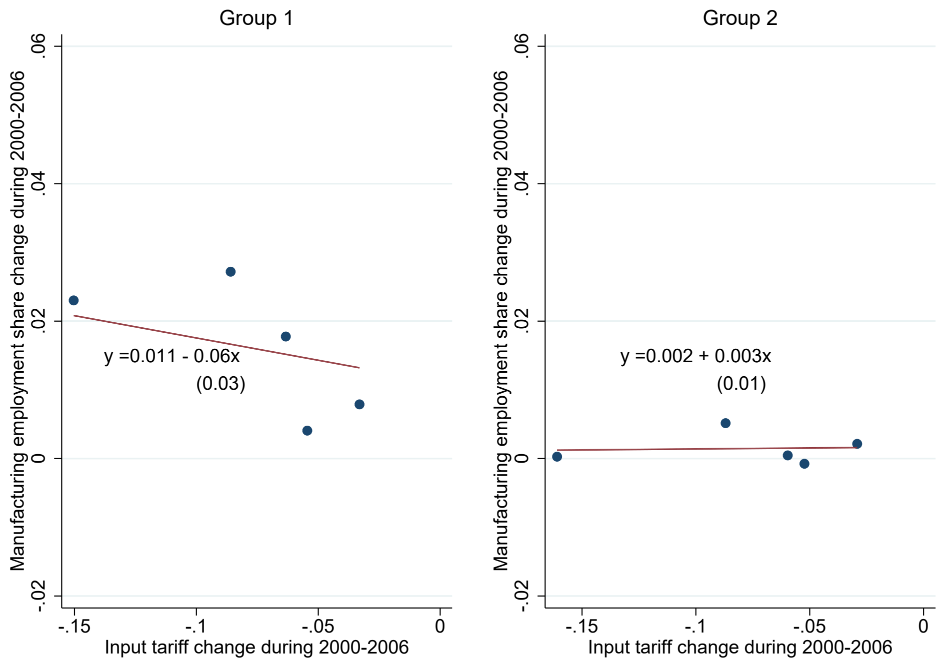
Our model predicts that the aggregate response to labor supply plays an important role in explaining the response of labor markdowns to input trade liberalizations. In this section, we present three pieces of evidence that are consistent with this mechanism. First, we show that input tariff reductions decrease labor markdowns more in regions with larger aggregate labor supply expansions. Second, we show that skill-intensive firms in industries that are more geographically exposed to skilled labor supply growth through college expansion reforms reduce markdowns more in response to tariff reductions. Finally, we find that larger firms, measured using skilled labor market shares, experience a larger reduction in labor markdowns in regions with greater expansion of the skilled labor supply.

3.3.1. Labor Markdowns and Aggregate Labor Supply

In this subsection, we test whether the response of labor markdowns to input trade liberalization is influenced by changes in an area's aggregate labor supply. We measure aggregate labor supply in the local labor markets as the ratio of total manufacturing employment of the labor market to the working-age population at the province level. To measure whether the aggregate labor supply in a given province has expanded when input tariffs fell, for each province separately, we regress the measure of aggregate labor supply on input tariffs for that province.[17] We then divide the provinces into two groups depending on whether the estimated province-level "aggregate labor supply elasticity" coefficient with respect to input tariffs is significantly negative.

[17] We also aggregate all the controls in the baseline regression to the labor market level and include them in the regression.

Figure 2: Manufacturing employment share adjustment and input tariff reduction.



Notes: The dots represent a binned scatter plot that partitions the data into five quintiles. The solid lines represent fitted values from regressing changes in manufacturing employment shares with respect to the working-age population on input tariff changes using all (non binned) observations. The changes of the variable are computed as the difference between the variable's value in 2006 and its value in 2000.

Figure 2 plots the change in aggregate labor supply between 2000 and 2006 on the change in input tariffs over the same period for the two groups of provinces. Group 1 includes the provinces that experienced a significant increase in aggregate labor supply following input trade liberalization. The graph suggests that on average, the aggregate labor supply increases by 0.6 percent for an extra 10 percent decrease in input tariffs. Group 2 includes the provinces that had no significant increase in aggregate labor supply. The graph shows that for these provinces, the change in aggregate labor supply between 2000 and 2006 is not significantly correlated with the change in input tariffs over the same period.

Table 6: The effect of tariffs on markdowns: Aggregate labor supply adjustments.

	(1)	(2)	(3)	(4)
	Dependent variable = log(markdown)			
	Sample period = 2000–2006			
	Group 1	Group 2	Group 1	Group 2
Input tariff	0.181***	0.117***	0.162***	0.099**
	(0.035)	(0.037)	(0.040)	(0.041)
Output tariff			0.028	0.020
			(0.019)	(0.017)
Observations	454,840	319,316	454,840	319,316
Adjusted R^2	0.979	0.975	0.979	0.975

Notes: This table presents the estimates of Equation (13) using firms from two groups of provinces. All regressions include the time fixed effect, the 2-digit CIC sector/industry fixed effect, and the firm fixed effect. The regressions also control for firm-level characteristics including total output, size of employment, capital-labor ratio, and total labor payments. These variables enter the regression in logarithms. Robust standard errors clustered at the industry-year pair are in parentheses. Significance: ***: 1%, **: 5%, *: 10%.

Our model predicts that input tariff reductions lower labor markdowns if and only if the aggregate labor supply increases enough. Therefore, we tested whether the impact of input trade liberalization on labor markdowns is different for firms that belong to these two groups. Table 6 shows that aggregate labor supply adjustments have played an important role in explaining the effect of input tariff reductions on labor markdowns. Column 1 shows that a 10 percent reduction in input tariffs decreased markdowns by approximately 1.8 percent for firms that experienced a significant increase in aggregate labor supply. Column 2 shows that the effect of tariffs on markdowns drops to approximately 1.2 percent when we look at firms which did not experience an increase in aggregate labor supply. The difference between the estimates in Columns 1 and 2 is statistically significant. Columns 3 and 4 show that this general pattern of tariff effect across the two groups is repeated even when output tariffs are included. Overall, the results suggest that input tariff reductions significantly lower labor markdowns in areas with larger aggregate labor supply expansions.

3.3.2. College Expansion Shocks

The previous results suggest that the adjustment of the aggregate labor supply is important to explain the response of labor markdowns to input trade liberalization. However, one may be concerned that changes in aggregate labor supply are not exogenous and may correlate with other changes in the labor market. In this subsection, we test the model predictions by utilizing an exogenous shock to the aggregate supply of skilled labor in China: the dramatic expansion of higher education that started in 1999.

In order to rejuvenate the economy in the wake of the Asian financial crisis, in June 1999, the central government of China made a decision to expand the scale of higher education. The expansion led to a dramatic increase in college enrollment throughout the country. The annual college recruitment in regular higher education institutions was less than 1 million students in 1997, gradually increasing from around 500,000 students in 1990. After the expansion in 1999, college recruitment sharply rose and steadily grew, exceeding 5 million by 2006 (Wang, 2014).

We exploit the differential exposure to the college expansion across industries to identify the effect of skilled labor supply expansion on the markdown response to input tariff reductions. For each industry, we construct a Bartik-style measure of the college expansion shock by interacting provincial shares of skilled labor with the provincial growth rates of college graduates. The expression of the shock is as follows:

$$\text{expansion shock}_{st} = \sum_{k} z_{sk} g_{kt},$$

where s indexes the 4-digit industry, k indexes the province, z_{sk} is the provincial share of skilled labor from the industry, and g_{kt} represents the growth rate of college graduates. We fix the provincial shares of skilled labor to 2004, which is the year for which the information on skilled labor is available. Since college expansion may be correlated with labor market changes inside the province that affect labor markdowns, we instrument for the college expansion in province k using the college expansion in other provinces. Specifically, we let expansion $\text{shock}_{st} = \sum_k z_{sk}\hat{g}_{kt}$ and $\hat{g}_{kt} = g_{-k,t}$ where $g_{-k,t}$ denotes the growth rate of college graduates in all provinces excluding province k.[18]

To test whether the expansion of skilled labor affects the impact of input trade liberalization on labor markdowns, we modify the regression to include an interaction term between the tariffs and the expansion shock:

$$log(\mu_{ist}) = \alpha_1 \text{tariff}_{st} + \alpha_2 \text{tariff}_{st} \times \text{expansion shock}_{st} + \mathbf{X}_{ist}\beta + \delta_t + \delta_s + \delta_i + \epsilon_{ist}. \quad (15)$$

The regression coefficient α_2 tells us whether differential exposure to college expansion shocks leads to differential responses of labor markdowns to trade liberalization.

Table 7 shows the results from estimating equation 15. The results suggest that the increase in the aggregate supply of skilled labor due to college expansion amplified the effect of trade liberalization on labor markdowns. Column 1 shows the results using all firms in the sample. We find that firms that experienced a larger increase in the supply of skilled labor reduced markdowns more after trade liberalization. Column 2 restricts the sample to skill-intensive firms, for which the effect of college expansion on the markdown response is even stronger. Columns 3 and 4 show that the result is robust to adding output tariffs into the regression. Overall, the analysis using the exogenous shock to skilled labor supply also suggests that the impact of input tariff reductions on labor markdowns is influenced by changes in aggregate labor supply.

[18] In the appendix Table A.14, we show the results about college expansion without using the instrument. The estimated coefficients are very similar to the ones in the main text (see Table 7).

Table 7: Effect of tariffs on markdowns with skill intensity and college expansion

	(1)	(2)	(3)	(4)
	Dependent variable = log(markdown)			
	Sample period = 2000–2006			
	All	Skill-intensive	All	Skill-intensive
Input tariffs	0.133***	0.181***	0.112***	0.156***
	(0.033)	(0.041)	(0.037)	(0.044)
Input tariffs × expansion shock	0.139*	0.254**	0.147*	0.260**
	(0.076)	(0.102)	(0.077)	(0.103)
Output tariffs			0.025*	0.034
			(0.015)	(0.023)
Observations	774,159	319,803	774,159	319,803
Adjusted R-squared	0.977	0.977	0.977	0.977
1st-stage F statistics	147.13	147.13	147.13	147.13
Mean of expan shock	0.251	0.251	0.251	0.251

Notes: This table presents the estimates from Equation (15). All regressions include the time fixed effect, the 2-digit CIC sector/industry fixed effect, and the firm fixed effect. The regressions also control for firm-level characteristics including total output, size of employment, capital-labor ratio, and total labor payments. These variables enter the regression in logarithms. Robust standard errors clustered at the industry-year pair are in parentheses. Significance: ***: 1%, **: 5%, *: 10%.

3.3.3. Skilled Labor Supply Expansion and Labor Market Share

We now more closely explore the impact of tariffs on labor markdowns in regions with college expansion reforms. In particular, we compute a measure of firm size that consists of its share of local skilled labor force and analyze the interaction between firm size, trade-induced labor markdown reduction, and aggregate supply of skilled labor. The results are presented in Table 8.

Table 8: Effect of tariffs on markdowns with skilled labor market share and college expansion

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variable = log(markdown)					
	Sample period: 2000–2006					
	All		High expansion areas		Low expansion areas	
Input tariffs	0.174***	0.206***	0.135***	0.158***	0.226***	0.263***
	(0.035)	(0.042)	(0.033)	(0.037)	(0.046)	(0.056)
Input tariffs ×	-0.134*		-0.034		-0.228***	
Firm's share (province)	(0.069)		(0.078)		(0.084)	
Input tariffs ×		-0.112**		-0.070		-0.150***
Firm's share (city)		(0.044)		(0.045)		(0.056)
Observations	434,330	408,195	209,923	194,220	224,406	213,974
Adjusted R-squared	0.977	0.978	0.977	0.978	0.977	0.977

Notes: This table estimates the effect of tariffs on labor markdowns and its relationship with firms' share of skilled labor in the local labor market. All regressions include the time fixed effect, the 2-digit CIC sector/industry fixed effect, and the firm fixed effect. The regressions also control for firm-level characteristics including total output, size of employment, capital-labor ratio, and total labor payments. These variables enter the regression in logarithms. Robust standard errors clustered at the industry-year pair are in parentheses. Significance: ***: 1%, **: 5%, *: 10%.

Focusing on Columns 1 and 2, we find that compared with those of small firms, the labor markdowns of large firms are significantly less affected by input tariff reductions. This result is consistent with the existing theory that suggests that firm size is substantially associated with the ability to exercise monopsony power in the local labor market.[19] Moreover, the results continue to show that the impact of tariff reductions on labor markdowns exhibits

[19] For example, Brooks et al. (2021*b*) show that labor markdowns are positively correlated with the firm's labor market share. Here, we focus on firms' market share in the skilled labor market, since we want to analyze the impact of college expansion reform on the exercise of monopsony power in the skilled labor market.

different patterns across regions with varying degrees of college expansion reforms. Columns 3 and 4 show the behavior of firms in provinces that experienced a large college expansion. In those high expansion areas, input tariff reductions led to a significant decrease in labor markdowns for small and large firms, and the impact on large firms is statistically indistinguishable from that on small firms. In contrast, when we focus on areas that experienced a small college expansion (Columns 5 and 6), we see that the impact of tariff reductions is concentrated on small firms, and the impact on large firms is significantly smaller and close to zero when firm sizes are measured at the province level. Overall, the results suggest that markdowns fell more for large firms located in regions that experienced larger college expansion reforms. The results support the model's predictions that aggregate labor supply expansion plays an important role in explaining the change in labor markdowns following input trade liberalization.

4. Aggregate Implications of Labor Markdown Changes

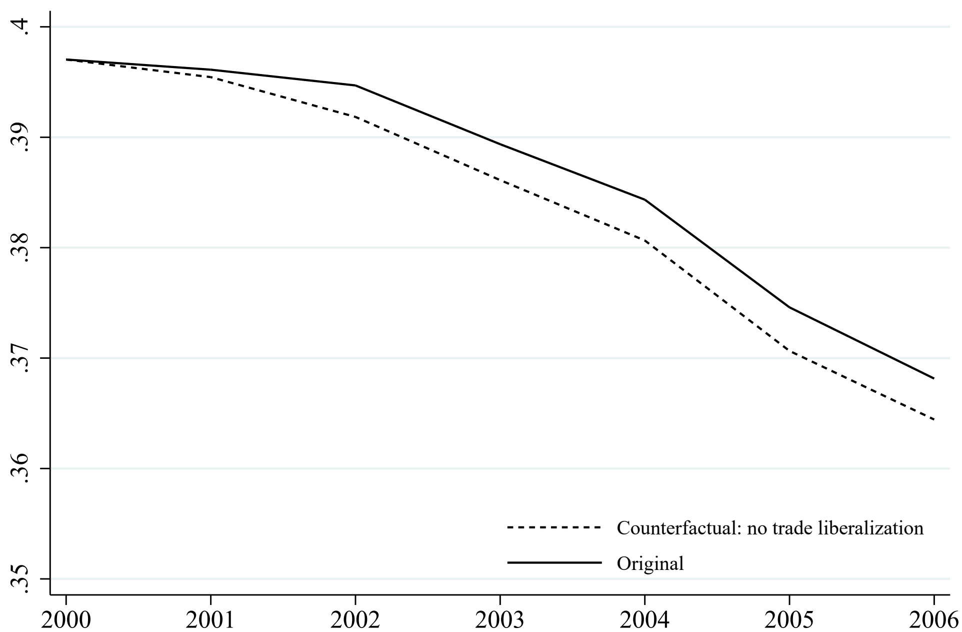
In this section, we investigate the change in aggregate labor share that arises from the impact of trade liberalization on labor markdowns. We also look at the contribution of trade liberalization to the evolution of the wage premium at skill-intensive firms through differential trade-induced changes in labor markdowns at skill-intensive firms.

4.1. Aggregate Labor Share Dynamics

We calculate the counterfactual labor share using the formula provided in Brooks et al. (2021*b*). Brooks et al. (2021*b*) show that the reciprocal of the labor share can be expressed as an equation of labor markdowns, product markups, and output elasticities with respect to materials and labor. To compute the counterfactual labor share, we replace the actual labor markdowns with the counterfactual labor markdowns that would happen in the absence of trade liberalization. See Appendix E for more details.

Figure 3 shows the actual and counterfactual labor share in Chinese manufacturing sector. The solid line shows the actual aggregate labor share in the data. The labor share in China decreases by approximately 3 percentage points between 2000 and 2006. The dotted line shows the counterfactual aggregate labor share in the absence of trade-driven markdown changes. The results suggest that if labor markdowns were not reduced due to trade liberalization, aggregate labor share would decrease by 0.4 percentage point (or 13 percent) more at the end of 2006.

Figure 3: Aggregate Labor Share in Manufacturing
Observed and Counterfactual



Notes: This graph plots the time path of aggregate labor's value-added share in the data, and counterfactual labor share in the absence of trade-driven markdown changes.

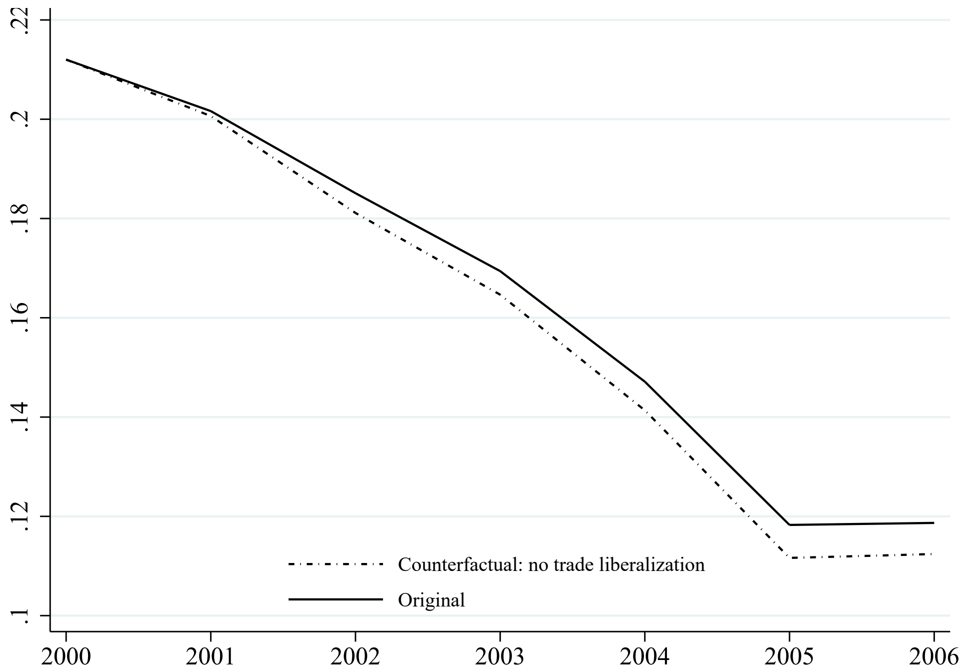
4.2. Skill-Intensive Firm Wage Premium

The results in Section 3.2.2 show that trade liberalization has differential impact on labor markdowns for skill-intensive and non-skill-intensive firms. This subsection estimates the change in the wage premium for skill-intensive firms that is explained by trade liberalization.

We calculate the wage premium by comparing the average wage of skill-intensive firms to that of non-skill-intensive firms. We regress the average wage on an indicator of skill-intensive firms and a large set of variables controlling for firm-specific characteristics.[20] We interpret the coefficient on the skill-intensive dummy as an estimate of wage premium of skill-intensive firms. To compute counterfactual wage premium in the absence of trade liberalization, we keep the marginal revenue product of labor unchanged, and only focus on the component of the wage premium driven by the change in labor markdowns of skill-intensive firms relative to labor markdowns of non-skill-intensive firms.

[20]We show the regression estimates in appendix Table E.1. In addition to the skill-intensive dummy, the regression includes 2-digit industry-by-year fixed effect, location-by-industry fixed effects, firm fixed effect, and time-varying firm characteristics such as output and exporting status. Our estimates of wage premium change very little if we include exporter-by-year fixed effects.

Figure 4: Wage Premium for Skill-Intensive Firms
Observed and Counterfactual



Notes: This graph plots the log wage difference between skill-intensive and non-skill-intensive firms after controlling for industry fixed effects, year fixed effects, location fixed effects, and time-varying firm characteristics. The solid line represents the time path of the skilled wage premium in the data. The dotted line represents the counterfactual wage premium where we assume the reduction in labor markdowns after trade liberalization for skill-intensive firms is the same as the reduction in labor markdowns for non-skill-intensive firms.

Figure 4 shows the actual and counterfactual wage premium for skill-intensive firms. In 2000, the average wage of skill-intensive firms is about 20 percent higher than the average wage of non-skill-intensive firms. This gap shrinks over time: By the end of the sample period, the wage premium for skill-intensive firms has declined to about 12 percent. The dotted line shows the counterfactual wage premium if trade liberalization reduces labor markdowns by the same amount for skill-intensive and non-skill-intensive firms: The wage premium at skill-intensive firms would have further decrease to almost 11 percent by 2006. Therefore, the reduction in wage premium between 2000 and 2006 would been larger, by 0.7 percentage points, in the absence of trade-induced markdown changes.

5. Conclusion

How does input trade liberalization affect firms' monopsony power in labor markets? We develop a simple model to trace how endogenous labor markdown changes after input tariff reductions, and to guide our empirical investigations. Our model shows that input tariff reductions lower firms' labor monopsony power if the aggregate labor supply expands enough to offset the labor concentrating effect of increased labor demand from incumbent firms.

Consistent with this labor supply elasticity mechanism, we show that following China's entry in the WTO and the ensuing input trade liberalization, firms labor markdowns are lower in labor markets with larger tariff reductions, especially for larger skill-intensive firms in locations where the aggregate labor of college-educated workers expand more.

Our results highlight the role of heterogeneous labor supply responses and skill intensity when considering the labor monopsony impact of trade reforms. One key caveat of our analysis is that we effectively take labor supply changes as given. Future research could fully endogenize labor supply decisions, along with rich labor supply elasticity heterogeneity when examining the effect of trade reforms on labor market power. This may be particularly important direction given the emerging divergence between findings in China and Brazil.

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Appendix A. Appendix: Tables for Robustness Checks

Table A.1: Migration costs and the impact of trade liberalization

	(1)	(2)	(3)	(4)
	Dependent variable = log(markdown)			
Input tariffs	0.147***	0.130***	0.223***	0.250***
	(0.033)	(0.037)	(0.041)	(0.047)
Output tariffs		0.020		-0.028
		(0.015)		(0.018)
lagged log(markup)			0.042***	0.042***
			(0.008)	(0.008)
log(migration cost)	0.012***	0.012***	0.011***	0.011***
	(0.002)	(0.002)	(0.002)	(0.002)
Firm characteristics	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	771,326	771,326	407,378	407,378
Adjusted R-squared	0.977	0.977	0.979	0.979

Notes: This table presents the estimates from Equation (13) including migration costs as an additional control in the regression. The migration cost is estimated following Tombe and Zhu (2019), and we include the log of the migration cost in the regression. All regressions include the time fixed effect, the 2-digit CIC sector/industry fixed effect, and the firm fixed effect. The regressions also control for firm-level characteristics including total output, size of employment, capital-labor ratio, and total labor payments. These variables enter the regression in logarithms. Robust standard errors clustered at the industry-year pair are in parentheses. Significance: ***: 1%, **: 5%, *: 10%.

Table A.2: Migration costs and the impact of trade liberalization

	(1)	(2)	(3)	(4)
	Dependent variable = log(markdown)			
Input tariffs	0.130***	0.119***	0.156***	0.182***
	(0.034)	(0.040)	(0.047)	(0.053)
Output tariffs		0.012		-0.025
		(0.016)		(0.021)
lagged log(markup)			0.025***	0.025***
			(0.008)	(0.008)
Input tariffs × $\mathbb{1}_{\text{skill intensity}}$	0.072**	0.074**	0.139***	0.133***
	(0.032)	(0.032)	(0.044)	(0.044)
log(migration cost)	0.012***	0.012***	0.011***	0.011***
	(0.002)	(0.002)	(0.002)	(0.002)
Firm characteristics	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	659,729	659,729	359,350	359,350
Adjusted R-squared	0.978	0.978	0.979	0.979

Notes: This table presents the estimates from Equation (14) including migration costs as an additional control in the regression. The migration cost is estimated following Tombe and Zhu (2019), and we include the log of the migration cost in the regression. All regressions include the time fixed effect, the 2-digit CIC sector/industry fixed effect, and the firm fixed effect. The regressions also control for firm-level characteristics including total output, size of employment, capital-labor ratio, and total labor payments. These variables enter the regression in logarithms. Robust standard errors clustered at the industry-year pair are in parentheses. Significance: ***: 1%, **: 5%, *: 10%.

Table A.3: Migration flows and the impact of trade liberalization

	(1)	(2)	(3)	(4)
	Dependent variable = log(markdown)			
	Low migration inflow changes	Low migration inflow changes	High migration inflow changes	High migration inflow changes
Input tariffs	0.100***	0.246***	0.199***	0.260***
	(0.037)	(0.045)	(0.054)	(0.076)
Output tariffs	0.025	-0.026	0.024	-0.014
	(0.015)	(0.017)	(0.026)	(0.036)
lagged log(markup)		0.065***		0.005
		(0.008)		(0.011)
Firm characteristics	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Observations	470,300	248,513	303,853	160,184
Adjusted R-squared	0.976	0.978	0.978	0.981

Notes: This table presents the estimates from Equation (13) using two subsamples. Columns 1 and 2 show the results using provinces with below-median migration inflows in 2000. Columns 3 and 4 show the results using provinces with above-median migration inflows. The change in migration inflows is calculated as the total inflow migrants in 2010 minus the total inflow migrants in 2000 divided by the population in 2000. All regressions include the time fixed effect, the 2-digit CIC sector/industry fixed effect, and the firm fixed effect. The regressions also control for firm-level characteristics including total output, size of employment, capital-labor ratio, and total labor payments. These variables enter the regression in logarithms. Robust standard errors clustered at the industry-year pair are in parentheses. Significance: ***: 1%, **: 5%, *: 10%.

Table A.4: Migration flows and the impact of trade liberalization

	(1)	(2)	(3)	(4)
	Dependent variable = log(markdown)			
	Low migration inflow changes	Low migration inflow changes	High migration inflow changes	High migration inflow changes
Input tariffs	0.096**	0.178***	0.161**	0.203**
	(0.039)	(0.052)	(0.065)	(0.094)
Output tariffs	0.015	-0.024	0.026	-0.007
	(0.016)	(0.020)	(0.028)	(0.039)
Input tariffs * 1skill intensity	0.077*	0.137**	0.068	0.101
	(0.040)	(0.053)	(0.049)	(0.071)
lagged log(markup)		0.046***		-0.008
		(0.008)		(0.011)
Firm characteristics	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Observations	391,558	214,062	270,585	146,463
Adjusted R-squared	0.977	0.978	0.979	0.981

Notes: This table presents the estimates from Equation (14) using two subsamples. Columns 1 and 2 show the results using provinces with below-median migration inflows in 2000. Columns 3 and 4 show the results using provinces with above-median migration inflows. The change in migration inflows is calculated as the total inflow migrants in 2010 minus the total inflow migrants in 2000 divided by the population in 2000. All regressions include the time fixed effect, the 2-digit CIC sector/industry fixed effect, and the firm fixed effect. The regressions also control for firm-level characteristics including total output, size of employment, capital-labor ratio, and total labor payments. These variables enter the regression in logarithms. Robust standard errors clustered at the industry-year pair are in parentheses. Significance: ***: 1%, **: 5%, *: 10%.

Table A.5: The effect of tariffs on markdowns: difference-in-difference estimation

	(1)	(2)	(3)	(4)
	Dependent variable = log(markdown)			
	Sample period: 2000–2006			
Input tariff$_{2000}$	0.018	-0.002	0.028	0.018
	(0.034)	(0.036)	(0.046)	(0.046)
Input tariff$_{2000}$	-0.049***	-0.049***	-0.057***	-0.057***
$\times \mathbb{1}\{$post-WTO dummy$\}$	(0.015)	(0.015)	(0.021)	(0.022)
Output tariff$_{2000}$		0.027		0.016
		(0.019)		(0.024)
lagged log(markup)			0.042***	0.042***
			(0.008)	(0.008)
Observations	774,159	774,159	408,703	408,703
Adjusted R-squared	0.977	0.977	0.979	0.979

Notes: All regressions include the time fixed effect, the 2-digit CIC sector/industry fixed effect, and the firm fixed effect. The regressions also control for firm-level characteristics including total output, size of employment, capital-labor ratio, and total labor payments. These variables enter the regression in logarithms. Robust standard errors clustered at the industry-year pair are in parentheses. Significance: ***: 1%, **: 5%, *: 10%.

Table A.6: The effect of tariffs on markdowns: difference-in-difference estimation

	(1)	(2)	(3)	(4)
	Dependent Variable = log(markdown)			
	Sample period: 2000–2006			
	Skill-intensive	Non-skill intensive	Skill-intensive	Non-skill intensive
Input tariff_{2000}	0.043	-0.017	0.050	0.035
	(0.046)	(0.062)	(0.058)	(0.091)
Input tariff_{2000}	-0.080***	-0.042*	-0.103***	-0.041
$\times \mathbb{1}\{\text{post-WTO dummy}\}$	(0.021)	(0.022)	(0.030)	(0.033)
Output tariff_{2000}	0.056*	-0.005	0.082**	-0.062
	(0.030)	(0.030)	(0.033)	(0.043)
lagged log(markup)			0.012	0.045***
			(0.009)	(0.010)
Observations	319,803	341,488	180,941	178,838
Adjusted R-squared	0.977	0.979	0.979	0.979

Notes: All regressions control for the time fixed effect, the 2-digit CIC sector/industry fixed effect, the firm fixed effect, and firm-level characteristics (total output, size of employment, capital-labor ratio, and total labor payments). The regressions also include an interaction term between the indicator for skill-intensive firms and time dummies. Robust standard errors clustered at the industry-year pair are in parentheses. Significance: ***: 1%, **: 5%, *: 10%.

Table A.7: The effect of tariffs on markdowns: alternative measures of markdowns

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variable = log(markdown)					
	Sample period: 2000–2006					
	DLW (baseline)	CD	CRS	DLW	CD	CRS
Input tariffs	0.125***	0.098***	0.058**	0.246***	0.209***	0.166***
	(0.037)	(0.030)	(0.029)	(0.047)	(0.039)	(0.032)
Output tariff	0.023	0.018	0.015	-0.025	-0.025	-0.030**
	(0.015)	(0.013)	(0.012)	(0.019)	(0.016)	(0.013)
lagged log(markup)				0.042***	0.056***	0.041***
				(0.008)	(0.008)	(0.006)
Observations	774,159	774,159	774,159	408,703	408,703	408,703
Adjusted R-squared	0.977	0.977	0.976	0.979	0.979	0.978

Notes: The regressions estimate the effect of tariffs on markdowns using different measures of markdowns. All regressions include the time fixed effect, the 2-digit CIC sector/industry fixed effect, and the firm fixed effect. The regressions also control for firm-level characteristics including total output, size of employment, capital-labor ratio, and total labor payments. These variables enter the regression in logarithms. Robust standard errors clustered at the industry-year pair are in parentheses. Significance: ***: 1%, **: 5%, *: 10%.

Table A.8: The role of skill intensity: alternative measures of markdowns

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variable = log(markdown)					
	Sample period: 2000–2006					
	DLW (baseline)	CD	CRS	DLW	CD	CRS
Input tariffs	0.112***	0.095***	0.077**	0.178***	0.181***	0.176***
	(0.040)	(0.034)	(0.030)	(0.054)	(0.054)	(0.053)
Input tariff$\times \mathbb{1}\{$skill intensive$\}$	0.076**	0.056*	0.022	0.130***	0.129***	0.126***
	(0.032)	(0.032)	(0.031)	(0.044)	(0.044)	(0.044)
Output tariff	0.017	0.008	0.000	-0.021	-0.022	-0.022
	(0.016)	(0.014)	(0.012)	(0.021)	(0.021)	(0.021)
lagged log(markup)				0.025***	0.037***	0.054***
				(0.008)	(0.008)	(0.006)
Observations	662,147	662,147	662,147	360,531	360,531	360,531
Adjusted R-squared	0.978	0.978	0.977	0.979	0.979	0.979

Notes: The regressions estimate the effect of tariffs on markdowns using different measures of markdowns. All regressions include the time fixed effect, the 2-digit CIC sector/industry fixed effect, and the firm fixed effect. The regressions also control for firm-level characteristics including total output, size of employment, capital-labor ratio, and total labor payments. These variables enter the regression in logarithms. The regressions also include an interaction term between the indicator for skill-intensive firms and time dummies. Robust standard errors clustered at the industry-year pair are in parentheses. Significance: ***: 1%, **: 5%, *: 10%.

Table A.9: The effect of tariffs on markdowns controlling for exporter-specific secular trends

	(1)	(2)	(3)	(4)
	Dependent Variable = log(markdown)			
	Sample period: 2000–2006			
Input tariffs	0.144***	0.131***	0.221***	0.249***
	(0.030)	(0.035)	(0.039)	(0.045)
Output tariffs		0.017		-0.029*
		(0.014)		(0.017)
lagged log(markup)			0.042***	0.042***
			(0.008)	(0.008)
$\mathbb{1}$\{exporter\} × $\mathbb{1}$\{t=2000\}	0.013***	0.013***		
	(0.003)	(0.003)		
$\mathbb{1}$\{exporter\} × $\mathbb{1}$\{t=2001\}	0.006**	0.006**	0.010***	0.010***
	(0.003)	(0.003)	(0.003)	(0.003)
$\mathbb{1}$\{exporter\} × $\mathbb{1}$\{t=2002\}	-0.004	-0.004	0.001	0.001
	(0.002)	(0.002)	(0.003)	(0.003)
$\mathbb{1}$\{exporter\} × $\mathbb{1}$\{t=2003\}	-0.002	-0.002	0.002	0.003
	(0.002)	(0.002)	(0.002)	(0.002)
$\mathbb{1}$\{exporter\} × $\mathbb{1}$\{t=2004\}	-0.003	-0.003	0.000	0.000
	(0.002)	(0.002)	(0.002)	(0.002)
$\mathbb{1}$\{exporter\} × $\mathbb{1}$\{t=2005\}	-0.004***	-0.004***	-0.002	-0.002
	(0.001)	(0.001)	(0.002)	(0.002)
$\mathbb{1}$\{exporter\} × $\mathbb{1}$\{t=2006\}	-0.008***	-0.008***	-0.005**	-0.005**
	(0.002)	(0.002)	(0.002)	(0.002)
Observations	774,156	774,156	408,702	408,702
Adjusted R-squared	0.977	0.977	0.979	0.979

Notes: All regressions include the time fixed effect, the 2-digit CIC sector/industry fixed effect, the firm fixed effect, and firm-level characteristics. Robust standard errors clustered at the industry-year pair are in parentheses. Significance: ***: 1%, **: 5%, *: 10%.

Table A.10: The role of skill intensity controlling for exporter-specific secular trends

	(1)	(2)	(3)	(4)
	Dependent Variable = log(markdown)			
	Sample period: 2000–2006			
Input tariffs	0.123***	0.115***	0.153***	0.181***
	(0.032)	(0.037)	(0.045)	(0.050)
Input tariff×$\mathbb{1}$\{skill intensive\}	0.079**	0.080**	0.140***	0.134***
	(0.032)	(0.032)	(0.044)	(0.044)
Output tariffs		0.009		-0.027
		(0.015)		(0.020)
lagged log(markup)			0.025***	0.025***
			(0.008)	(0.008)
$\mathbb{1}$\{exporter\} × $\mathbb{1}$\{t=2000\}	0.015***	0.015***		
	(0.003)	(0.003)		
$\mathbb{1}$\{exporter\} × $\mathbb{1}$\{t=2001\}	0.009***	0.008***	0.013***	0.013***
	(0.003)	(0.003)	(0.004)	(0.004)
$\mathbb{1}$\{exporter\} × $\mathbb{1}$\{t=2002\}	-0.004	-0.004	0.002	0.002
	(0.003)	(0.003)	(0.003)	(0.003)
$\mathbb{1}$\{exporter\} × $\mathbb{1}$\{t=2003\}	-0.001	-0.001	0.003	0.003
	(0.002)	(0.002)	(0.002)	(0.002)
$\mathbb{1}$\{exporter\} × $\mathbb{1}$\{t=2004\}	-0.002	-0.002	0.001	0.001
	(0.002)	(0.002)	(0.002)	(0.002)
$\mathbb{1}$\{exporter\} × $\mathbb{1}$\{t=2005\}	-0.004***	-0.004***	-0.002	-0.002
	(0.001)	(0.001)	(0.002)	(0.002)
$\mathbb{1}$\{exporter\} × $\mathbb{1}$\{t=2006\}	-0.008***	-0.008***	-0.005**	-0.005**
	(0.002)	(0.002)	(0.002)	(0.002)
Observations	662,146	662,146	360,530	360,530
Adjusted R-squared	0.978	0.978	0.979	0.979

Notes: All regressions include the time fixed effect, the 2-digit CIC sector/industry fixed effect, the firm fixed effect, and firm-level characteristics. The regressions also include an interaction term between the indicator for skill-intensive firms and time dummies. Robust standard errors clustered at the industry-year pair are in parentheses. Significance: ***: 1%, **: 5%, *: 10%.

Table A.11: The effect of tariffs on markdowns with province-specific secular trends

	(1)	(2)	(3)	(4)
	Dependent Variable = log(markdown)			
	Sample period: 2000–2006			
Input tariff	0.144***	0.134***	0.226***	0.256***
	(0.033)	(0.037)	(0.043)	(0.048)
Output tariff		0.013		-0.030
		(0.015)		(0.019)
lagged log(markup)			0.045***	0.045***
			(0.008)	(0.008)
Province×Year FE	Yes	Yes	Yes	Yes
Observations	774,159	774,159	408,703	408,703
Adjusted R-squared	0.977	0.977	0.979	0.979

Notes: All regressions include firm-level characteristics, the time fixed effect, the 2-digit CIC sector/industry fixed effect, the firm fixed effect, and the province-by-year fixed effect. Robust standard errors clustered at the industry-year pair are in parentheses. Significance: ***: 1%, **: 5%, *: 10%.

Table A.12: The role of skill intensity with province-specific secular trends

	(1)	(2)	(3)	(4)
	Dependent variable = log(markdown)			
	Sample period: 2000–2006			
Input tariff	0.126***	0.121***	0.158***	0.187***
	(0.034)	(0.040)	(0.049)	(0.055)
Input tariff$\times\mathbb{1}${skill intensive}	0.075**	0.076**	0.138***	0.132***
	(0.032)	(0.033)	(0.045)	(0.045)
Output tariff		0.005		-0.028
		(0.016)		(0.022)
lagged log(markup)			0.028***	0.028***
			(0.008)	(0.008)
Province$\times$Year FE	Yes	Yes	Yes	Yes
Observations	662,147	662,147	360,531	360,531
Adjusted R-squared	0.978	0.978	0.978	0.978

Notes: This table presents the estimates from equation (14). All regressions control for the time fixed effect, the 2-digit CIC sector/industry fixed effect, the firm fixed effect, and firm-level characteristics (total output, size of employment, capital-labor ratio, and total labor payments). The regressions also include an interaction term between the indicator for skill-intensive firms and time dummies. Robust standard errors clustered at the industry-year pair are in parentheses. Significance: ***: 1%, **: 5%, *: 10%.

Table A.13: Imported input intensity and the impact of trade liberalization

	(1)	(2)	(3)	(4)
	Dependent variable = log(markdown)			
	All	2001–2006	2001–2006	2001–2006
Input tariffs	0.125***	0.209***	0.217***	0.220***
	(0.037)	(0.046)	(0.056)	(0.048)
Output tariffs	0.023	-0.005	-0.006	-0.006
	(0.015)	(0.017)	(0.017)	(0.017)
Input tariffs × lagged imported input HHI			-0.019	
			(0.046)	
Input tariffs × lagged imported input share				-0.789
				(0.495)
Firm-level characteristics	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	774,159	692,181	692,178	692,178
Adjusted R-squared	0.977	0.978	0.978	0.978

Notes: This table tests whether the effect of input trade liberalization on labor markdowns varies with the firms' presence in imported input markets. We measure the firm's presence in imported input markets using the concentration in its imported input market (columns 1 and 2) or its imported input share (columns 3 and 4). All regressions include the time fixed effect, the 2-digit CIC sector/industry fixed effect, and the firm fixed effect. The regressions also control for firm-level characteristics including total output, size of employment, capital-labor ratio, and total labor payments. These variables enter the regression in logarithms. Robust standard errors clustered at the industry-year pair are in parentheses. Significance: ***: 1%, **: 5%, *: 10%.

Table A.14: Effect of tariffs on markdowns with skill intensity and college expansion

	(1)	(2)	(3)	(4)
	Dependent variable = log(markdown)			
	Sample period = 2000–2006			
	All	Skill-intensive	All	Skill-intensive
Input tariff	0.129***	0.171***	0.107***	0.145***
	(0.032)	(0.041)	(0.037)	(0.044)
Input tariff × expansion shock	0.161**	0.304***	0.171**	0.310***
	(0.080)	(0.108)	(0.079)	(0.108)
Output tariff			0.026*	0.035
			(0.015)	(0.023)
Observations	774,159	319,803	774,159	319,803
Adjusted R^2	0.977	0.977	0.977	0.977
Mean of expan shock	0.244	0.244	0.244	0.244

Notes: This table presents the estimates from Equation (15). All regressions include the time fixed effect, the 2-digit CIC sector/industry fixed effect, and the firm fixed effect. The regressions also control for firm-level characteristics including total output, size of employment, capital-labor ratio, and total labor payments. These variables enter the regression in logarithms. Robust standard errors clustered at the industry-year pair are in parentheses. Significance: ***: 1%, **: 5%, *: 10%.

Appendix B. Appendix: Markdown Measurements

In this appendix, we describe the steps we take to construct measurements of markups and markdowns. To construct measures of markups, we adopt the approach suggested by de Loecker and Warzynski (2012), which builds upon the insights from Hall (1987). de Locker and Warzynski show that the markup for firm i at time t can be expressed as

$$\mu_{it} = \frac{\theta_{it}^{M}}{\alpha_{it}^{M}},$$

where M indicates any flexibly chosen, price-taking input, θ_{it} is the output elasticity on input M, and α_{it} is the share of output revenue spent on input M. We follow the IO literature and assume materials as the flexible-chosen inputs. We directly compute the factor payment share α_{it} using our production data, since the data contain detailed firm-level information, including gross output and material expenditures.[21] To estimate the output elasticity of materials, we use the production function estimation of Ackerberg, Caves and Frazer (2015), as in de Loecker and Warzynski (2012). First, we estimate a polynomial regression of logged output and obtain a nonparametric estimate of logged output free of measurement error. Then, we construct measures of productivity under the assumption of a 3rd-order translog specification of gross output. Finally, we estimate all coefficients in the production function by relying on the law of motion for productivity. The output elasticity of materials is computed based on the estimated coefficients of the production function.

Although the above approach for estimating markups is standard in the IO literature (see de Loecker and Eeckhout, 2020; Hershbein, Macaluso and Yeh, 2022; Brooks et al., 2021*b*), it has some important shortcomings. First, this approach assumes that the production function is constant for all firms within an industry and differs only by a factor-neutral productivity parameter. Second, the identification of the production function relies on assumptions that

[21] In our data, material expenditures include the value of raw materials and intermediate input expenses during production, administrative, and operative processes.

preclude the estimation of the output elasticity of materials, which is necessary to apply the de Loecker and Warzynski (2012) formula.[22] In light of these shortcomings, we also test our baseline results using two alternative estimates of markups. In the first alternative approach, we estimate markups using the gross profit margin, which is computed as $\frac{\text{sales}}{\text{costs}}$. The gross profit margin is a valid estimate of the markup if the production function is constant returns to scale and the firm is price-taking in its inputs.[23] The second alternative approach assumes that the production function is Cobb-Douglas. Under this strong assumption, the output elasticity of materials is constant for all firms, and we choose $\theta^M = 0.8$ so that the average markup from using this approach equals the average measured using the gross profit margin method.

To compute labor markdowns, we first compute the ratio of the labor-based markup to the materials-based markup. The equation can be expressed as

$$\frac{\mu_{it}^L}{\mu_{it}^M} = \frac{\theta_{it}^L}{\alpha_{it}^L} \cdot \frac{\alpha_{it}^M}{\theta_{it}^M},$$

where α_{it}^L and α_{it}^M represent the factor payment share for labor and materials, and θ_{it}^L and θ_{it}^M represent the output elasticities. This equation comes naturally from solving the firm's profit maximization problem and is derived formally as in Hershbein, Macaluso and Yeh (2022). Normally, $\frac{\mu_{it}^L}{\mu_{it}^M}$ represents any unnamed distortion on labor relative to materials. Following the literature, we assume that there is no exercise of market power in the market for materials. Therefore, $\frac{\mu_{it}^L}{\mu_{it}^M}$ identifies only distortion to labor.

Second, we follow Brooks et al. (2021*b*) and interpret the comovement of $\frac{\mu_{it}^L}{\mu_{it}^M}$ with a firm's

[22]See Morlacco (2019) for recent work that uses data on French firms to highlight significant monopsony market power for imported intermediate inputs relative to domestic intermediate inputs. Our paper assumes instead that Chinese importers are price-takers for materials. Morlacco (2019) also discusses challenges to the estimations of markups when this assumption does not hold. We address these potential biases in our robustness exercises.

[23]The costs of production include labor payments, material expenditures, and payments to capital. Labor payments and material expenditures are directly from the data. To compute the payments to capital, like Brooks et al. (2021*b*), we assume a standard depreciation rate of $\delta = 0.05$ and an interest rate of $r = 0.10$ so that the return to capital for a Chinese manufacturing firm is $\delta + r = 0.15$.

labor market share as the exercise of monopsony power in the labor market. Specifically, we estimate the following equation:

$$\frac{\mu_{it}^{L}}{\mu_{it}^{M}} = \Gamma_t + \delta_i + \beta s_{it}^{L} + \epsilon_{it}, \qquad \text{(Appendix B.1)}$$

where $s_{it}^{L} = \frac{w_i l_i}{\sum_{i \in l} w_i l_i}$ denotes firm i's share in the labor market l at time i.We rescale the ratio $\frac{\mu_{it}^{L}}{\mu_{it}^{M}}$ so that it has an average intercept of one in the equation (Appendix B.1). Rescaling assures us that eliminating the market power in the labor market (i.e., the component of this markdown that covaries with labor market share) is equivalent to setting the average markdown to one.

The final step of computing markdowns requires us to define the appropriate labor market for computing a firm's labor market share. We consider labor markets to be segmented both geographically and by type of work. Concerning geography, we believe that provinces are an appropriate choice for the labor market, since cross-province migration in China is restricted by the Hukou system. Regarding the type of work, we assume that workers have a degree of specialization and hence cannot move perfectly across 4-digit industries.

Appendix C. Appendix: Model with Derivations and Proofs

Environment

We consider an economy in which firms can exercise labor market power in their local labor market indexed by $k \in \mathcal{K}$. Each labor market k is populated by a continuum of workers who elastically supply labor to the discrete set $\mathcal{I}_k = \{1, \dots, N_k\}$ of firms operating locally.

Firm Problem

Let a firm indexed by i have a production function $y_i = z_i F(\ell_i, m_i)$ where ℓ_i is the firm's labor input and m_i is the firm's intermediate input. We assume the firm is price-taking in the market for intermediate inputs m. Given tariffs τ_k and world prices $\tilde{r}$, we denote the intermediate input prices $r_k \equiv (1+\tau_k)\tilde{r}$.

However, the firm can exercise labor market power when hiring labor ℓ in its labor market k, that $\frac{\partial w_{i,k}}{\partial \ell_i} \neq 0$ where $w_{i,k}$ denotes the wage in i's labor market k. The firm is also assumed to have market power in its output market, that is $\frac{\partial p_i}{\partial y_i} \neq 0$ where p_i denotes the price of firm i's output.

The problem of a firm i located in location k, given the inverse demand function $p(y_i; \cdot)$, the choices of other firms $\{\ell_j\}_{j \neq i}$ and intermediate input prices $r_k \equiv (1+\tau_k)\tilde{r}$ is

$$\max_{\ell_i, m_i} \quad p(y_i; \cdot) y_i - w_{i,k}(\ell_i; \cdot)\ell_i - r_k m_i \tag{2}$$

$$\text{s.t. } y_i = z_i F(\ell_i, m_i)$$

Optimality conditions and the price-taking assumption for r_k yield:

$$\frac{r_k}{z_i F_{m_i}(\cdot)} = \frac{\partial p(y_i)}{\partial y_i} \times y_i + p(y_i) \quad \text{(Appendix C.1)}$$

$$\frac{w_{i,k}(\ell_i)}{z_i F_{\ell_i}(\cdot)} = \frac{\partial p(y_i)}{\partial y_i} \times y_i + p(y_i) - \frac{\partial w_{i,k}(\ell_i)}{\partial \ell_i} \times \ell_i \times \frac{1}{z_i F_{\ell_i}(\cdot)} \quad \text{(Appendix C.2)}$$

where $F_\ell(\ell, m) \equiv \partial F(\ell, m)/\partial \ell$ and $F_m(\ell, m) \equiv \partial F(\ell, m)/\partial m$.

Note that in the absence of labor market power, we have $\frac{\partial w_{i,k}(\ell_i)}{\partial \ell_i} = 0$ and therefore the ratio of factor payment shares equals the ratio of output elasticities:

$$\frac{r_k}{z_i F_{m_i}(\cdot)} = \frac{w_{i,k}}{z_i F_{\ell_i}(\cdot)} \Rightarrow \frac{r_k m_i}{w_{i,k} \ell_i} = \frac{F_{m_i}(\cdot) m_i}{F_{\ell_i}(\cdot) \ell_i}. \quad \text{(Appendix C.3)}$$

Markups and Markdowns

We now define markups and markdowns before characterizing how markups vary with changes in input tariffs. The definitions below are useful as they map into measurements and estimation techniques we use in the empirical parts.

Definition 1 (Firm-level labor supply elasticities)**.** *The inverse labor supply faced by a firm i is defined as*

$$\varepsilon_{i,k}^{-1}(\ell_i) \equiv \frac{\partial \log w_{i,k}(\ell_i)}{\partial \log \ell_i} = \frac{\ell_i}{w_{i,k}(\ell_i)} \frac{\partial w_{i,k}(\ell_i)}{\partial \ell_i}. \quad \text{(Appendix C.4)}$$

Definition 2 (Firm-level labor supply elasticities)**.** *The inverse labor supply faced by a firm i is defined as*

$$\varepsilon_{i,k}^{-1}(\ell_i) \equiv \frac{\partial \log w_{i,k}(\ell_i)}{\partial \log \ell_i} = \frac{\ell_i}{w_{i,k}(\ell_i)} \frac{\partial w_{i,k}(\ell_i)}{\partial \ell_i}. \quad \text{(Appendix C.5)}$$

Definition 3 (Inverse product demand elasticities)**.** *The inverse product demand elasticity* *faced by firm i is defined as:*

$$-\sigma_i^{-1}(y_i) \equiv \frac{\partial \log p(y_i)}{\partial \log y_i} = \frac{y_i}{p(y_i)} \frac{\partial p(y_i)}{\partial y_i}. \tag{Appendix C.6}$$

Definition 4 (Output elasticities and factor payment shares)**.** *The output elasticities from firm i's production function with respect to materials and labor are defined as:*

$$\theta_{m_i}(\ell_i, m_i) \equiv \frac{\partial \log z_i F(\ell_i, m_i)}{\partial \log m_i} = \frac{m_i F_{m_i}(\cdot)}{F(\cdot)} \tag{Appendix C.7}$$

and

$$\theta_{\ell_i}(\ell_i, m_i) \equiv \frac{\partial \log z_i F(\ell_i, m_i)}{\partial \log \ell_i} = \frac{\ell_i F_{\ell_i}(\cdot)}{F(\cdot)}. \tag{Appendix C.8}$$

Definition 5 (Output elasticities and factor payment shares)**.** *The materials and labor payment shares for firm i are denoted by:*

$$\alpha_{m_i}(\ell_i, m_i) \equiv \frac{r_k m_i}{p(y_i) z_i F(\cdot)} \tag{Appendix C.9}$$

and

$$\alpha_{\ell_i}(\ell_i, m_i) \equiv \frac{\ell_i w_{i,k}(\ell_i)}{p(y_i) z_i F(\cdot)}. \tag{Appendix C.10}$$

Before deriving labor markdowns in the context of our model, we use these optimality conditions to state two standard measurement results on labor market distortions and markup estimations. First, we state the common result that firm-level demand elasticities operate as a labor wedge in the allocation of labor.

More generally, we get from the optimality conditions that

$$\frac{r_k}{z_i F_{m_i}(\cdot)} = \frac{w_{i,k}(\ell_i)}{z_i F_{\ell_i}(\cdot)} + \frac{\partial w_{i,k}(\ell_i)}{\partial \ell_i} \times \ell_i \times \frac{1}{z_i F_{\ell_i}(\cdot)}. \tag{Appendix C.11}$$

Rearranging the terms, we then get the relationship below which we will leverage later:

$$\frac{F_{\ell_i}(\cdot)}{F_{m_i}(\cdot)} = \frac{w_{i,k}(\ell_i)}{r_k}\left[1 + \frac{\ell_i}{w_{i,k}(\ell_i)}\frac{\partial w_{i,k}(\ell_i)}{\partial \ell_i}\right] \qquad \text{(Appendix C.12)}$$

Lemma 1 (Labor market power as labor wedge)**.** *The firm optimality conditions imply the standard formulation that labor market power, in the sense of positive firm-level inverse labor supply elasticities* ($\varepsilon_{i,k}^{-1}(\ell_i) > 0$)*, acts as a wedge distorting the allocation of labor relative to the competitive market allocation:*

$$\frac{F_{\ell_i}(\cdot)}{F_{m_i}(\cdot)} = \frac{\lambda}{\mu} = \frac{w_{i,k}(\ell_i)}{r_k}\left[1 + \varepsilon_{i,k}^{-1}(\ell_i)\right]. \qquad (3)$$

Moreover, we get that

$$\frac{r_k}{z_i F_{m_i}(\cdot)} = \frac{\partial p(y_i)}{\partial y_i} \times y_i + p(y_i) \qquad \text{(Appendix C.13)}$$

$$\frac{r_k}{z_i F_{m_i}(\cdot)} = p(y_i)\left[\frac{\partial p(y_i)}{\partial y_i} \times \frac{y_i}{p(y_i)} + 1\right] \qquad \text{(Appendix C.14)}$$

The second common result shows that materials-based markups depend on product demand elasticities and push materials marginal revenue above their marginal cost.

Theorem 7 (Markup over intermediate input)**.** *The inverse product demand elasticity faced by the firm implies a markup* $\left[1 - \sigma_i^{-1}(y_i)\right]^{-1}$ *over intermediate input prices* r_k *such that:*

$$p(y_i) = \left[1 - \sigma_i^{-1}(y_i)\right]^{-1} \frac{r_k}{z_i F_{m_i}(\cdot)}. \qquad (6)$$

Similarly, for labor, the ratio of the marginal cost and the marginal product satisfies:

$$
\begin{aligned}
\frac{w_{i,k}(\ell_i)}{z_i F_{\ell_i}(\cdot)} &= \frac{\partial p(y_i)}{\partial y_i} \times y_i + p(y_i) - \frac{\partial w_{i,k}(\ell_i)}{\partial \ell_i} \times \ell_i \times \frac{1}{z_i F_{\ell_i}(\cdot)} \\
\frac{w_{i,k}(\ell_i)}{z_i F_{\ell_i}(\cdot) p(y_i)} &= \left[1 - \sigma_i^{-1}(y_i)\right] - \frac{\partial w_{i,k}(\ell_i)}{\partial \ell_i} \times \ell_i \times \frac{1}{z_i F_{\ell_i}(\cdot) p(y_i)} \\
\frac{w_{i,k}(\ell_i)}{z_i F_{\ell_i}(\cdot) p(y_i)} &= \left[1 - \sigma_i^{-1}(y_i)\right] - \varepsilon_{i,k}^{-1}(\ell_i) \times \frac{w_{i,k}(\ell_i)}{z_i F_{\ell_i}(\cdot) p(y_i)}
\end{aligned}
$$

As a result, we can derive that the labor-based markup is a function of both product market frictions and labor market monopsony power. Following the literature, we define labor markdowns as the labor-based markup divided by the materials-based markup, an input for which we assume the firm is a price-taker. The theorem below states these standard results formally.

Lemma 2 (Labor markdowns)**.** *The labor markdown–the ratio of the labor-based markup and the materials-based markup– for firm i equals*

$$\left[1 + \varepsilon_{i,k}^{-1}(\ell_i)\right]. \tag{4}$$

The results above form the basis of the estimation techniques used in the paper and in the literature. The corollary below states how factor shares and output elasticities are used to measure markups and markdowns, as we do in the empirical section.

Corollary 8 (Factor payment shares, output elasticities, and markup estimation)**.** *Markups can be derived from factor payment shares and output elasticities since*

$$\theta_{m_i} = \left[1 - \sigma_i^{-1}(y_i)\right]^{-1} \alpha_{m_i} \tag{Appendix C.15}$$

and

$$\theta_{\ell_i} = \left[1 + \varepsilon_{i,k}^{-1}(\ell_i)\right] \left[1 - \sigma_i^{-1}(y_i)\right]^{-1} \alpha_{\ell_i}. \tag{Appendix C.16}$$

For verification, note that this yields, as expected:

$$\begin{aligned}\left[1+\varepsilon_k^{-1}(\ell_i)\right]\frac{w_{i,k}(\ell_i)}{z_iF_{\ell_i}(\cdot)p(y_i)} &= \left[\sigma_i^{-1}(y_i)+1\right]\\ \frac{r_k}{z_iF_{m_i}(\cdot)p(y_i)} &= \left[\sigma_i^{-1}(y_i)+1\right]\\ \left[1+\varepsilon_k^{-1}(\ell_i)\right]\frac{w_{i,k}(\ell_i)}{r_k} &= \frac{F_{\ell_i}(\cdot)}{F_{m_i}(\cdot)}\end{aligned}$$

Having re-derived these identities in the context of our environment, we now make simplifying assumptions and turn to the endogenous response of the labor markdown to exogenous changes in the tariffs over intermediate inputs.

Deriving Optimal Allocations

The generality of the previous section allowed us to incorporate the measurement and estimation of markups and markdowns used in our empirical exercises. We now make a couple of simplifying parametric assumptions in order to derive an analytical characterization of markdowns. First, we assume that the firm has a Cobb-Douglas production function. Second, we restrict the demand to the standard constant elasticity of the substitution system.

Assumption 1 (Cobb-Douglas production function)**.** *The production function satisfies* $y_i = z_iF(\ell, m) = z_i\ell^{\lambda}m^{\mu}$ *with* $\lambda > 0,\ \mu > 0$. *The implied output elasticities with respect to labor and materials satisfy* $\theta_\ell(\ell, m) = \lambda$ *and* $\theta_m(\ell, m) = \mu$.

Assumption 2 (Constant inverse demand elasticity)**.** *The inverse demand function satisfies* $p(y_i) = Ay_i^{-\sigma^{-1}}$ *with* $\sigma > 1$ *and* $A > 0$. *The inverse product demand elasticity faced by the firm is therefore given by* $-\sigma_i^{-1}(y_i) = -\sigma^{-1}$.

Recall that the objective of the firm is

$$\max_{\ell_i, m_i} \quad p(y_i;\cdot)y_i - w_{i,k}(\ell_i;\cdot)\ell_i - r_k m_i$$
$$\text{s.t. } y_i = z_i F(\ell_i, m_i)$$

Substituting for $\alpha_{m_i} = \left[1 - \sigma_i^{-1}(y_i)\right]\theta_{m_i}$, we obtain:

$$\max_{\ell_i, y_i} \quad p(y_i;\cdot)y_i - w_{i,k}(\ell_i;\cdot)\ell_i - \left[1 - \sigma_i^{-1}(y_i)\right]\theta_{m_i} p(y_i;\cdot)y_i$$

or

$$\max_{\ell_i, y_i} \quad \Big(1 - \left[1 - \sigma_i^{-1}(y_i)\right]\theta_{m_i}\Big) p(y_i;\cdot)y_i - w_{i,k}(\ell_i;\cdot)\ell_i.$$

Denote $\tilde{\mu} \triangleq \left[1 - \sigma^{-1}\right]\mu$, $\tilde{\lambda} \triangleq \left[1 - \sigma^{-1}\right]\lambda$, and $\tilde{z}_i \triangleq z_i^{1-\sigma^{-1}}$.

Let us denote output elasticities and productivity parameters adjusted for the demand elasticity as $\tilde{\mu} \triangleq \left[1 - \sigma^{-1}\right]\mu$, $\tilde{\lambda} \triangleq \left[1 - \sigma^{-1}\right]\lambda$, and $\tilde{z}_i \triangleq z_i^{1-\sigma^{-1}}$.

We can rewrite the optimal intermediate input share formula to yield

$$\frac{r_k m_i}{p(y_i)y_i} = \left[1 - \sigma^{-1}\right]\mu$$
$$r_k m_i = \tilde{\mu} \times A \times \left[\tilde{z}_i \times \ell_i^{\tilde{\lambda}} m_i^{\tilde{\mu}}\right].$$

We get as a result that the materials demanded satisfies:

$$m_i^{1-\tilde{\mu}} = \frac{1}{r_k}\tilde{\mu} \times A \times \left[\tilde{z}_i \times \ell_i^{\tilde{\lambda}}\right]. \qquad \text{(Appendix C.17)}$$

An additional substitution in the formula for revenues yields:

$$
\begin{aligned}
p(y_i)y_i &= A\tilde{z}_i \times \ell_i^{\tilde{\lambda}} \left[m_i^{1-\tilde{\mu}}\right]^{\frac{\tilde{\mu}}{1-\tilde{\mu}}} \\
p(y_i)y_i &= A\tilde{z}_i \times \ell_i^{\tilde{\lambda}} \left[\frac{1}{r_k}\tilde{\mu} \times A \times \left[\tilde{z}_i \times \ell_i^{\tilde{\lambda}}\right]\right]^{\frac{\tilde{\mu}}{1-\tilde{\mu}}} \\
p(y_i)y_i &= \left[\frac{1}{r_k}\tilde{\mu}\right]^{\frac{\tilde{\mu}}{1-\tilde{\mu}}} \left\{A \times \left[\tilde{z}_i \times \ell_i^{\tilde{\lambda}}\right]\right\}^{\frac{1}{1-\tilde{\mu}}}.
\end{aligned}
$$

The firm's problem can then be written as a labor demand problem such that:

$$
\begin{aligned}
&\max_{\ell_i} \quad (1-\tilde{\mu})\, p(y_i;\cdot)y_i - w_{i,k}(\ell_i;\cdot)\ell_i \\
&\max_{\ell_i} \quad (1-\tilde{\mu}) \left[\frac{1}{r_k}\tilde{\mu}\right]^{\frac{\tilde{\mu}}{1-\tilde{\mu}}} \left\{A \times \left[\tilde{z}_i \times \ell_i^{\tilde{\lambda}}\right]\right\}^{\frac{1}{1-\tilde{\mu}}} - w_{i,k}(\ell_i;\cdot)\ell_i \\
&\max_{\ell_i} \quad B(r_k) \times \left[\tilde{z}_i \times \ell_i^{\tilde{\lambda}}\right]^{\frac{1}{1-\tilde{\mu}}} - w_{i,k}(\ell_i;\cdot)\ell_i
\end{aligned}
\tag{7}
$$

where $B(r_k) \triangleq (1-\tilde{\mu})\,[\tilde{\mu}/r_k]^{\frac{\tilde{\mu}}{1-\tilde{\mu}}}\,[A]^{\frac{1}{1-\tilde{\mu}}}$.

The first-order conditions with respect to ℓ_i yield:

$$
\frac{\tilde{\lambda}}{1-\tilde{\mu}} B(r_k) \times \left[\tilde{z}_i \times \ell_i^{\tilde{\lambda}}\right]^{\frac{1}{1-\tilde{\mu}}} \times \frac{1}{\ell_i} = w_{i,k}(\ell_i;\cdot) + \frac{\partial w_{i,k}(\ell_i;\cdot)}{\partial \ell_i}\ell_i \tag{Appendix C.18}
$$

$$
\frac{\tilde{\lambda}}{1-\tilde{\mu}} B(r_k) \times \left[\tilde{z}_i \times \ell_i^{\tilde{\lambda}}\right]^{\frac{1}{1-\tilde{\mu}}} \times \frac{1}{w_{i,k}(\ell_i;\cdot)\ell_i} = 1 + \frac{\partial w_{i,k}(\ell_i;\cdot)}{\partial \ell_i}\frac{\ell_i}{w_{i,k}(\ell_i;\cdot)} \tag{Appendix C.19}
$$

The first-order conditions with respect to ℓ_i imply that the equilibrium labor allocations $\{\ell_i\}_i$ jointly satisfy a system of equations such that

$$
\frac{\tilde{\lambda}}{1-\tilde{\mu}} B(r_k) \times \left[\tilde{z}_i \times \ell_i^{\tilde{\lambda}}\right]^{\frac{1}{1-\tilde{\mu}}} \times \frac{1}{w_{i,k}(\ell_i;\cdot)\ell_i} = 1 + \varepsilon_k^{-1}(\ell_i) \quad \forall\, i. \tag{8}
$$

In order to gain more analytical tractability, we turn to an assumption on the wage function faced by the firm. In particular, we assume a log-linear wage function with respect to the firm's demand.

Assumption 3 (Wage function)**.** *Given other firms' labor demands* $\{\ell_j : j \neq i\}$, *the wage function for a given firm* i *demanding* ℓ_i *units of labor in labor market* k *satisfies*

$$w_{i,k}(\ell_i, \cdot) = \left[\frac{\ell_i^{\varphi}}{\mathcal{L}_{-i}^{\varphi} + \ell_i^{\varphi}}\right]^{\frac{\eta}{\varphi}} \left(\mathcal{L}_{-i}^{\varphi} + \ell_i^{\varphi}\right)^{\frac{\nu}{\varphi}},$$

where $\mathcal{L}_{-i}^{\varphi} \triangleq \sum_{j \neq i, j \in \mathcal{I}_k} \ell_j^{\varphi}$.

Returning to the FOCs, we get

$$\begin{aligned}
\frac{\partial \log w_k(\ell_i)}{\partial \log \ell_i} &= \frac{\partial \left[\eta \log(\ell_i) + \frac{\nu-\eta}{\varphi} \log(\mathcal{L}_{-i}^{\varphi} + \exp(\varphi \log \ell_i))\right]}{\partial \log \ell_i} \\
\varepsilon_k^{-1}(\ell_i) &= \eta + \frac{\nu - \eta}{\varphi} \frac{\varphi \exp(\varphi \log \ell_i)}{\mathcal{L}_{-i}^{\varphi} + \exp(\varphi \log \ell_i)} \\
\varepsilon_k^{-1}(\ell_i) &= \eta + (\nu - \eta) \frac{\ell_i^{\varphi}}{\mathcal{L}_{-i}^{\varphi} + \ell_i^{\varphi}}.
\end{aligned}$$

Therefore, under this modified log linear wage assumption, the labor supply elasticity faced by firm i is

$$\varepsilon_k^{-1}(\ell_i) \equiv \frac{\partial \log w_k(\ell_i)}{\partial \log \ell_i} = \eta + (\nu - \eta) \frac{\ell_i^{\varphi}}{\mathcal{L}_{-i}^{\varphi} + \ell_i^{\varphi}}.$$

It is important to note that in the common case of an iso-elastic, that is $(\nu - \eta) = 0$, we have a constant firm-level inverse labor supply elasticity $\varepsilon_k^{-1}(\ell_i)$. In that case, the labor markdown $(1 + \varepsilon_k^{-1}(\ell_i))$ would also be constant and would not vary with tariff changes.

Note also that under the BHM formulation s.t.

$$\begin{aligned}
\log w &\propto \frac{1}{\eta_{BHM}} n_i + \left(\varphi_{BHM} - \frac{1}{\eta_{BHM}}\right) \log N_{-i} \\
\log w &\propto \frac{1}{\eta_{BHM}} n_i + \left(\varphi_{BHM} - \frac{1}{\eta_{BHM}}\right) \left(\frac{1 + \eta_{BHM}}{\eta_{BHM}}\right)^{-1} \log \left(N_{-i}^{\frac{1+\eta_{BHM}}{\eta_{BHM}}} + n_i^{\frac{1+\eta_{BHM}}{\eta_{BHM}}}\right),
\end{aligned}$$

we have the following mapping: $\eta = \frac{1}{\eta_{BHM}}$, $\varphi = \frac{1+\eta_{BHM}}{\eta_{BHM}}$, $\nu = \varphi_{BHM}$.

More generally, under the log-linear wage assumption above, we derive the firm's optimal labor demand decision in the following theorem.

Theorem 3 (Optimal labor demand)**.** *The optimal labor demanded by firm i, given other firms' strategies $\mathcal{L}_{-i}$ and given intermediate input prices $r_k \equiv (1+\tau_k)\tilde{r}$, solves*

$$\left(1+\eta+(\nu-\eta)\frac{\ell_i^{\varphi}}{\mathcal{L}_{-i}^{\varphi}+\ell_i^{\varphi}}\right)\left(\frac{\ell_i^{\varphi}}{\mathcal{L}_{-i}^{\varphi}+\ell_i^{\varphi}}\right)^{\frac{-(\nu-\eta)}{\varphi}} \ell_i^{(1+\nu)-\frac{\tilde{\lambda}}{1-\tilde{\mu}}} = \frac{\tilde{\lambda}}{1-\tilde{\mu}} B(r_k)\,[\tilde{z}_i]^{\frac{1}{1-\tilde{\mu}}}. \qquad (9)$$

The optimal labor demand equation implicitly defines the firm's labor demand as a function of the other firms' strategies $\mathcal{L}_{-i}$ and the material price $r_k \equiv (1+\tau_k)\tilde{r}$. The dependence on other firms' decisions highlights that markdowns are jointly determined as a labor market equilibrium outcome. The next assumption allows us to capture labor market clearing conditions and to study the implied equilibrium markdown outcomes.

Combining the aggregate labor supply condition above with the firm inverse labor supply elasticity, we derive an intuitive and useful result on markdowns in the case of a symmetric equilibrium. Indeed, when all local firms are homogeneous, $\ell_i = \ell \Rightarrow \ell = L_k/N_k$ and the implied equilibrium number of firms N_k also governs equilibrium markdowns.

Corollary 9 (Entry and labor market power in symmetric equilibria)**.** *In a symmetric equilibrium (that is, $z_i = z_k, \ell_i = \ell_k \ \forall i \in N_k$), the extensive margin N_k of active firms governs the equilibrium labor markdown which simplifies to:*

$$\left[1+\varepsilon_k^{-1}(\ell_k)\right] = 1+\eta+\frac{(\nu-\eta)}{N_k}.$$

Moreover, in this symmetric equilibrium, after substituting for the aggregate labor market condition ($N_k \times \ell = L_k$), the optimal firm labor demand implies an equilibrium firm entry equation.

$$\left(1+\eta+(\nu-\eta)\frac{1}{N_k}\right)\left(\frac{1}{N_k}\right)^{\frac{-(\nu-\eta)}{\varphi}} \ell^{(1+\nu)-\frac{\tilde{\lambda}}{1-\tilde{\mu}}} = \frac{\tilde{\lambda}}{1-\tilde{\mu}}\,[\tilde{z}]^{\frac{1}{1-\tilde{\mu}}}\, B(r_k). \qquad \text{(Appendix C.20)}$$

This equilibrium condition implies

$$\ell^{(1+\nu)-\frac{\tilde{\lambda}}{1-\tilde{\mu}}} = \frac{\tilde{\lambda}}{1-\tilde{\mu}} [\tilde{z}]^{\frac{1}{1-\tilde{\mu}}} B(r_k) (N_k)^{-\frac{(\nu-\eta)}{\varphi}} \left(1+\eta+\frac{1}{N_k}(\nu-\eta)\right)^{-1}. \quad \text{(Appendix C.21)}$$

Using the aggregate labor market condition: $N_k \times \ell = L_k$, we get:

$$\left[\frac{L_k}{N_k}\right]^{(1+\nu)-\frac{\tilde{\lambda}}{1-\tilde{\mu}}} = \frac{\tilde{\lambda}}{1-\tilde{\mu}} [\tilde{z}]^{\frac{1}{1-\tilde{\mu}}} B(r_k) (N_k)^{-\frac{(\nu-\eta)}{\varphi}} \left(1+\eta+\frac{1}{N_k}(\nu-\eta)\right)^{-1}. \quad \text{(Appendix C.22)}$$

We also showed previously that, in this case, the markdown is a simple function of the number of operating firms. Therefore, this firm entry equation closes the local labor market equilibrium.Technically, the equilibrium number of firms N_k needs to be an integer. We consider the equilibrium condition on the real line for the purpose of our variational analysis.

Corollary 4 (Symmetric Local Equilibrium and Entry)**.** *In a symmetric equilibrium (that is, $z_i = z_k$ and $\ell_i = \ell_k$ $\forall i \in N_k$), given materials prices r_k and aggregate labor L_k, the number of firms N_k satisfies*

$$\left(N_k\right)^{\frac{(\nu-\eta)}{\varphi}} \left(1+\eta+(\nu-\eta)\frac{1}{N_k}\right) \left(\frac{L_k}{N_k}\right)^{(1+\nu)-\frac{\tilde{\lambda}}{1-\tilde{\mu}}} = \frac{\tilde{\lambda}}{1-\tilde{\mu}} [\tilde{z}]^{\frac{1}{1-\tilde{\mu}}} B(r_k)$$

with $\ell_k = \frac{L_k}{N_k}$. Furthermore, the labor markdown is $\left[1+\varepsilon_k^{-1}(\ell_k)\right] = 1+\eta+\frac{(\nu-\eta)}{N_k}$.

Taking logs, we get:

$$\left((1+\nu)-\frac{\tilde{\lambda}}{1-\tilde{\mu}}-\frac{(\nu-\eta)}{\varphi}\right)\log N_k - \log\left(1+\eta+\frac{(\nu-\eta)}{N_k}\right) \quad \text{(Appendix C.23)}$$

$$= \left((1+\nu)-\frac{\tilde{\lambda}}{1-\tilde{\mu}}\right)\log L_k \quad \text{(Appendix C.24)}$$

$$-\log\left(\frac{\tilde{\lambda}}{1-\tilde{\mu}}\right) - \left(\frac{1}{1-\tilde{\mu}}\right)\log\tilde{z} \quad \text{(Appendix C.25)}$$

$$-\log B(r_k) \quad \text{(Appendix C.26)}$$

where $B(r_k) \triangleq (1-\tilde{\mu})\,[\tilde{\mu}/r_k]^{\frac{\tilde{\mu}}{1-\tilde{\mu}}}\,\left[A\right]^{\frac{1}{1-\tilde{\mu}}}$.

Note that

$$\left((1+\nu) - \frac{\tilde{\lambda}}{1-\tilde{\mu}} - \frac{(\nu-\eta)}{\varphi}\right) = \left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \frac{\varphi-1}{\varphi}\nu + \frac{\eta}{\varphi}\right) > 0$$

and

$$\left((1+\nu) - \frac{\tilde{\lambda}}{1-\tilde{\mu}}\right) = \left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \nu\right) > 0.$$

We are now ready to study how entry, and thereby markdowns, change with input tariff reductions. By taking the aggregate labor supply L_k as given, we effectively abstracted from the household labor market choice problem. We introduce an additional assumption capturing how this aggregate supply changes with local input tariff changes, say due to changes in wages.

Assumption 4 (Aggregate labor supply elasticity)**.** *Input tariff changes affect equilibrium labor supply through wages such that*

$$\frac{\partial \log L_k}{\partial \log((1+\tau_k)\tilde{r})} = \frac{\partial \log L_k}{\partial \log w_k} \times \frac{\partial \log w_k}{\partial \log((1+\tau_k)\tilde{r})} \triangleq -\kappa \leq 0.$$

Discussion This assumption is a reduced-form way of capturing the elasticity of labor supply across locations and labor markets, when local wages and local labor demand change in response to reduced intermediate input tariffs. In a full model with labor market choice, this elasticity would be fully endogenous to labor market conditions across locations. Since we do not model the location choice margin, we think our assumption is a simple and clear way to state the key condition needed to understand our results. In our model with symmetric firms, if the labor supply does not expand, fewer firms would operate in response to increased labor demand arising from lower input prices. As shown earlier, labor market power is decreasing in the number of operating firms. This assumption therefore allows for labor force expansions that offset this mechanism. We formalize this finding in the theorem below.

First, note that

$$\begin{aligned}\frac{\partial \log\left(1+\eta+\frac{(\nu-\eta)}{N_k}\right)}{\partial \log N_k} &= \frac{N_k}{\left(1+\eta+\frac{(\nu-\eta)}{N_k}\right)}\frac{\partial\left(1+\eta+\frac{(\nu-\eta)}{N_k}\right)}{\partial N_k} \\ &= -\frac{N_k}{\left(1+\eta+\frac{(\nu-\eta)}{N_k}\right)}\frac{(\nu-\eta)}{(N_k)^2} \\ &= -\frac{(\nu-\eta)}{(1+\eta)N_k+(\nu-\eta)}.\end{aligned}$$

Taking derivatives $\frac{\partial}{\partial \log r_k}$ on the equilibrium conditions, we then get

$$\frac{\partial \log N_k}{\partial \log r_k} = \frac{\left(\frac{\tilde{\mu}}{1-\tilde{\mu}}\right)-\left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}}+\nu\right)\kappa}{\left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}}+\frac{\varphi-1}{\varphi}\nu+\frac{\eta}{\varphi}\right)+\left[\left(\frac{1+\eta}{\nu-\eta}\right)N_k+1\right]^{-1}}$$

by applying the chain rule and substituting for the aggregate labor supply elasticity term.

Theorem 5 (Intermediate input prices and labor market power)**.** *Labor markdowns* $(1+\varepsilon_k^{-1})$ *decline (and the equilibrium number* N_k *of firms increases) with lower intermediate input prices iff*

$$\left(\frac{\tilde{\mu}}{1-\tilde{\mu}}\right)-\left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}}+\nu\right)\kappa<0 \Longleftrightarrow \kappa>\frac{\left(\frac{\tilde{\mu}}{1-\tilde{\mu}}\right)}{\left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}}+\nu\right)}. \tag{11}$$

This theorem summarizes a key insight from our simple model. While the firm-level labor supply elasticity shapes its exercise of labor market power, its equilibrium labor markdown response to a change in input tariffs also critically depends on the aggregate labor supply elasticity. We will test these key implications in our data using a couple of relevant variations across labor markets.

Before turning to the evidence supporting this mechanism, we also characterize the role of skill intensity in the effect of input trade liberalization on markdowns.

The assumption we make here in mapping labor intensity in the model to skill intensity is that even though both skilled and unskilled labor are subject to frictions, skilled labor markets are more subject to monopsony power frictions. We argue that due to both government regulation and extensive supply, firms are more likely to be price-takers for unskilled labor.

In the context of our model, we explore the role of skill intensity by applying $\frac{\partial}{\partial\tilde{\lambda}}$ to $\frac{\partial \log N_k}{\partial \log r_k}$:

$$
\begin{aligned}
\frac{\partial^2 \log N_k}{\partial \log r_k\, \partial\tilde{\lambda}} &= \frac{\partial}{\partial\tilde{\lambda}} \frac{\left(\frac{\tilde{\mu}}{1-\tilde{\mu}}\right) - \left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \nu\right)\kappa}{\left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \frac{\varphi-1}{\varphi}\nu + \frac{\eta}{\varphi}\right) + \left[\left(\frac{1+\eta}{\nu-\eta}\right)N_k + 1\right]^{-1}} \\
&= \frac{-\left(\frac{-1}{1-\tilde{\mu}}\right)\kappa\left\{\left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \frac{\varphi-1}{\varphi}\nu + \frac{\eta}{\varphi}\right) + \left[\left(\frac{1+\eta}{\nu-\eta}\right)N_k + 1\right]^{-1}\right\}}{\left\{\left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \frac{\varphi-1}{\varphi}\nu + \frac{\eta}{\varphi}\right) + \left[\left(\frac{1+\eta}{\nu-\eta}\right)N_k + 1\right]^{-1}\right\}^2} \\
&\quad - \frac{\left\{\left(\frac{\tilde{\mu}}{1-\tilde{\mu}}\right) - \left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \nu\right)\kappa\right\}\left(\frac{-1}{1-\tilde{\mu}} + X\right)}{\left\{\left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \frac{\varphi-1}{\varphi}\nu + \frac{\eta}{\varphi}\right) + \left[\left(\frac{1+\eta}{\nu-\eta}\right)N_k + 1\right]^{-1}\right\}^2}
\end{aligned}
$$

where $X \triangleq \frac{\partial\left[\left(\frac{1+\eta}{\nu-\eta}\right)N_k+1\right]^{-1}}{\partial\tilde{\lambda}} = -\left(\frac{1+\eta}{\nu-\eta}\right)\left[\left(\frac{1+\eta}{\nu-\eta}\right)N_k + 1\right]^{-2}\frac{\partial N_k}{\partial\tilde{\lambda}}$.

Combining this, we get

$$
\begin{aligned}
\frac{\partial^2 \log N_k}{\partial \log r_k\, \partial\tilde{\lambda}} &= \frac{-\left(\frac{-1}{1-\tilde{\mu}}\right)\kappa\left\{\left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \frac{\varphi-1}{\varphi}\nu + \frac{\eta}{\varphi}\right) + \left[\left(\frac{1+\eta}{\nu-\eta}\right)N_k + 1\right]^{-1}\right\}}{\left\{\left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \frac{\varphi-1}{\varphi}\nu + \frac{\eta}{\varphi}\right) + \left[\left(\frac{1+\eta}{\nu-\eta}\right)N_k + 1\right]^{-1}\right\}^2} \\
&\quad - \frac{\left\{\left(\frac{\tilde{\mu}}{1-\tilde{\mu}}\right) - \left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \nu\right)\kappa\right\}\left(\frac{-1}{1-\tilde{\mu}} + -\left(\frac{1+\eta}{\nu-\eta}\right)\left[\left(\frac{1+\eta}{\nu-\eta}\right)N_k + 1\right]^{-2}\frac{\partial N_k}{\partial\tilde{\lambda}}\right)}{\left\{\left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \frac{\varphi-1}{\varphi}\nu + \frac{\eta}{\varphi}\right) + \left[\left(\frac{1+\eta}{\nu-\eta}\right)N_k + 1\right]^{-1}\right\}^2}
\end{aligned}
$$

$$\frac{\partial^2 \log N_k}{\partial \log r_k\, \partial\tilde{\lambda}} = \frac{\left(\frac{1}{1-\tilde{\mu}}\right)\kappa\left\{\left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \frac{\varphi-1}{\varphi}\nu + \frac{\eta}{\varphi}\right) + \left[\left(\frac{1+\eta}{\nu-\eta}\right)N_k + 1\right]^{-1}\right\}}{\left\{\left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \frac{\varphi-1}{\varphi}\nu + \frac{\eta}{\varphi}\right) + \left[\left(\frac{1+\eta}{\nu-\eta}\right)N_k + 1\right]^{-1}\right\}^2}$$

$$+ \frac{\left\{\left(\frac{\tilde{\mu}}{1-\tilde{\mu}}\right) - \left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \nu\right)\kappa\right\}\left(\frac{1}{1-\tilde{\mu}} + \left(\frac{1+\eta}{\nu-\eta}\right)\left[\left(\frac{1+\eta}{\nu-\eta}\right)N_k + 1\right]^{-2}\frac{\partial N_k}{\partial\tilde{\lambda}}\right)}{\left\{\left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \frac{\varphi-1}{\varphi}\nu + \frac{\eta}{\varphi}\right) + \left[\left(\frac{1+\eta}{\nu-\eta}\right)N_k + 1\right]^{-1}\right\}^2}$$

$$\frac{\partial^2 \log N_k}{\partial \log r_k\, \partial\tilde{\lambda}} = \frac{\left(\frac{1}{1-\tilde{\mu}}\right)\kappa\left\{\left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \frac{\varphi-1}{\varphi}\nu + \frac{\eta}{\varphi}\right) + \left[\left(\frac{1+\eta}{\nu-\eta}\right)N_k + 1\right]^{-1}\right\}}{\left\{\left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \frac{\varphi-1}{\varphi}\nu + \frac{\eta}{\varphi}\right) + \left[\left(\frac{1+\eta}{\nu-\eta}\right)N_k + 1\right]^{-1}\right\}^2}$$

$$+ \frac{\left\{\left(\frac{\tilde{\mu}}{1-\tilde{\mu}}\right) - \left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \nu\right)\kappa\right\}\left(\frac{1}{1-\tilde{\mu}}\right)}{\left\{\left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \frac{\varphi-1}{\varphi}\nu + \frac{\eta}{\varphi}\right) + \left[\left(\frac{1+\eta}{\nu-\eta}\right)N_k + 1\right]^{-1}\right\}^2}$$

$$+ \frac{\left\{\left(\frac{\tilde{\mu}}{1-\tilde{\mu}}\right) - \left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \nu\right)\kappa\right\}\left(\left(\frac{1+\eta}{\nu-\eta}\right)\left[\left(\frac{1+\eta}{\nu-\eta}\right)N_k + 1\right]^{-2}\frac{\partial N_k}{\partial\tilde{\lambda}}\right)}{\left\{\left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \frac{\varphi-1}{\varphi}\nu + \frac{\eta}{\varphi}\right) + \left[\left(\frac{1+\eta}{\nu-\eta}\right)N_k + 1\right]^{-1}\right\}^2}$$

$$\frac{\partial^2 \log N_k}{\partial \log r_k\, \partial\tilde{\lambda}} = \frac{\left(\frac{1}{1-\tilde{\mu}}\right)\left\{\kappa\left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \frac{\varphi-1}{\varphi}\nu + \frac{\eta}{\varphi}\right) + \kappa\left[\left(\frac{1+\eta}{\nu-\eta}\right)N_k + 1\right]^{-1}\right\}}{\left\{\left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \frac{\varphi-1}{\varphi}\nu + \frac{\eta}{\varphi}\right) + \left[\left(\frac{1+\eta}{\nu-\eta}\right)N_k + 1\right]^{-1}\right\}^2}$$

$$+ \frac{\left(\frac{1}{1-\tilde{\mu}}\right)\left\{\left(\frac{\tilde{\mu}}{1-\tilde{\mu}}\right) - \kappa\left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \nu\right)\right\}}{\left\{\left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \frac{\varphi-1}{\varphi}\nu + \frac{\eta}{\varphi}\right) + \left[\left(\frac{1+\eta}{\nu-\eta}\right)N_k + 1\right]^{-1}\right\}^2}$$

$$+ \frac{\left\{\left(\frac{\tilde{\mu}}{1-\tilde{\mu}}\right) - \left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \nu\right)\kappa\right\}\left(\left(\frac{1+\eta}{\nu-\eta}\right)\left[\left(\frac{1+\eta}{\nu-\eta}\right)N_k + 1\right]^{-2}\frac{\partial N_k}{\partial\tilde{\lambda}}\right)}{\left\{\left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \frac{\varphi-1}{\varphi}\nu + \frac{\eta}{\varphi}\right) + \left[\left(\frac{1+\eta}{\nu-\eta}\right)N_k + 1\right]^{-1}\right\}^2}$$

$$\frac{\partial^2 \log N_k}{\partial \log r_k\, \partial \tilde{\lambda}} = \frac{\left(\frac{1}{1-\tilde{\mu}}\right)\left\{\left(\frac{\tilde{\mu}}{1-\tilde{\mu}}\right) - \kappa\left(\frac{\nu-\eta}{\varphi}\right) + \kappa\left[\left(\frac{1+\eta}{\nu-\eta}\right)N_k + 1\right]^{-1}\right\}}{\left\{\left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \frac{\varphi-1}{\varphi}\nu + \frac{\eta}{\varphi}\right) + \left[\left(\frac{1+\eta}{\nu-\eta}\right)N_k + 1\right]^{-1}\right\}^2}$$
$$+ \frac{\left\{\left(\frac{\tilde{\mu}}{1-\tilde{\mu}}\right) - \left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \nu\right)\kappa\right\}\left(\left(\frac{1+\eta}{\nu-\eta}\right)\left[\left(\frac{1+\eta}{\nu-\eta}\right)N_k + 1\right]^{-2}\frac{\partial N_k}{\partial \tilde{\lambda}}\right)}{\left\{\left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \frac{\varphi-1}{\varphi}\nu + \frac{\eta}{\varphi}\right) + \left[\left(\frac{1+\eta}{\nu-\eta}\right)N_k + 1\right]^{-1}\right\}^2}$$

Let us now take the derivatives of the equilibrium conditions to get $\frac{\partial N_k}{\partial \tilde{\lambda}}$:

$$-\frac{1}{1-\tilde{\mu}}\log N_k + \left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \frac{\varphi-1}{\varphi}\nu + \frac{\eta}{\varphi}\right)\frac{\partial \log N_k}{\partial \tilde{\lambda}}$$
$$+\frac{(\nu-\eta)}{(1+\eta)N_k + (\nu-\eta)}\frac{\partial \log N_k}{\partial \tilde{\lambda}}$$
$$= -\frac{1}{1-\tilde{\mu}}\log L_k - \frac{1}{\tilde{\lambda}}$$

Therefore, we group terms to get

$$\frac{\partial \log N_k}{\partial \tilde{\lambda}} = \left(\frac{1}{1-\tilde{\mu}}\log N_k - \frac{1}{1-\tilde{\mu}}\log L_k - \frac{1}{\tilde{\lambda}}\right)$$
$$\bigg/ \left\{\left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \frac{\varphi-1}{\varphi}\nu + \frac{\eta}{\varphi}\right) + \frac{(\nu-\eta)}{(1+\eta)N_k + (\nu-\eta)}\right\}$$

$$\frac{\partial \log N_k}{\partial \tilde{\lambda}} = -\frac{1}{1-\tilde{\mu}}\left(\log\frac{L_k}{N_k} + \frac{1-\tilde{\mu}}{\tilde{\lambda}}\right)$$
$$\bigg/ \left\{\left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \frac{\varphi-1}{\varphi}\nu + \frac{\eta}{\varphi}\right) + \frac{(\nu-\eta)}{(1+\eta)N_k + (\nu-\eta)}\right\}$$

$$\frac{\partial \log N_k}{\partial \tilde{\lambda}} = -\frac{1}{1-\tilde{\mu}}\left(\log\frac{L_k}{N_k} + \frac{1-\tilde{\mu}}{\tilde{\lambda}}\right)$$
$$\bigg/ \left\{\left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \frac{\varphi-1}{\varphi}\nu + \frac{\eta}{\varphi}\right) + \left[1 + \left(\frac{1+\eta}{\nu-\eta}\right)N_k\right]^{-1}\right\}$$

Noting that $\frac{\partial N_k}{\partial \tilde{\lambda}} = N_k \frac{\partial \log N_k}{\partial \tilde{\lambda}}$, we conclude that

$$\frac{\partial N_k}{\partial \tilde{\lambda}} = -\frac{1}{1-\tilde{\mu}} N_k \left(\log \frac{L_k}{N_k} + \frac{1-\tilde{\mu}}{\tilde{\lambda}}\right) \Bigg/ \left\{ \left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \frac{\varphi - 1}{\varphi}\nu + \frac{\eta}{\varphi} \right) + \left[\left(\frac{1+\eta}{\nu - \eta} \right) N_k + 1 \right]^{-1} \right\}.$$

We can now return to the original derivations and substitute to rewrite $\frac{\partial^2 \log N_k}{\partial \log r_k \, \partial \tilde{\lambda}}$ as

$$\begin{aligned}\frac{\partial^2 \log N_k}{\partial \log r_k \, \partial \tilde{\lambda}} = & \frac{\left(\frac{1}{1-\tilde{\mu}}\right) \left\{ \left(\frac{\tilde{\mu}}{1-\tilde{\mu}}\right) - \kappa \left(\frac{\nu-\eta}{\varphi}\right) + \kappa \left[\left(\frac{1+\eta}{\nu-\eta}\right) N_k + 1 \right]^{-1} \right\}}{\left\{ \left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \frac{\varphi-1}{\varphi}\nu + \frac{\eta}{\varphi} \right) + \left[\left(\frac{1+\eta}{\nu-\eta}\right) N_k + 1 \right]^{-1} \right\}^2} \\ & - \frac{\left(\frac{1+\eta}{\nu-\eta}\right) \left[\left(\frac{\tilde{\mu}}{1-\tilde{\mu}}\right) - \left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \nu\right)\kappa \right] \left[\left(\frac{1+\eta}{\nu-\eta}\right) N_k + 1 \right]^{-2}}{\left\{ \left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \frac{\varphi-1}{\varphi}\nu + \frac{\eta}{\varphi} \right) + \left[\left(\frac{1+\eta}{\nu-\eta}\right) N_k + 1 \right]^{-1} \right\}^2} \\ & \times \left(\frac{1}{1-\tilde{\mu}}\right) N_k \left(\log \frac{L_k}{N_k} + \frac{1-\tilde{\mu}}{\tilde{\lambda}}\right) \\ & \quad \Bigg/ \left\{ \left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \frac{\varphi-1}{\varphi}\nu + \frac{\eta}{\varphi} \right) + \left[\left(\frac{1+\eta}{\nu-\eta}\right) N_k + 1 \right]^{-1} \right\}\end{aligned}$$

$$\begin{aligned}\frac{\partial^2 \log N_k}{\partial \log r_k \, \partial \tilde{\lambda}} = & \frac{\left(\frac{1}{1-\tilde{\mu}}\right) \left\{ \left(\frac{\tilde{\mu}}{1-\tilde{\mu}}\right) - \kappa \left(\frac{\nu-\eta}{\varphi}\right) + \kappa \left[\left(\frac{1+\eta}{\nu-\eta}\right) N_k + 1 \right]^{-1} \right\}}{\left\{ \left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \frac{\varphi-1}{\varphi}\nu + \frac{\eta}{\varphi} \right) + \left[\left(\frac{1+\eta}{\nu-\eta}\right) N_k + 1 \right]^{-1} \right\}^2} \\ & + \frac{\left(\frac{1+\eta}{\nu-\eta}\right) \left[\left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \nu\right)\kappa - \left(\frac{\tilde{\mu}}{1-\tilde{\mu}}\right) \right] \left[\left(\frac{1+\eta}{\nu-\eta}\right) N_k + 1 \right]^{-2}}{\left\{ \left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \frac{\varphi-1}{\varphi}\nu + \frac{\eta}{\varphi} \right) + \left[\left(\frac{1+\eta}{\nu-\eta}\right) N_k + 1 \right]^{-1} \right\}^2} \\ & \times \frac{\left(\frac{1}{1-\tilde{\mu}}\right) N_k \left(\log \frac{L_k}{N_k} + \frac{1-\tilde{\mu}}{\tilde{\lambda}}\right)}{\left(\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \frac{\varphi-1}{\varphi}\nu + \frac{\eta}{\varphi} \right) + \left[\left(\frac{1+\eta}{\nu-\eta}\right) N_k + 1 \right]^{-1}}\end{aligned}$$

Since $N_k \geq 1$ and $\nu > \eta > 0$,

$$\kappa \left[\left(\frac{1+\eta}{\nu - \eta} \right) N_k + 1 \right]^{-1} \in \left(0, \kappa \frac{\nu - \eta}{1+\nu} \right]$$

which implies

$$\left(\frac{\tilde{\mu}}{1-\tilde{\mu}} \right) - \kappa \left(\frac{\nu - \eta}{\varphi} \right) + \kappa \left[\left(\frac{1+\eta}{\nu - \eta} \right) N_k + 1 \right]^{-1} > \left(\frac{\tilde{\mu}}{1-\tilde{\mu}} \right) - \kappa \left(\frac{\nu - \eta}{\varphi} \right)$$

We can see that if

$$\left(\frac{\tilde{\mu}}{1-\tilde{\mu}} \right) > \kappa \left(\frac{\nu - \eta}{\varphi} \right)$$

and

$$\log \frac{L_k}{N_k} + \frac{1-\tilde{\mu}}{\tilde{\lambda}} > 0$$

then

$$\frac{\partial^2 \log N_k}{\partial \log r_k \, \partial \tilde{\lambda}} > 0.$$

Note that the second condition $\log \frac{L_k}{N_k} + \frac{1-\tilde{\mu}}{\tilde{\lambda}} > 0$, is equivalent to $\frac{\partial N_k}{\partial \tilde{\lambda}} < 0$. We will assume it is satisfied below because it holds trivially if z or A is large enough since

$$\left[\frac{L_k}{N_k} \right]^{\nu + \frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}}} = \left(\frac{\tilde{\lambda}}{1-\tilde{\mu}} \right) \left(\frac{1}{\nu - \eta} \right) [\tilde{z}]^{\frac{1}{1-\tilde{\mu}}} B(r_k) \, (N_k)^{-\frac{\nu-\eta-\varphi}{\varphi}} \left[\left(\frac{1+\eta}{\nu - \eta} \right) N_k + 1 \right]^{-1}$$

and $B(r_k) \triangleq (1-\tilde{\mu}) \, [\tilde{\mu}/r_k]^{\frac{\tilde{\mu}}{1-\tilde{\mu}}} \, [A]^{\frac{1}{1-\tilde{\mu}}}$.

The equation above allows us to characterize whether the cross-derivative is positive: that is, as we found in the data, whether an input tariff reduction leads to a greater labor markdown reduction when the skill intensity is higher. We show in the theorem below the restriction needed for this amplification result to be true.

Theorem 6 (Labor intensity, input tariffs, and equilibrium number of firms)**.** *Skill intensity amplifies the increase in the number of firms and, equivalently, the associated reduction in markdowns arising from a decline in input prices; that is,*

$$\frac{\partial \log N_k}{\partial \log r_k} < 0 \quad \textit{and} \quad \frac{\partial^2 \log N_k}{\partial \log r_k \, \partial \tilde{\lambda}} > 0,$$

when

$$\kappa \in \left(\frac{\frac{\tilde{\mu}}{1-\tilde{\mu}}}{\frac{1-\tilde{\mu}-\tilde{\lambda}}{1-\tilde{\mu}} + \nu}, \frac{\frac{\tilde{\mu}}{1-\tilde{\mu}}}{\frac{\nu-\eta}{\varphi}} \right). \tag{12}$$

Note that the two conditions in the theorem above require as a necessary condition

$$1 + \left(1 - \frac{1}{\varphi}\right)\nu + \frac{\eta}{\varphi} > \frac{\tilde{\lambda}}{1-\tilde{\mu}}. \qquad \text{(Appendix C.27)}$$

This necessary condition guarantees the existence of κ and is always true since

$$1 + \left(1 - \frac{1}{\varphi}\right)\nu + \frac{\eta}{\varphi} > 1 > \frac{\tilde{\lambda}}{1-\tilde{\mu}}. \qquad \text{(Appendix C.28)}$$

Appendix D. Appendix: Model with Location Choice

Here, we propose a micro-foundation for the labor supply function assumptions in the main text. We build on the location choice problem in Berger, Herkenhoff and Mongey (2022), henceforth BHM. Before presenting the environment, it is important to discuss the tension we face in modelling worker location choice. Allowing for discrete location introduces a double-nest of strategic interactions across firms, not only within a location but also across locations. BHM use instead a continuum of locations, which effectively means that firms in each island take economy-wide prices as given. Citing findings in Malmberg and Hössjer (2018) and Malmberg (2013), BHM argue that the CES specification across a continuum of locations is a limit of the discrete choice problem as the number of locations becomes infinitely large.

Environment

Consider an economy in which local labor markets are indexed by k and belong to a continuum $\mathcal{K} = [0, 1]$. Each labor market k is populated by workers who belong to a representative household. The representative household elastically supplies labor to the discrete set $\mathcal{I}_k = \{1, \ldots, N_k\}$ of firms operating locally on each atomistic island $k \in \mathcal{K}$. Firms can exercise labor market power in their local labor market.

Household Problem

Assume the household chooses labor allocations and consumption to solve:

$$\begin{aligned}
\mathcal{U} = \max_{\ell_{i,k}} & U(\mathbb{C}) - V(\mathbb{L}) \\
& \text{s.t.} \\
& \mathbb{C} = \mathbb{W}\mathbb{L} + \Pi \\
& \mathbb{L}^{\frac{\theta+1}{\theta}} \equiv \int_{\mathcal{K}} \mathcal{L}_k^{\frac{\theta+1}{\theta}} dk \\
& \mathcal{L}_k^{\frac{\eta_k+1}{\eta_k}} \equiv \sum_{i \in \mathcal{I}_k} \ell_{i,k}^{\frac{\eta_k+1}{\eta_k}} \\
& \mathbb{W}\mathbb{L} = \int_{\mathcal{K}} \mathcal{W}_k \mathcal{L}_k dk \\
& \mathcal{W}_k \mathcal{L}_k = \sum_{i \in \mathcal{I}_k} w_{i,k} \ell_{i,k}
\end{aligned}$$

Household Optimization The household first order conditions yield

$$\frac{U'(\mathbb{C})}{V'(\mathbb{L})} \frac{\partial \mathbb{L}}{\partial \mathcal{L}_k} \frac{\partial \mathcal{L}_k}{\ell_{i,k}} = w_{i,k}$$

This yields

$$\frac{w_{i,k}}{\mathbb{W}} = \left(\frac{\ell_{i,k}}{\mathcal{L}_k}\right)^{\frac{1}{\eta_k}} \left(\frac{\mathcal{L}_k}{\mathbb{L}}\right)^{\frac{1}{\theta}}$$

Suppose that

$$U(\mathbb{C}) = \mathbb{C} \text{ and } V(\mathbb{L}) = (\mathbb{L})^{\frac{1+\nu}{\nu}}$$

Under these assumptions, we derive the extended version of the wage function we had assumed in the main text:

Assumption 5 (Wage function)**.** *Given the labor demanded by other firms,* $\{\ell_j : j \neq i\}$*, the*

958 *wage function for a given firm i demanding ℓ_i units of labor in labor market k satisfies*

$$w_k(\ell_i, \cdot) = \left(\frac{\ell_{i,k}}{\mathcal{L}_k}\right)^{\frac{1}{\eta_k}} \left(\frac{\mathcal{L}_k}{\mathbb{L}}\right)^{\frac{1}{\theta}} (\mathbb{L})^{-\frac{1}{\nu}}. \quad \text{(Appendix D.1)}$$

959 The labor supply elasticity faced by firm i yields

$$\varepsilon_{i,k}(\ell_{i,k}) \equiv \frac{\partial \log w_{i,k}(\ell_{i,k})}{\partial \log \ell_{i,k}} = \frac{1}{\eta_k} + \left(\frac{1}{\theta} - \frac{1}{\eta_k}\right)\left(\frac{\ell_{i,k}}{\mathcal{L}_k}\right)^{\frac{1+\eta_k}{\eta_k}}. \quad \text{(Appendix D.2)}$$

960 Equations Appendix D.1 and Appendix D.2 show that the labor supply location choice
961 model presented here is a special case of Assumption 3 in the main text. They also highlight
962 that η_k is also a potential source of heterogeneity across labor markets.

Appendix E. Appendix: Counterfactual Aggregate Outcomes

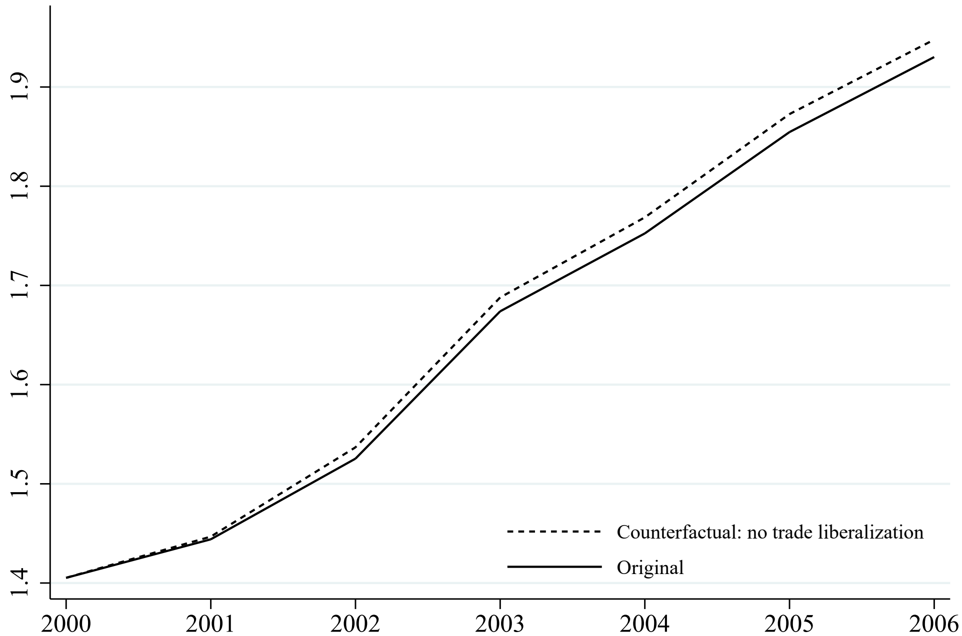
Brooks et al. (2021*b*) show that the reciprocal of the labor share depends on product markups and labor markdowns in the following way:

$$\frac{1}{\eta_L} = \sum_{i=1}^{I} \sum_{k=1}^{K} \sum_{n=1}^{N_{ki}} \left[\frac{\mu_{nki}^L}{\mu_{nki}^M} \frac{\mu_{nki}^M - \theta_{nki}^M}{\theta_{nki}^L} \omega_{nki}^L \right]. \tag{Appendix E.1}$$

where $\frac{\mu_{nki}^L}{\mu_{nki}^M}$ is labor markdown of firm i in industry n in location k and θ_{nki} refers to the output elasticity of firm i with respect to material or labor. ω_{nki}^L is the labor share of firm i in the national labor pool. Using this equation, we calculate the counterfactual labor share in the absence of trade liberalization.

To compute counterfactual labor share, we first compute counterfactual labor markdown in the absence of trade liberalization. Using the coefficient in the Column (2) of Table 2, we compute the counterfactual markdown of a given firm holding industry tariffs at the level equal to that of year 2000. The counterfactual markdown represents the level of markdown if input tariffs do not decrease as a result of trade liberalization. Figure E.1 shows the counterfactual markdowns aggregate to the national level weighted by firms' output share. We then replace the actual labor markdown with the counterfactual markdown in the equation Appendix E.1 to compute the counterfactual labor share.

Figure E.1: Aggregate labor markdowns in manufacturing



Notes: The solid line plots the average labor markdown of Chinese manufacturing firms, weighted by firm's output. The dotted line plots the counterfactual labor markdown assuming input tariffs do not change since 2000.

Table E.1: Wage premium of skill-intensive firms over time

Dependent variable = log(compensation per worker)	
$\mathbb{1}\{\text{skill intensive}\} \times \mathbb{1}\{\text{year=2000}\}$	0.212***
	(0.005)
$\mathbb{1}\{\text{skill intensive}\} \times \mathbb{1}\{\text{year=2001}\}$	0.202***
	(0.005)
$\mathbb{1}\{\text{skill intensive}\} \times \mathbb{1}\{\text{year=2002}\}$	0.185***
	(0.004)
$\mathbb{1}\{\text{skill intensive}\} \times \mathbb{1}\{\text{year=2003}\}$	0.169***
	(0.004)
$\mathbb{1}\{\text{skill intensive}\} \times \mathbb{1}\{\text{year=2004}\}$	0.147***
	(0.003)
$\mathbb{1}\{\text{skill intensive}\} \times \mathbb{1}\{\text{year=2005}\}$	0.118***
	(0.002)
$\mathbb{1}\{\text{skill intensive}\} \times \mathbb{1}\{\text{year=2006}\}$	0.119***
	(0.002)
$\mathbb{1}\{\text{exporter}\}$	0.050***
	(0.002)
log(output)	0.109***
	(0.001)
Industry× year FE	Yes
Industry × location FE	Yes
Observations	690,772
Adjusted R-squared	0.339

Note: Standard errors clustered at the firm level are in parentheses. Significance: ***: 1%, **: 5%, *: 10%.