# Monopsony Power and Export Product Quality *

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**Abstract**

With mounting interest in the interaction between trade and imperfectly competitive labor markets, this paper proposes a novel product quality upgrading mechanism to link the two. This paper extends the Melitz model by incorporating monopsonistically competitive labor markets and firms' endogenous quality choices. The model predicts that firms produce and export high-quality products in response to increasing marginal costs stemming from labor market imperfection, which can be viewed as the generalized Washington apple effect. Using detailed Chinese firm production and export data, the empirical evidence confirms the model's prediction. Using the minimum wage and shift-share-based predicted migration as instrumental variables for firms' monopsony power, the empirical results further confirm the existence of the causality. Further analysis using quota cancellation under the Multifiber Arrangement as an exogenous demand shock finds that the impact of firms' monopsony power on their export product quality is stronger for firms experiencing output expansion.

**Keywords**: Product Quality, Monopsony Power, Washington Apple Effect, Increasing Marginal Cost
**JEL Code**: F12, F14, F16, J42, L15

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## 1 Introduction

Product quality upgrading in developing countries is often viewed as the evidence of industrial upgrading, economic growth, and development (Amiti & Khandelwal 2013). The drivers of quality upgrading are the focus of industrial policy in developing countries and are widely studied in the literature (Harrison & Rodríguez-Clare 2010). There has been much research on the input-side drivers, including imported intermediate inputs (Bas & Strauss-Kahn 2015) and labor supply in the domestic market, such as studies on human capital, labor migration, labor costs, strikes and labor union (Imbert et al. 2022, Kini et al. 2022, Krueger & Mas 2004, Li et al. 2017, Stokey 1991). However, few studies have noted that the labor markets are far from perfectly competitive (Manning 2021). Firms with monopsony power in the labor market face an upward-sloping labor supply curve and thus have increasing marginal labor costs, which affect firms' production and export behaviors (Egger et al. 2021). To the best of our knowledge, this paper is the first one to investigate the impact of firms' monopsony power on their product quality.

We first document three stylized facts, which suggest the preliminary evidence of the impact of firms' monopsony power on their product quality and justify the foundation of our theoretical model. First, imperfect competition in the labor market is a deep-rooted empirical finding based on empirical research on both developed countries and developing countries (Manning 2003a; 2011; 2021), and discounting it could be a serious oversight. Second, output expansion increases firms' labor cost and the impact is more significant for firms with greater monopsony power. Third, firms with greater monopsony power export products with higher prices, which are the commonly used proxy variable for product quality.

Motivated by these stylized facts, we develop a simple and tractable model of endogenous firm quality choice. Firms use labor and intermediate inputs to produce final goods, and they choose the optimal quality and quantity to balance between the two factor costs. Following Card et al. (2018), Egger et al. (2021) and Jha & Rodriguez-Lopez (2021), we incorporate monopsonistic competition in the labor market into the model, which is the main innovation of our model, compared with the traditional Melitz-type model (Melitz 2003). Individual firms now face an upward-sloping labor supply curve. As a result, the increasing labor costs due to monopsony power induce firms to use less labor, produce fewer outputs, and upgrade product quality by using high-quality intermediate inputs. The effect of firms' monoposony power, as revealed in our model, can be view as a generalized *"Washington apple effect"*, which is that high specific trade costs make higher quality goods relatively cheaper to produce and transport (Feenstra & Romalis 2014).[1] In our case, the rising labor costs stemming from the imperfectly competitive labor market play a similar role as the specific trade costs in *"Washington apple effect"*.

Guided by our model, we use detailed production and export data on Chinese manufacturing firms to explore the impact of firms' monopsony power on their export product quality. Following Brooks et al.

[1]This is also known as the Alchian-Allen effect, initially developed by Alchian & Allen (1977) and formally tested by Hummels & Skiba (2004), which also found quality drivers from the perspective of the input side and described the impact of unit shipping costs on the quality composition of firms' products.

(2021a;b), we estimate firm-level variable markdown as a measurement of firms' monopsony power in the labor market, which is defined as the ratio of the marginal revenue product of labor (MRPL) over the wage. The quality is estimated using Khandelwal et al. (2013)'s method, which is at the firm-destination country-product (Harmonized System (HS) 6-digit-year)-level. Our baseline results confirm the model's prediction and show that firms' monopsony power has a significantly positive effect on their export product quality. The results are robust to adding additional controls, contemporary policy changes, alternative measures of markdown and quality, alternative empirical specifications, as well as subsample analysis.

To cope with the potential endogeneity problem stemming from the potential reverse causality, we use the minimum wage and shift-share-based expected net (in) migration as instrumental variables (IV) for firms' labor market power. The intuition is that, the minimum wage can restrict firms' labor market power and shield low-skill workers from wage suppression (Naidu et al. 2018), while migration can alter the labor supply elasticity, which is the key determinant of firms' labor market power (Manning 2003a). The IV regression results are also in line with our baseline results, which rules out the endogeneity concern. Utilizing the cancellation of export quotas under the Multifiber Arrangement (MFA) as an exogeneous demand shock that influences firms' output scale, we find that the impact of firms' monopsony power on their export product quality is stronger for firms experiencing output expansion and firms with greater monopsony power.

Finally, we perform several heterogeneity analyses and find that, the impact of firms' monopsony power on their product quality is more significant for foreign invested firms, firms engaging in import assembly-type processing trade and firms with lower managerial efficiency and shorter production length along the production line. In addition, there is a stronger response of firms' export product quality to their monopsony power when firms export to high-income countries, export differentiated products, and export products with inelastic demand, which make it more profitable to upgrade product quality.

This paper contributes to several branches of the literature. First, our work complements the research on the drivers of product quality upgrading. Based on Verhoogen (2021), the drivers of quality upgrading can be classified into four categories: (1) productivity (Hallak & Sivadasan 2009, Johnson 2012, Kugler & Verhoogen 2012); (2) the drivers of knowledge, such as learning by doing (Atkin et al. 2017); (3) output-side drivers, including consumer preferences (Manova & Zhang 2012, Verhoogen 2008) and the degree of competition in output markets (Amiti & Khandelwal 2013); and (4) input-side drivers, such as imported intermediate inputs (Bas & Strauss-Kahn 2015, Fan et al. 2015b) and credit constraints (Fan et al. 2015a). Specifically, for labor market factors, the literature mainly focuses on the impacts of human capital (Stokey 1991), skill intensity (Imbert et al. 2022), labor costs (Li et al. 2017), strikes (Krueger & Mas 2004), and labor unions (Kini et al. 2022) on product quality. However, on the one hand, the literature on labor market factors and product quality is relatively sparse. On the other hand, this literature has largely ignored the implications of imperfect competition in the labor market, which constitutes the void that our paper aims at filling. By incorporating a monopsonistic competitive labor market into the model, our paper shows that firms' monopsony power motivates them to improve their product quality.

Our work also contributes to the rapidly growing interdisciplinary area of research on trade and labor market power. Previous literature mainly focused on the impact of trade liberalization on the magnitude of labor market power (Ahsan & Mitra 2014, Dobbelaere & Wiersma 2020, Felix 2021, Kondo et al. 2021, Macedoni & Tyazhelnikov 2019, MacKenzie 2021, Pham 2021). Some other papers relate trade to labor market power from the perspective of import competition (Boulhol et al. 2011, Caselli et al. 2021b, Mertens 2020), international status (Dobbelaere & Kiyota 2018), firms' profit share (Macedoni 2021), wage inequality (Jha & Rodriguez-Lopez 2021), and foreign direct investment (FDI) liberalization (Lu et al. 2019). The most relevant paper for our work is the study by Egger et al. (2021). They propose that firms' monopsony power motivates them to act small in the domestic product market and offshore some production tasks, to avoid the high cost of labor in the domestic labor market. In the same vein, our work shows that firms produce higher quality products in response to the rising domestic labor costs originating from imperfect competition in the labor market. Together with Jha & Rodriguez-Lopez (2021) and Egger et al. (2021), our work suggests that imperfect competition in the labor market can influence the gains from trade and firms' production and export behavior, which deserves more attention and further investigation.

Our work also enriches the literature on increasing marginal costs and their interaction with trade. First, as pointed out by Ahn & McQuoid (2017), firms' increasing marginal costs are widespread and their two main sources are physical constraints and financial constraints. Our work suggests that the imperfectly competitive labor market can serve as an additional source of firms' increasing marginal costs. Second, traditional trade models, like those of Melitz (2003) and Eaton & Kortum (2002), assume constant marginal costs. Under this assumption, firms' product markets across different destinations are independent. However, the substantial body of empirical findings of a negative correlation between firms' domestic product market and export product market is in stark contrast to the constant marginal costs assumption but stands for the increasing marginal costs assumption.[2] Almunia et al. (2021), Bergstrand et al. (2021) and Pavlov (2021) introduce increasing marginal costs in trade. Together, our work suggests that it is necessary to reconsider trade with non-constant marginal costs.

The remainder of the paper is organized as follows. Section 2 describes the data and documents the stylized facts that motivate our model. Section 3 presents the model featuring endogenous product quality choice and highlighting the impact of monopsonistic competition in the labor market. Section 4 introduces the empirical specification and the methodology for estimating firms' markdowns and their export product quality. Section 5 provides the corresponding empirical results, including the baseline results, robustness checks, expansion analysis, heterogeneity analysis, and so on. Section 6 concludes.

[2]For an in-depth review of the literature on the negative correlation between firms' export sales and domestic sales, Ahn et al. (2011) section 1A and Pavlov (2021) section 1 provide a good overview. Meanwhile, Appendix C Table C.1 demonstrates that this phenomenon exists in China as well.

## 2 Data and Stylized Facts

### 2.1 Data

**Production Data** The production data are from the Annual Survey of Industrial Firms (ASIF data) collected by China's National Bureau of Statistics (NBS). These data have been widely used in many influential researches (Brandt et al. 2017; 2012, Fan et al. 2018a; 2015b, Yu 2015). This data set covers all state-owned enterprises (SOEs) and non-state-owned enterprises (non-SOEs) with annual sales greater than RMB 5 million ($ 770,000). It records complete information on the three major accounting statements (i.e., balance sheet, profit and loss account, and cash flow statement), which allows us to measure firms' monopsony power in the labor market. Although the data set contains rich information, some samples are still noisy and are therefore misleading (Brandt et al. 2014). Following Cai & Liu (2009), Brandt et al. (2017; 2012; 2014) and Yu (2015), we drop the outliers, reporting errors and only retain firms in the manufacturing industry. Appendix A shows the details.

**Export Data** The highly-disaggregated annual export data for each firm and product (Customs data) are from China's General Administration of Customs. The data provides detailed information on firms' exports and imports, including value, quantity, trade regime (e.g., processing trade or ordinary trade), destination country, customs name, shipment type, transportation type for each transaction at the HS 8-digit product level, and firms' basic information (i.e., firm name, location, telephone, zip code, contact person and so on). It is worth noting that, in the Customs data, some trading companies which do not engage in production (Ahn et al. 2011). Following Brandt et al. (2017), we delete these trading companies by identifying key words in their firm names. The Customs data enables us to measure firms' export product quality.

**Merged Data Set** Although the production data and export data both have firms' identification numbers, they follow different coding rules. Hence, we can not directly merge these two data sets using firms' identification numbers. Instead, we use two methods to match these data sets by using other common variables. First, we matched the two data sets using firms' name and year information. Second, we use contact information, including the firm's telephone number and contact person, to merge the two data sets. The detailed annual matching results are explained in Table A1 in Appendix A . Finally, the sample for 2000-2007 covers 110,122 common trading firms, including both importers and exporters. Briefly, it covers 45% of the total export value and 38% of the total import value reported by the Customs database.[3]

### 2.2 Stylized Facts

This section describes three stylized facts that provide the empirical underpinnings of our model: (1) individual firms face an upward-sloping labor supply curve, (2) greater monopsony power is associated with

[3]Our matching methodology and matching results are highly comparable to those in other studies that use the same data sets, such as Yu (2015), Fan et al. (2015a) and Wang & Yu (2012).

greater sensitivity to increasing marginal labor costs, and (3) firms with greater monopsony power tend to export high-price products.

#### 2.2.1 Stylized Fact 1: Labor Markets Are Monopsonistic

In a perfectly competitive labor market, each firm faces an infinitely elastic labor supply curve. However, it is increasingly recognized that labor markets are pervasively imperfectly competitive (Manning 2003b; 2011).[4] The key idea of an imperfectly competitive labor market is that each firm faces an upward-sloping labor supply curve.[5] If a firm wants to hire an additional worker, it must increase the wage for not only the additional worker, but also for its current employees. Generally, there are two approaches to demonstrate the imperfect competition in the labor market, the labor supply elasticity approach and the labor market concentration approach. On the one hand, researchers have directly measured the labor supply elasticity of firms and found a finite result (Azar et al. 2019a, Ransom & Sims 2010) [6]. On the other hand, other researchers have demonstrated a negative correlation between labor market concentration and wages (Azar et al. 2020, Benmelech et al. 2020, Hershbein et al. 2018, Jarosch et al. 2019)[7].

With particular interest in China, a vibrant body of work has proven that the Chinese labor market is far away from perfect competition.[8]

Brooks et al. (2021b) construct a structural model to directly estimate firms' monopsony power in the labor market and prove its pervasive existence. Dong & Putterman (2000; 2002) and Liu et al. (2014) point out that Chinese firms have labor market power over their employees as well. Moreover, Chen & Lu (2016), Du & Qu (2009) and Jian et al. (2016) find that the growth of labor returns lags behind the growth of labor

[4]The imperfectly competitively labor market was neglected for a long time until there was a persistent decrease in the labor share across countries (Dorn et al. 2017, Karabarbounis & Neiman 2014) and wage growth stagnation (Gould 2014) which brought it back to the center of the debate.

[5]The imperfectly competitive labor market originates from search frictions (Burdett & Mortensen 1998, Wu 2020) and preference heterogeneity (Card et al. 2018). The former means that it takes time for workers to find and change jobs, while the latter indicates that jobs are horizontally differentiated across firms.

[6]For an in-depth review of this strand of literature, Sokolova & Sorensen (2021) provide a meta-analysis of literature estimating labor supply elasticity. Their work suggests that US labor supply elasticity lies between 1.21 and 4.29, with an average of 3.75. Naidu et al. (2018) also provide an extensive survey of relevant studies, and they give a range between 1 and 5.

[7]Other studies demonstrate imperfect competition in labor market indirectly. For instance, firms do not have incentives to provide general training when the labor market is perfectly competitive. Hence, the extensive existence of general training offered by firms confirms the presence of imperfect competition in the labor market. (Acemoglu 1997, Acemoglu & Pischke 1998; 1999a;b, Booth & Zoega 2008). Other papers speak to this from the perspective of impact of the minimal wage on employment (Azar et al. 2019b, Munguia Corella 2020, Okudaira et al. 2019, Soundararajan 2019). An increase in the minimal wage causes unemployment in a perfectly competitive labor market. However, this effect disappears or even reverses in an imperfectly competitive labor market.

[8]The phenomenon that firms have monopsony power in the labor market is also found in developed countries and other developing countries, including India (Brooks et al. 2021a;b, MacKenzie 2021), the United States (Berger et al. 2019), Italy (Caselli et al. 2021a), Colombia (Amodio & De Roux 2021), Germany Mertens (2022) and France (Caselli et al. 2021b).

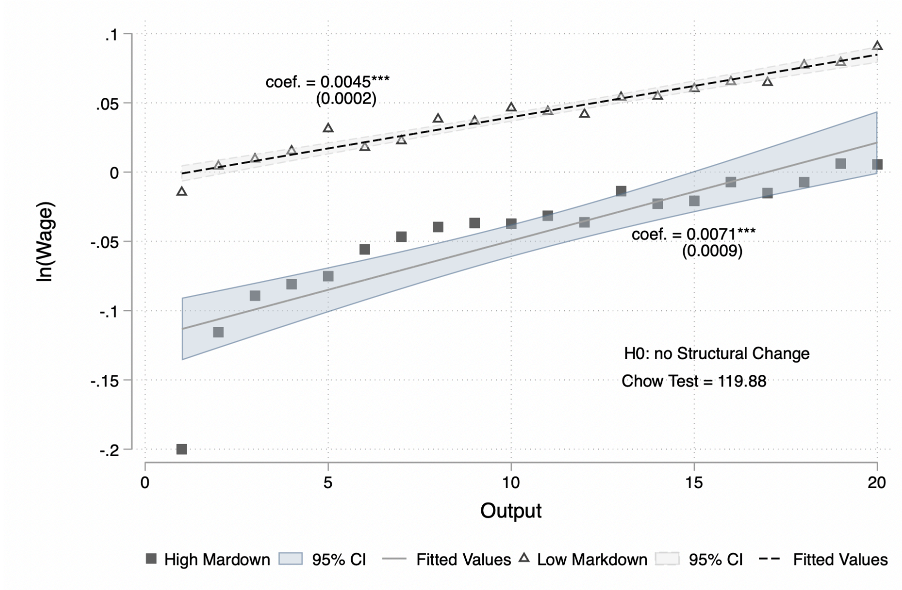
productivity, which is exactly the consequence of firms' monopsony power in the labor market.[9]

**Stylized Fact 1.** *Firms compete with each other monopsonistically in the labor market, that is, firms face an upward-sloping labor supply curve.*

### 2.2.2 Stylized Fact 2: The Unit Labor Cost of Firms with Greater Monopsony Power Is More Sensitive to Output Expansion

Figure 1 displays the relationship between firms' output and its average wage for firms with different levels of monopsony power. [10]

Figure 1: The Relationship between Firms' Output and Their Average Wage




Notes: Merged data are used. The y-axis denotes the average wage (in log), which is the residual obtained by regressing the average wage (in log) on domestic output (in log), TFP (in log), firm fixed effects and year fixed effects. TFP is obtained from the estimation of production function in Ackerberg et al. (2015). We divide the firms into 20 groups from lowest to highest in terms of exports for the high-markdown subsample and the low-markdown subsample, respectively. The x-axis represents the output group number. Firms with markdowns above the CIC2 industry-year-level 75th percentile are designated as "High Markdown" and firms with markdowns below the CIC2 industry-year-level 25th percentile are designated as "Low Markdown." The dashed line and triangle scatter refers to firms with monopsony power lower than the 25th percentile. and the solid line and square scatter refers to firms with monopsony power higher than the 75th percentile.

[9]In the early stage of industrialization in China, the rural surplus labor was viewed as an unlimited and cheap labor supply for industrialization, and labor's wage persisted at a subsistence level. However, during the sample period of this study, the expanding industrial sector has exhausted the rural surplus labor and labor shortage has become an emerging issue since 2003 (Cai 2010, Cai & Wang 2010). As a result, the industrial firms must compete for the limited labor force, leading to a dramatic increase in wages (Cai & Du 2011, Zhang et al. 2011).

[10]Figure B1 in Appendix B , shows the relationship between firms' output and its average income for firms with high labor market power and low labor market power. The results and implications are the same.

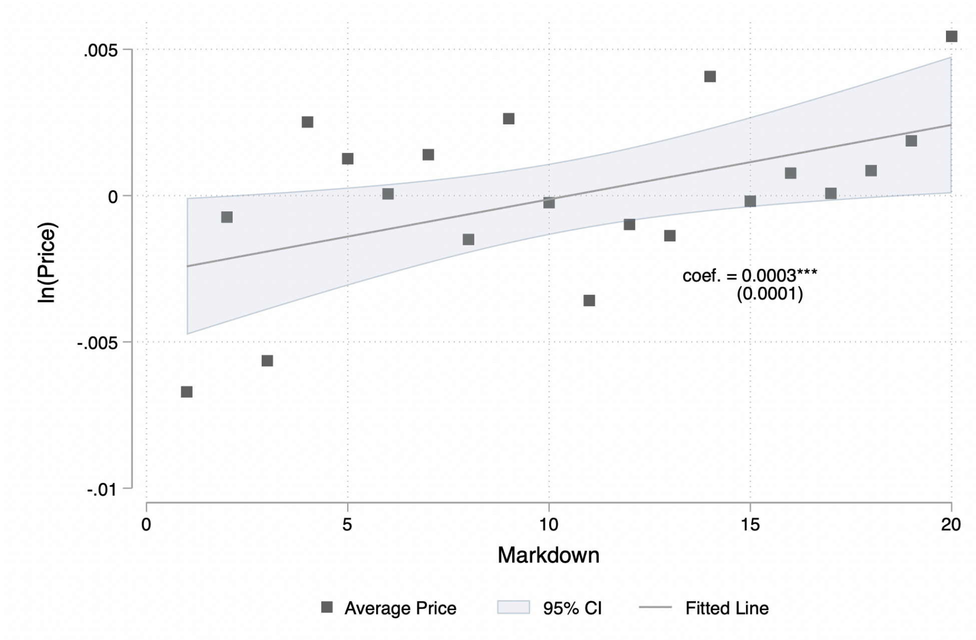
The lines are upward-sloping, which further verifies stylized fact 2. More importantly, compared to firms with low markdowns, the line for firms with high markdowns is steeper. The implication is that output expansion raises the cost of labor in the domestic labor market for firms with high monopsony power to a larger extent compared to firms with low monopsony power. The Chow test results also support that the coefficients are statistically different from each other.

**Stylized Fact 2.** *For firms that have greater monopsony power in the labor market, their domestic cost of labor is more sensitive in response to output expansion.*

### 2.2.3 Stylized Fact 3: Firms with Monopsony Power Tend to Export High-Price Products

Figure 2 displays the relationship between firms' monopsony power and the average prices of their export products. The line is upward-sloping, which indicates that firms with monopsony power in the labor market tend to export high-priced products. According to Hallak (2006), Kugler & Verhoogen (2012) and Manova & Zhang (2012), who use product price as the proxy variable for product quality, we can infer that firms with monopsony power tend to export high-quality products as well.

Figure 2: The Relationship between Firms' Monopsony Power and Their Export Product Prices




Notes: Merged data are used. Product price is defined as the unit value of the product at the HS 6 digit-destination country-firm level. The y-axis denotes the price (in log), which is the residual obtained by regressing product price (in log) on TFP (in log), year-HS 6 digit-destination country fixed effects and firm fixed effects. The TFP is obtained from estimating production function following Ackerberg et al. (2015). We divide the firms into 20 groups from lowest to highest in terms of markdown. The x-axis represents the markdown group number.

**Stylized Fact 3.** *Firms with greater monopsony power in the labor market tend to export high-price products.*

## 3 Model

In this section, we develop a partial equilibrium model to rationalize the stylized facts and explore how monopsony power in the labor market affects firms' export quality. The model is an extension of the Melitz (2003), allowing for monopsonistic competition in the labor market and endogenous quality choice. As a result, firms are heterogeneous in two dimensions: productivity and the degree of monopsony power. There are two symmetric countries with monopolistic competition in their final-good markets. Each firm produces one differentiated final good.

### 3.1 Preference and Demand

In each country, a representative household supplies one unit of labor, and derives utility from the consumption of differentiated final goods with the following CES utility function:[11]

$$U = \left[\int_{\omega\in\Omega} \Big(q(\omega)z(\omega)\Big)^{\frac{\sigma-1}{\sigma}} d\omega\right]^{\frac{\sigma}{\sigma-1}} \tag{1}$$

where $q(\omega)$ is the quantity of variety $\omega$ consumed, $z(\omega)$ is the quality of variety $\omega$, $\Omega$ is the set of differentiated goods available for purchase, and $\sigma > 1$ is the constant elasticity of substitution between varieties. Since each firm produces a single variety, $\omega$ also indexes an individual firm. The demand for variety $\omega$ in each country is then given by:

$$q(\omega) = z(\omega)^{\sigma-1}\frac{p(\omega)^{-\sigma}}{P^{1-\sigma}}E \tag{2}$$

where $p(\omega)$ is the price of variety $\omega$, $P$ is an aggregate quality-adjusted price index, and $E$ is the total expenditure.[12] Both the aggregate price index and total expenditure are exogenous for individual firms.

### 3.2 Factor Market

Suppose there are two factors of production, labor and intermediate inputs. Guided by stylized fact 1, firms have monopsony power, so they are no longer price-takers in the labor market. Following Card et al. (2018), Egger et al. (2021), and Jha & Rodriguez-Lopez (2021), we assume that firms face the following inverse labor supply function:

$$w_L(\omega) = L(\omega)^{\rho(\omega)} \tag{3}$$

[11]The utility function is consistent with Kugler & Verhoogen (2012), Khandelwal et al. (2013), and Fan et al. (2015b).

[12]$P = \left[\int_{\omega\in\Omega} \Big(p(\omega)/z(\omega)\Big)^{1-\sigma} d\omega\right]^{\frac{1}{1-\sigma}}$, and the maximum utility of the representative consumer is given by $U = \frac{E}{P}$.

where $w_L(\omega)$ is the wage paid by firm $\omega$, $L(\omega)$ is firm $\omega$'s total employment, and $\rho(\omega) > 0$ is the inverse wage elasticity of labor supply, which varies across firms.[13] Equation (3) has two properties. First, $\frac{\partial w_L}{\partial L} = \rho L^{\rho-1} > 0$, implying that a firm faces an upward-sloping labor supply curve, and hiring more workers requires an increase in the cost of labor.[14] Second, a firm's monopsony power can be measured using the ratio of the MRPL relative to wage, that is, the markdown (denoted by $\Psi$). The larger the markdown is, the lower is the wage firms pay, and the more monopsony power firms have. Together with equation (3), a firm's markdown is given by:

$$\Psi(\omega) = \frac{\text{MRPL}(\omega)}{w_L(\omega)} = \frac{\text{MPL}(\omega) \times \text{MC}(\omega)}{w_L(\omega)} = 1 + \frac{\partial w_L(\omega)}{\partial L(\omega)} \frac{L(\omega)}{w_L(\omega)} = 1 + \rho(\omega) \tag{4}$$

where MPL is the marginal product of labor and MC is marignal cost of production. Equation (4) implies that a firm's markdown only depends on $\rho(\omega)$. The higher $\rho(\omega)$ is, the more inelastic labor supply is, and hence the more monopsony power the firm has. In the extreme case where $\rho(\omega) = 0$, the labor supply is perfectly elastic and the wage is fixed at 1, so firms have no monopsony power.

Following Kugler & Verhoogen (2012), we assume that the intermediate input market is perfectly competitive. Intermediate-input suppliers produce quality-differentiated composite intermediate inputs by using homogeneous individual intermediates. We normalize the price of homogeneous individual intermediates to 1. The production function of the composite intermediate input is

$$M(m, z_M) = \frac{m}{z_M^{\alpha}} \tag{5}$$

where $M$ is the quantity of the composite intermediate input, $m$ is the amount of homogeneous individual intermediates used, and $z_M$ is the quality of the composite intermediate input. We assume $\alpha > 1$, reflecting that producing higher-quality composite inputs requires more individual intermediates and the cost of quality upgrading is increasing.[15]

From equation (5), the unit cost of the composite intermediate input of quality $z_M$ is $z_M^{\alpha}$, which equals the purchase price $w_M$ faced by a final-good producer in equilibrium:

$$w_M(z_M) = z_M^{\alpha} \tag{6}$$

[13]The functional form of equation (3) is quite close to those of Card et al. (2018), Egger et al. (2021), and Jha & Rodriguez-Lopez (2021). The main difference is that in the models in those studies, the elasticity of labor supply is constant across firms. In our model, the elasticity of labor supply is heterogeneous, as well as the monopsony power of firms.

[14]Appendix C documents empirical evidence of the existence of increasing marginal cost by demonstrating the negative correlation between firms' domestic sales and export sales and the positive impact of output expansion on firms' labor costs.

[15]The assumption is aligned with Feenstra & Romalis (2014), Fan et al. (2020), and Cui et al. (2022).

### 3.3 Production

Given firm productivity $\varphi(\omega)$, we assume that the production function of final goods follows the Leontief functional form:

$$q(\omega) = \varphi(\omega)\ min\Big\{L(\omega), M(\omega)\Big\} \tag{7}$$

where $q(\omega)$ is the quantity of final goods, $L(\omega)$ is the amount of labor hired by the firm, and $M(\omega)$ is the amount of composite intermediate inputs purchased from intermediate input suppliers. From equation (7), firms use labor and intermediate inputs in a fixed proportion to produce final goods, which is similar to Verhoogen (2008).[16] The labor and intermediate inputs requirements to produce one unit of final goods are decreasing in firm productivity. Moreover, the labor requirements are equal to the intermediate input requirements in equilibrium, given by:

$$L(\omega) = M(\omega) = \frac{q(\omega)}{\varphi(\omega)} \tag{8}$$

The quality of the final goods depends on the quality of the composite intermediate inputs used in production, given by:

$$z(\omega) = z_M(\omega) \tag{9}$$

So, the unit cost of final goods is given by:

$$c(\omega) = \frac{w_L(\omega) + w_M(z)}{\varphi(\omega)} \tag{10}$$

### 3.4 Profit Maximization

We denote non-exporting firms with superscript $N$, and exporting firms with superscript $T$. Non-exporting firms only sell in the domestic market, while exporting firms sell in both the domestic and export markets. Due to data limitations, we can only observe firms' export behavior, such as product price and quantity, and measure the export quality accordingly. Therefore, in the following theoretical part, we mainly focus on exporting firms. We provide the results for non-exporting firms in Appendix D, and the conclusions still hold.

[16]For example, a textile firm requires a specific number of workers and amount of cloth to produce a textile product, and there is no substitution between the two inputs. Cameron (1952) uses data from Australian manufacturing industries to test the fixed input coefficients postulate of the Leontief production function. He finds that the materials coefficients are approximately constant for a long period, usually a decade or more, implying that there is no substitution between inputs. We present an alternative and more flexible production function specification in Appendix H, following Artuc et al. (2022). Firms produce final goods following the Leontief combination of intermediate inputs with a Cobb-Douglas aggregation of labor and capital. Our model propositions still apply in this alternative model.

Let the subscript $d$ denote variables related to the domestic market, and subscript $x$ denote variables related to the export market. There is an iceberg trade cost $\tau \geq 1$, such that $\tau$ units of final goods must be shipped by an exporting firm for 1 unit to arrive in the export market. Firms face no trade costs when selling in the domestic market.

For an exporting firm, the total profit is the following:[17]

$$\pi^T = \left[p_d - \frac{w_L + w_M(z_d)}{\varphi}\right] q_d + \left[p_x - \tau \frac{w_L + w_M(z_x)}{\varphi}\right] q_x \tag{11}$$

where $p_r$ is the price of product $\omega$ sold in market $r \in \{d, x\}$, $q_r$ is the quantity of product $\omega$ sold in market $r$, and $z_r$ is the product quality chosen by the firm in market $r$. Using equation (2), we solve the inverse demand function as $p_r = q_r^{-\frac{1}{\sigma}} z_r^{\frac{\sigma-1}{\sigma}} P^{\frac{\sigma-1}{\sigma}} E^{\frac{1}{\sigma}}$. Due to the iceberg trade cost $\tau$, an exporting firm's total output is $q = q_d + \tau q_x$.[18] Together with equations (3), (6), (8), and (9), the optimal total employment of an exporting firm is given by:[19]

$$L = \left(\varphi^{\sigma-1} A\right)^{\frac{\alpha}{\beta\rho+\alpha}} \left(\frac{1+\rho}{\alpha-1}\right)^{-\frac{\beta}{\beta\rho+\alpha}} \tag{12}$$

where $A \equiv \left(1+\tau^{1-\sigma}\right)\left(\frac{\sigma-1}{\sigma\alpha}\right)^{\sigma} P^{\sigma-1} E > 0$ and $\beta \equiv \sigma\alpha - \sigma + 1 > 0$, as $\sigma > 1$ and $\alpha > 1$.

In equilibrium, the domestic quality and export quality chosen by an exporting firm are the same, that is, $z_d = z_x$. For convenience, we omit the subscript and denote the optimal quality of an exporting firm with $z$, which is given by:

$$z = \left(\frac{\Psi w_L}{\alpha - 1}\right)^{\frac{1}{\alpha}} = \left(\varphi^{\sigma-1} A\right)^{\frac{\rho}{\beta\rho+\alpha}} \left(\frac{1+\rho}{\alpha-1}\right)^{\frac{1}{\beta\rho+\alpha}} \tag{13}$$

The first equality presents the relationship between $z$ and the firm's marginal cost of labor, which equals the product of markdown $\Psi$ and labor wage $w_L$. The implication is that the higher marginal cost of labor is associated with quality upgrading. Next, we explore the impact of labor monopsony power on firms' product quality. To simplify the analysis, we take the natural logarithm of the second equality in equation (13). Then, we take the derivative of $\ln z$ with respect to $\rho$, which is given by:[20]

$$\frac{\partial \ln z}{\partial \rho} = \left(\frac{1}{\beta\rho + \alpha}\right)\left(\ln L + \frac{1}{1+\rho}\right) > 0 \tag{14}$$

[17]For simplicity of notation, we suppress the index $\omega$.

[18]For an exporting firm, the domestic and export markets are no longer independent as shown in Appendix C: domestic or export expansion increases the wage faced by an exporting firm. We have $\frac{\partial \ln w_L}{\partial \ln q} = \rho$, implying that the greater is the firm's monopsony power, the more sensitive its labor costs are to output expansion. which is in line with stylized fact 2.

[19]See Appendix E for a detailed derivation of the profit maximization problem of an exporting firm.

[20]The logarithmic transformation is monotonically increasing and does not change the derivative's sign with respect to $\rho$.

with $\ln L > 0$ by assumption.[21] Equation (14) shows that firms product quality $z$ is increasing in the firms' monopsony power, and thus we have the following proposition:

**Proposition 1.** *Firms that have greater monopsony power produce (and export) higher-quality products.*

The intuition is that firms' marginal cost of labor is increasing with their monopsony power. Thus, firms use less labor and produce fewer outputs (see Appendix E for details) and instead embed more quality per quantity unit. This can be view as a generalized "*Washington apple*" effect, which states that high specific trade costs make higher quality goods relatively cheaper to produce and transport. In our model, the increasing marginal cost of labor due to the monopsonistic competitive labor market plays a similar role as specific trade costs. Following Feenstra & Romalis (2014), we convert the profit maximization problem in equation (11) to a cost minimization problem in Appendix F, to illustrate how a variant of the Washington apple effect works in our model.

In addition, the domestic and export prices set by an exporting firm satisfy that $p_x = \tau p_d$, and the optimal domestic price is given by:

$$\begin{aligned} p_d &= \left(\frac{\sigma}{\sigma-1}\right)\left(\frac{\Psi w_L + w_M}{\varphi}\right) \\ &= \frac{\sigma}{\sigma-1}\frac{\alpha}{\varphi}\left(\varphi^{\sigma-1}A\right)^{\frac{\alpha\rho}{\beta\rho+\alpha}}\left(\frac{1+\rho}{\alpha-1}\right)^{\frac{\alpha}{\beta\rho+\alpha}} \end{aligned} \tag{15}$$

The first equality shows that there are two wedges between the price and the average cost per unit given by equation (10): one is the markup $\frac{\sigma}{\sigma-1}$ stemming from the monopolistic product market, and the other is the markdown $\Psi$ originating from the monopsonistic labor market. From the second equality, we obtain that the derivatives of $\ln p_d$ and $\ln p_x$ with respect to $\rho$ are given by:

$$\frac{\partial \ln p_r}{\partial \rho} = \left(\frac{\alpha}{\beta\rho+\alpha}\right)\left(\ln L + \frac{1}{1+\rho}\right) > 0, \; r \in \{d, x\} \tag{16}$$

The following proposition is immediate from equation (16):

**Proposition 2.** *Firms that have greater monopsony power sell their products at higher prices.*

Proposition 2 is consistent with stylized fact 3. The intuition is that having greater monopsony power increases a firm's marginal cost of labor, as well as the cost of intermediate inputs because higher-quality outputs require higher-quality inputs. Hence, the product price is increasing in firms' monopsony power.

[21] It is reasonable to make such an assumption. On the one hand, the Chinese manufacturing firms covered in our sample are all large firms whose annual sales exceed RMB 5 million ($\$770,000$). On the other hand, Chinese SOEs need to meet a minimum level of employment to fulfill their social responsibility, which is regulated by the government (Lu & Yu 2015). In practice we drop firms with fewer than eight workers as they are under a different legal regime in China according to Brandt et al. (2012) and Yu (2015). Therefore, the assumption $\ln L > 0$ always holds.

## 4 Empirical Strategy

### 4.1 Baseline Specification

We run the following specification to determine the causality between firms' monopsony power and export product quality empirically:[22]

$$ln(z_{fhct}) = \beta_1 ln(\Psi_{ft}) + \boldsymbol{\gamma}\mathrm{X}_{ft} + \lambda_{hct} + \lambda_f + \varepsilon_{fhct} \tag{17}$$

where $z_{fhct}$ denotes the quality of product $h$ (HS 6-digit level) exported by firm $f$ to country $c$ in year $t$; and $\Psi_{ft}$ is firm $f$'s monopsony power in the labor market in year $t$, measured by the firm's markdown. $\mathrm{X}_{ft}$ consists of other firm-level attributes that may have influence on product quality. Following Kugler & Verhoogen (2012), Fan et al. (2015b), and Ge et al. (2015), we include employment (in log), capital-labor ratio (in log), an indicator variable for whether the firm is an SOE, an indicator variable for whether the firm is a foreign invested enterprise (FIE), and total factor productivity (TFP) (in log). In addition, we include the product-destination country-year fixed effects, $\lambda_{hct}$, to control for the time-varying product and destination country demand shocks, and include firm fixed effects $\lambda_f$ to control for the time invariant firm characteristics. [23] Standard errors are clustered at the firm level to account for possible correlation of different products within a firm.

Our theoretical model predicts that the coefficient of the log($\Psi$), $\beta$ (i.e., the elasticity of product quality with respect to firms' markdown) should be positive, which indicates that firms with greater monopsony power in the labor market export higher quality products. The next subsection describes the construction of the variable used in equation (17).

### 4.2 Measurement of Key Variables

#### 4.2.1 Export Product Quality

We measure export quality following Khandelwal et al. (2013) and Fan et al. (2015b). According to equation (2), the foreign demand for domestic product $h$ is given by:

$$q_{fhct} = z_{fhct}^{\sigma-1}\frac{p_{fhct}^{-\sigma}}{P_{ct}^{1-\sigma}}E_{ct} \tag{18}$$

where $q_{fhct}$ denotes the demand for product $h$ (at the HS 6-digit level) exported by firm $f$ to destination

[22]On the one hand, using the log value of markdown as the regressor variable is also found in Kondo et al. (2021), Lu et al. (2019), and Caselli et al. (2021b). On the other hand, the log(markdown) is approximately normally distributed. Moreover, the log of quality is widely used in the trade literature, such as Kugler & Verhoogen (2012), Manova & Zhang (2012), Bas & Strauss-Kahn (2015), Ge et al. (2015) and Fan et al. (2015b; 2018b).

[23]Following Fan et al. (2015b), we also control the product-destination country-firm fixed effects and year fixed effects, and the results are comparable to our baseline results. Table B4 in Appendix B shows the details.

country $c$ in year $t$, $z_{fhct}$ denotes the quality of the product, $p_{fhct}$ denotes the price of the product, $P_{ct}$ is the price index, and $E_{ct}$ is the total income in the destination country. We take the logarithm of equation (18) and use the following ordinary least squares (OLS) regression to infer product quality:

$$\ln q_{fhct} + \sigma \ln p_{fhct} = \alpha_h + \alpha_{ct} + \epsilon_{fhct} \tag{19}$$

where $\alpha_h$ is product fixed effects at the HS 6-digit level, which capture differences in prices and demands across products, and $\alpha_{ct}$ is country-year fixed effects, which absorb destination price index $P_{ct}$ and income $E_{ct}$. The estimated export product quality is $\ln z_{fhct} = \frac{\hat{\epsilon_{fhct}}}{\sigma-1}$. $\hat{\epsilon_{fhct}}$ is the estimated residual of equation (19). $\sigma$ is the elasticity of substitution and we use the estimates from Broda & Weinstein (2006). Since the products of different HS 2-digit categories are not comparable, we infer the export quality for each HS 2-digit category separately.

#### 4.2.2 Monopsony Power

Our algorithm for estimating firm monopsony power in the labor market follow the work of Brooks et al. (2021a;b).[24] They construct a structural model with monopolistic competition in the product market and monopsonistic competition in the input market. The key point of their paper can be summarized by the following equation:

$$\mu_m^{\text{DLW}} = \mu \times \Psi_m \tag{20}$$

where $\mu_m^{\text{DLW}}$ refers to the markup formula in De Loecker & Warzynski (2012) (DLW), and $m$ denotes different inputs, such as capital (K), labor (L), and intermediate inputs (M). $\mu$ represents the firms' true markup in the product market and does not vary across the inputs. $\Psi_m$ represents the firms' markdown in input market $m$. Equation (20) elucidates that when the input market is not perfectly competitive, the De Loecker & Warzynski (2012) formula markup is actually the product of the true markup ($\mu$) and the input-specific markdown ($\Psi_m$). Since $\mu$ does not vary with inputs, we can take the ratio of equation (20) for different inputs to eliminate $\mu$, that is:

$$\frac{\mu_m^{\text{DLW}}}{\mu_{m'}^{\text{DLW}}} = \frac{\Psi_m}{\Psi_{m'}} \tag{21}$$

Brooks et al. (2021a;b) further assume that there exists a factor (empirically, we use intermediate input) for which all firms are price takers, that is, $\Psi_M \equiv 1$. With this assumption and focusing on the labor

[24] In the literature, measurement of the firms' labor market power is generally based on exploring the deviation between the wages paid by firms to their employees and the marginal revenue created by employees (i.e., MRPL), including the ratio of the two (Brooks et al. 2021a;b, Caselli et al. 2021b, Kondo et al. 2021, MacKenzie 2021) or the difference between the two (Mertens 2020). More specifically, Caselli et al. (2021b) and Kondo et al. (2021) apply an algorithm that is similar ours. Moreover, our model is consistent with that of Brooks et al. (2021a;b), whose algorithm for estimating the markdown can directly apply to our model and empirical estimation. Appendix G shows the details.

market, equation (21) can be further expressed as follows:

$$\frac{\mu_L^{\text{DLW}}}{\mu_M^{\text{DLW}}} = \frac{\Psi_L}{1} = \Psi_L$$

Equation (21) is at the core of our methodology to estimate a firm's monopsony power in the labor market. It shows that, we can derive the labor markdown by dividing two DLW markups. Hence, to obtain a precise estimate of monopsony power, we need measures of the DLW markups. We estimate the DLW markups according to De Loecker & Warzynski (2012), which is:

$$\mu_m^{\text{DLW}} = \frac{\theta_m}{\alpha_m} \tag{22}$$

where $\theta_m$ refers to the output elasticity of input m, and $\alpha_m$ denotes the firm-specific payment share of input $m$. The former can be obtained by production function estimation, while the latter is directly observable in the data.[25] However, OLS estimation of the production function suffers from two endogeneity problems: simultaneity bias (transmission bias) and sample selection (attrition). To solve the endogeneity problem, we adopt the control function approach (also called proxy variable approach) to estimate the production function. We use the Ackerberg et al. (2015) (ACF) method as the baseline for empirical analysis since it has been widely used in a good deal of influential research.[26] We also use other production function estimation approaches for robustness checks.

### 4.3 Summary Statistics

Table 1 presents the summary statistics for the aforementioned important variables in our data. The mean value of product quality is 0.99, and the standard deviation is 5.39, implying that there is a significant variation in the level of quality across firm-product-destination pairs. The mean value of markdown is 1.44, which is in line with Brooks et al. (2021b)'s estimation and suggests that 30.56% percent of employees' income is taken by firms instead and supports our stylized fact 1.[27] Table 1 also shows the summary statistics for important production variables, which are in line with the literature.

[25] Since we can not observe quantity in the ASIF database, we adjust the factor share by using the exponential of the first stage regression residual of the production function estimation, according to De Loecker & Warzynski (2012). We can conduct this adjustment only if the production function is estimated following Ackerberg et al. (2015), Gandhi et al. (2020), Levinsohn & Petrin (2003) and Olley & Pakes (1992), instead of simple OLS regression or OLS regression with firm fixed effects. For the details on the implementation, please refer to De Loecker & Warzynski (2012).

[26] We include the Olley & Pakes (1992) selection correction terms to correct for attrition bias as in Ackerberg et al. (2015), Levinsohn (1993) . Appendix B displays the estimated average output elasticity of different production factors using the ACF method.

[27] The mean value of the markdown is slightly different from Brooks et al. (2021b) estimation. This is because they re-scale the markdown by normalizing the markdown to 1 for firms with zero local labor market share. Otherwise, our estimation is comparable to theirs.

Table 1: Summary Statistics

| Variable | # of Obs. | Mean | Median | Std. Dev. |
|---|---|---|---|---|
| $\ln(\text{Quality}_{\text{KSW}})$ | 5,374,106 | 0.99 | 0.70 | 5.39 |
| $\text{Markdown}_{\text{ACF}}$ | 294,543 | 1.44 | 0.88 | 1.72 |
| $\text{TFP}_{\text{ACF}}$ | 294,543 | 3.21 | 2.97 | 1.12 |
| Output | 294,848 | 96.09 | 34.52 | 168.63 |
| Intermediate Input | 295,224 | 65.28 | 24.39 | 106.70 |
| Capital | 295,081 | 30.72 | 8.16 | 61.69 |
| Employment | 295,386 | 374.42 | 191 | 510.33 |

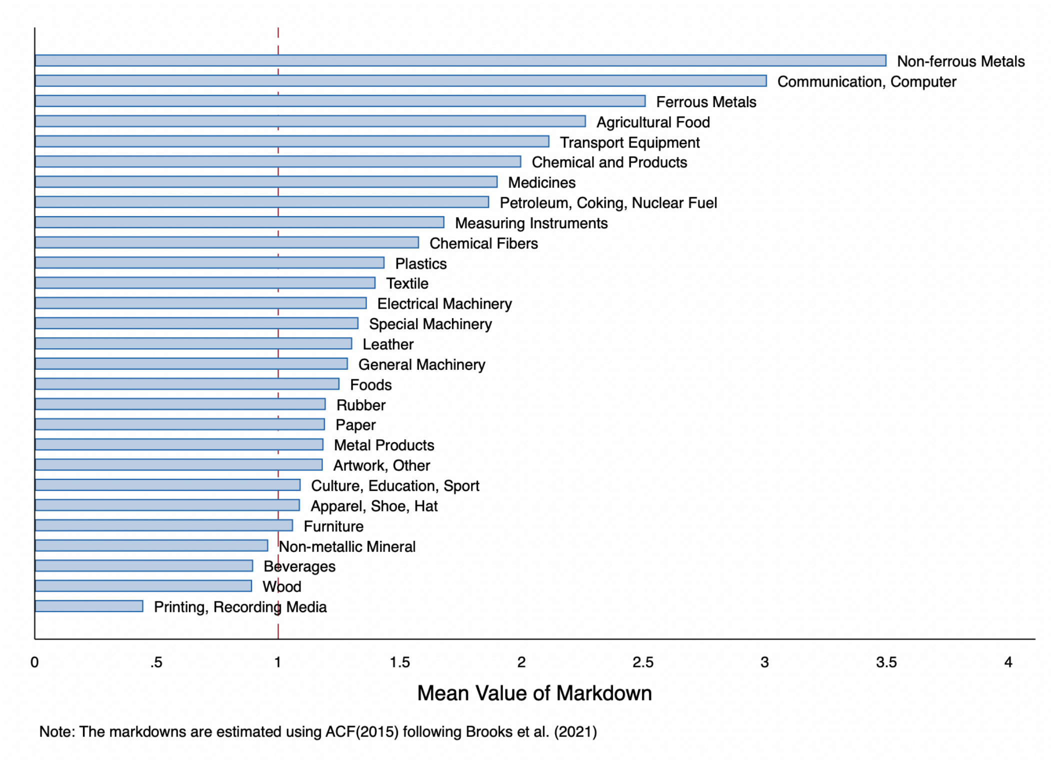
Notes: Merged data are used. Output, Intermediate input, and capital are in millions of RMB (in real value), and the unit of employment is people. The deflators for output, input, and capital are provided by Brandt et al. (2012).

Figure 3 displays the mean value of markdown across China Industry Classification System 2-digit (CIC 2) industries. For most industries, the mean value of markdown is greater than 1, which suggests that the labor market power was pervasive in Chinese manufacturing industries during that time.[28] Meanwhile, for the top 5 industries with the largest output during that time, communications and computers, electrical machinery, textiles, apparel, general machinery, and transport equipment, their markdowns are all larger than one, which again verifies stylized fact 1.[29]

[28]We compare our estimation results of labor market power with those of Pham (2021), who also estimates the labor market distortion for Chinese manufacturing industries from 1998 to 2007 following Gandhi et al. (2020). The labor market distortion in Pham (2021)'s paper is the product of firms' markdown in the labor market and markup in the product market, which is exactly the De Loecker & Warzynski (2012) formula for markup in our paper. As a result, we calculate the correlation between our estimation of the DLW formula markup and the labor market distortion reported in Pham (2021) Table 1. The correlations are 0.65 and 0.67 in terms of mean value and median value, respectively, for the Ackerberg et al. (2015)-type markdown, and 0.56 and 0.66 for the Gandhi et al. (2020)-type markdown. In sum, our estimation of the markdown is reasonable and comparable to the literature.

[29]Figure B3 in Appendix B, shows the average annual total output of each CIC-2 industry from 2000 to 2007.

Figure 3: Markdown by CIC 2-Digit Industry




Notes: Merged data are used. The Tobacco and Recycling and Disposal of Waste Industries were dropped due to lack of observations.

## 5 Empirical Results

This section reports the empirical results. We start with the baseline analysis and then provide robustness checks from different perspectives. To eliminate concern about endogeneity, instrumental variable (IV) regression is also used. Finally, thanks to the comprehensive information provided by our data, we conduct fruitful heterogeneity analysis from the perspective of firms' attributes and their export behavior. All these results support that the increase in firms' monopsony power in labor market improves firms' export product quality.

### 5.1 Baseline Results

We report the baseline estimation results in Table 2. In column (1), we only include the regressor of interest, the log(markdown), and fixed effects. The positive estimation of the parameter supports our theoretical predication: an increase in firms' monopsony power in the labor market improves firms' export product quality. In column (2), we add firm-level control variables to eliminate the possible concern about omitted variables. These controls leave the core results unaffected. In column (3), we further control for the other contemporary policy reforms, which may serve as confounding factors in our estimation. During the sample period, China has experienced several important policy reforms, including reform of SOEs, the relaxation of FDI regulation, and trade liberalization. Inspired by Lu & Yu (2015), we use the share of SOEs among domestic firms at the CIC 4-digit level and the number of foreign firms (in log) at the CIC 4-digit level to control for the first two policy reforms. For trade liberalization, we control for import tariff on both inputs and outputs at the CIC 4-digit level, which are provided by Brandt et al. (2017). China has also went through an export product market expansion at the same time. To take this into account, we add total export at the CIC 4-digit level as an additional control variable. Qualitatively, the signs, significance, and the magnitude of the coefficient of interest are confirmed. The increase in firms' monopsony power is associated with an improvement in firms' export product quality.

Table 2: Baseline Results: The Impact of Firms' Monopsony Power on its Export Product Quality

| | (1) | (2) | (3) |
|---|---|---|---|
| Dependent Variables | $\ln(\text{Quality}_{\text{KSW}})$ | $\ln(\text{Quality}_{\text{KSW}})$ | $\ln(\text{Quality}_{\text{KSW}})$ |
| $\ln(\text{Markdown}_{\text{ACF}})$ | 0.106*** | 0.156*** | 0.157*** |
| | (0.010) | (0.011) | (0.011) |
| Control | No | Yes | Yes |
| Confounding Factors | No | No | Yes |
| Observations | 4,950,628 | 4,950,628 | 4,938,398 |
| Adjusted $R^2$ | 0.387 | 0.388 | 0.388 |

Notes: Robust standard errors clustered at the firm level are in parentheses, ***, **, and * denote significance at the 1%, 5%, 10% level, respectively. Merged data are used for the regression. The dependent variable is firm-product-destination country-year level export product quality. In column (1), we only use the log(markdown) as the explanatory variable. In column (2), we add firm-level covariates. In column (3), we further control the confounding factors. In each column, we control for, product-destination country-year fixed effects and firm fixed effects. The TFP was obtained from production function estimation using Ackerberg et al. (2015).

### 5.2 Robustness Checks

#### 5.2.1 Robustness Check 1: Alternative Measures of Quality and Markdown

For the benchmark analysis, we use quality estimated according to Khandelwal et al. (2013). We use Ackerberg et al. (2015) to estimate the production function and obtain the markdown due to its wide adoption. Here, we use alternative measures of quality and markdown to demonstrate that our results are robust across different measurement strategies.

First, we use the unit prices of firms' exports product as the proxy for firms' export product quality and estimate the impact of firms' monopsony power on its export product prices according to (17). Column (1) in Table 3 displays the results. It turns out that firms' monopsony power has a significant positive impact on firms' export product prices, which is consistent with our baseline results.

Second, we use the theoretical framework of Feenstra & Romalis (2014) to measure a firms' export quality, which is given by: [30]

$$\ln z_{fhct} = \theta_h \left[ \ln \left( \kappa_{1hc}\, p_{fhct} \right) - \ln \left( \frac{w_t}{\varphi_{ft}} \right) \right] \tag{23}$$

where $z_{fhct}$ is the quality of the product $h$ (at the HS 6-digit level) exported by firm $f$ to destination country $c$ in year $t$; $p_{fhct}$ is the export price obtained from the Customs data; $w_t$ is the price of the composite input, which we can compute using the ASIF data, $\varphi_{ft}$ is the firm productivity; and $\theta_h$ and $\kappa_{1hc}$ are both parameters that we can borrow directly from Feenstra & Romalis (2014). Column (2) in Table 3 shows that the coefficient of markdown remains significantly positive at the 1% level when using the alternative measurement of quality.

As aforementioned in section 4, the intermediate input is of vital significance for estimating labor market power. Naturally, the production function must incorporate the intermediate input and hence obeys the gross output formula. However, Gandhi et al. (2020) (GNR) and Orr et al. (2018) point out that estimation of the gross output production function and the estimation of the value-added production function are not interchangeable theoretically. Previous methods, like Ackerberg et al. (2015), may confront the lack of identification for estimation of the output elasticity of the intermediate input. Nevertheless, the state of the art method of production function estimation (Gandhi et al. 2020), can identify the output elasticity of the intermediate input by using the cross-equation constraint between the production function and the first-order condition with respect to the intermediate input. Moreover, it allows the output elasticity of input to differ across firms within the same industry, which is superior to the Cobb-Douglas production function set up.[31] Therefore, we use the method of Gandhi et al. (2020) and De Loecker & Warzynski (2012) to estimate the markup and markdown, which we use for robustness analysis. We use another production function estimation method (Levinsohn & Petrin 2003, Olley & Pakes 1992) (LP and OP respectively) to estimate the markup and markdown as an additional robustness check, since they differ from each other in terms of the timing assumption of labor determination or the proxy variable.

In Table 3, columns (3) to (7) shows the results using different production function estimation methods[32]. All these five columns comport well with our baseline results, which demonstrates that our results are robust to the proxy variables for TFP and different assumptions about the timing of the labor input.

[30]The detailed micro-level data used in this paper enable us to extend the measurement of quality by Feenstra & Romalis (2014) from country-level to firm-HS 6-digit product-destination country level.

[31]The Cobb-Douglas production setup implies that the elasticity is constant within sectors, hence, the heterogeneity of firms' markdown only stems from heterogeneity in firms' input shares, which might be underestimated.

[32]In particular, the cutting-edge production function estimation method, Gandhi et al. (2020), is a non-parametric estimation method, which has no functional form assumption on the production function.

Table 3: Robustness Check: Alternative Measurements of Quality and Markdown

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|---|
| | Alternative Quality | | Alternative Markdown | | | | |
| | ACF | F&R | OP | LP | OLS | OLS FE | GNR |
| Dependent Variables | ln(Price) | ln($\text{Quality}_{\text{F\&R}}$) | ln($\text{Quality}_{\text{KSW}}$) | | | | |
| ln(markdown) | 0.015*** | 0.006*** | 0.140*** | 0.143*** | 0.153*** | 0.168*** | 0.086*** |
| | (0.003) | (0.002) | (0.015) | (0.010) | (0.010) | (0.011) | (0.0113) |
| Observations | 4,938,398 | 4,785,436 | 3,062,827 | 4,773,289 | 4,781,560 | 4,938,473 | 4,862,653 |
| Adjusted $R^2$ | 0.831 | 0.842 | 0.407 | 0.389 | 0.389 | 0.388 | 0.388 |

Notes: Robust standard errors clustered at the firm level are in parentheses, ***, **, and * denote significance at 1%, 5%, 10% level, respectively. In column (1), the dependent variable is product unit price (in log) at the firm-destination country-HS 6-digit level and the control variables TFP (in log) is obtained from production function estimation using Ackerberg et al. (2015). In column (2), the dependent variable is product quality (in log) at the firm-destination country-HS 6-digit level, estimated using the adjusted method based on Feenstra & Romalis (2014), and the control variables TFP (in log) is obtained from production function estimation using Ackerberg et al. (2015). In columns (3) to (7), the dependent variable is markdown (in log) obtained from production function estimation using Olley & Pakes (1992), Levinsohn & Petrin (2003), OLS, OLS with fixed effects and Gandhi et al. (2020), respectively. The TFP estimations are the same, with the exception in column (7). In column (7), we use labor productivity instead, measured by value added per worker. In each column, we add firm's control variables and confounding factors, product-destination country-year fixed effects and firm fixed effects. ACF=Ackerberg et al. (2015), F&R = Feenstra & Romalis (2014), FE = Fixed Effects, GNR = Gandhi et al. (2020), LP = Levinsohn & Petrin (2003), OP = Olley & Pakes (1992), OLS = Ordinary Least Squares.

### 5.2.2 Robustness Check 2: Firm-Level Regression

The previous empirical analysis is conducted with dependent variables at the firm-product-destination country level. In this section, we aggregate the product quality to the firm level. We adopt two different aggregation strategies and find very similar results.

Our first approach follows Lim et al. (2018), where the firm-level quality in year $t$ is given by:

$$z_{ft}^{\text{LTY}} = \sum_{(h,c)} \omega_{fhct} \left( z_{fhct} - \bar{z}_{hct} \right) \tag{24}$$

where $\omega_{fhct} = \frac{p_{fhct} q_{fhct}}{\sum_{(h,c)} p_{fhct} q_{fhct}}$, which is the share of firm $f's$ exports to market $(h, c, t)$ over its total exports in year $t$. Since quality is not comparable across product $h$, we demean quality using the average quality in market $(h, c, t)$, that is $z_{fhct} - \bar{z}_{hct}$.

The second approach relies on Feenstra & Romalis (2014). Define the quality-adjusted price as $\hat{p}_{fhct} = \frac{p_{fhct}}{z_{fhct}}$. Then, using the same method as equation (24), we aggregate over product $h$ and destination country

$c$ to obtain both the firm-level price index and the quality-adjusted price index. Finally, dividing the former by the latter, we obtain the firm-level quality as follows:

$$z_{ft}^{FR} = \frac{p_{ft}}{\hat{p}_{ft}} \tag{25}$$

Next, we re-estimate the impact of monopsony power on firms' export product quality according to the following empirical specification:

$$ln(z_{ft}) = \tilde{\beta}_1 ln(\Psi_{ft}) + \boldsymbol{\gamma}\mathrm{X}_{ft} + \lambda_t + \lambda_f + \varepsilon_{ft} \tag{26}$$

where $z_{ft}$ denotes firm $f$'s aggregate product quality in year $t$, and $\lambda_t$ denotes year fixed effects. Other variables are defined in the same way as in the baseline regression (17). Table 4 displays the results. Columns (1) and (2) show that firms' monopsony power in the labor market has a significant positive impact on its average export product quality, which is consistent with our baseline results. In column (3), we change the dependent variable from firm-level quality to the firm-level price index and estimate using equation (26). The result is in keeping with our benchmark analysis.

Table 4: Robustness Check: Firm-Level Regressions

| Dependent Variables | (1)<br>$\ln(\text{Quality}_{\text{KSW}}^{\text{LTY}})$ | (2)<br>$\ln(\text{Quality}_{\text{K\&R}}^{\text{LTY}})$ | (3)<br>ln(Price) |
|---|---|---|---|
| $\ln(\text{markdown}_{\text{ACF}})$ | 0.298*** | 0.128*** | 0.022*** |
| | (0.012) | (0.019) | (0.005) |
| Observations | 264,316 | 264,316 | 264,316 |
| Adjusted $R^2$ | 0.847 | 0.620 | 0.910 |

Notes: Robust standard errors clustered at the firm level are in parentheses, ***, **, and * denote significance at the 1%, 5%, 10% level, respectively. Merged data are used. In columns (1) and (2), the dependent variable is firm-year level aggregated export product quality (in log). In column (3), the dependent variable is firm-year level aggregated export product unit price (in log). In each column, we control for firm-level control variables, confounding factors, firm fixed effects and year fixed effects. The TFP is obtained from production function estimation using Ackerberg et al. (2015).

#### 5.2.3 Robustness Check 3: Subsample Regression

In this section, we estimate the impact of firms' monopsony power on its export product quality using several subsamples. First of all, we use a balanced panel subsample that only includes incumbent firms, to eliminate the influence of firm entry and exit on our estimation. Jha & Rodriguez-Lopez (2021) point that firms having monopsony power have a lower probability of being exporters. This phenomenon exists in China as well, as Figure B2 and Table B2, in Appendix B, show in detail. As a result, using a balanced panel can also cope with the potential sample selection problem. In Table 5, column (1) displays the results. Our baseline results hold forthe balanced panel subsample.

Moreover, on the one hand, Muehlemann et al. (2013) point out that firms' monopsony power in the labor market is differentiated by the skill levels of their employees. Bachmann et al. (2022) demonstrate that workers performing different production tasks are exposed to different degrees of monospony power.[33] On the other hand, producing high-quality products requires more intensive use of skilled workers (Brambilla & Porto 2016, Verhoogen 2008). As a result, the skill intensity of firms' employees is correlated with firms' monopsony power in the labor market and also has an impact on firms' quality, which may cause omitted variables bias in our estimation. To address this concern, we use the cross-sectional sample from 2004 for a robustness check. The ASIF from 2004 provides detailed information on the educational and technical backgrounds of firms' employees. Utilizing this information, we can calculate the ratio of the skilled labor based on educational background and technical background, respectively, as additional controls.[34] In Table 5, columns (2) and (3) exhibit the results. The coefficient of interest remains positive and statistically significant at the 1% level, which is in line with our main results.

[33]For China in particular, Fleisher & Wang (2004) finds that the degrees of wage suppression for production workers and skilled workers are different.

[34]In Table 5, column (2), we use the share of workers with education above high school as an additional control variable, including those with master, graduate and junior college degrees. In Table 5, column (3), we use the share of workers with technical titles, including senior titles, intermediate technical titles, junior technical title and senior technicians.

Table 5: Robustness Check: Subsample Regressions

| | (1) | (2) | (3) |
|---|---|---|---|
| | Balanced Panel | Subsample 2004 | |
| Dependent Variables | $\ln(\text{Quality}_{\text{KSW}})$ | | |
| $\ln(\text{markdown}_{\text{ACF}})$ | 0.174*** | 0.193*** | 0.202*** |
| | (0.023) | (0.029) | (0.029) |
| Skill Labor Ratio (Educational Background) | No | Yes | No |
| Skill Labor Ratio (Technical Background) | No | No | Yes |
| Observations | 888,723 | 700,120 | 533,598 |
| Adjusted $R^2$ | 0.446 | 0.257 | 0.274 |

Notes: Robust standard errors clustered at the firm level are in parentheses, ***, **, and * denote significance at the 1%, 5%, 10% level, respectively. Merged data are used for regression. The dependent variable is firm-product-destination country-year level export product quality (in log). In column (1), we only use the incumbent firm subsample for the balanced panel analysis to eliminate the impact of firm dynamics. Product-destination country-year fixed effects and firm fixed effects are controlled. In columns (2) and (3), we use a cross-sectional data for year 2004, since the ASIF data in 2004 report the educational and technical backgrounds of employees. Product-destination country fixed effects and CIC 4-digit industry fixed effects are controlled instead. In each column, we add firm-level control variables and confounding factors. The TFP is obtained from production function estimation using Ackerberg et al. (2015).

#### 5.2.4 Robustness Check 4: Alternative Empirical Specification

The previous analysis used the long-term variation in markdown and export product quality. Following Fan et al. (2015b; 2018b), we conduct a time difference regression but extend it to multiple time intervals. This approach can further eliminate the problem of omitted variables and tackle the issue of autocorrelation.

$$\Delta ln(z_{fhc}) = \beta_1 \Delta ln(\Psi_f) + \gamma \Delta \mathrm{X}_f + \lambda_{hct} + \varepsilon_{fhc} \tag{27}$$

where $\Delta$ denotes the change in any variable between year $t$ and year $t-s$, that is, $\Delta x = x_t - x_{t-s}, s = 1, 2, 3, 4, 5, 6$. Table 6 displays the results. Our results are robust to different periods of variation. Firms' monopsony power in the labor market can improve their export product quality not only in the short run, but also in the long run.

Table 6: Robustness Check: Alternative Empirical Specification (Time Difference)

| Dependent Variables | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | $\Delta\ln(\text{Quality}_{\text{KSW}})$ | | | | | |
| | 1-year | 2-year | 3-year | 4-year | 5-year | 6-year |
| $\Delta\ln(\text{markdown}_{\text{ACF}})$ | 0.190*** | 0.254*** | 0.242*** | 0.254*** | 0.260*** | 0.310*** |
| | (0.009) | (0.013) | (0.016) | (0.024) | (0.032) | (0.044) |
| Observations | 1,824,963 | 1,014,193 | 582,456 | 309,524 | 169,566 | 83,256 |
| Adjusted $R^2$ | 0.183 | 0.224 | 0.269 | 0.322 | 0.364 | 0.403 |

Notes: Robust standard errors clustered at the firm level are in parentheses, ***, **, and * denote significance at the 1%, 5%, 10% level, respectively. Merged data are used for the regression. The dependent variable is firm-product-destination country-year level export product quality (in log). In each column, we control for, firm-level covariates, confounding factors, product-destination country-year fixed effects. The TFP is obtained from production function estimation using Ackerberg et al. (2015).

#### 5.2.5 Robustness Check 5: One-Year Lag Regression

There may be concern that the benchmark empirical specification may suffer from an endogeneity problem that stems from the simultaneous relationship between product quality and firms' monopsony power in the labor market. Therefore, following the spirit of Brandt et al. (2017), we use one-year lag ln(markdown) as an explanatory variables and re-estimate our baseline results according to equation (17). Table 7 displays the empirical results, which comport well with our baseline results. This serves as a preliminary evidence that our results are not threatened by an endogeneity problem. In the next section, we adopt an IV approach to address the endogeneity problem more seriously.

Table 7: Robustness Check: One Year Lag Regression

| Dependent Variables | (1)<br>$\ln(\text{Quality}_{\text{KSW}})$ | (2)<br>$\ln(\text{Quality}_{\text{KSW}})$ | (3)<br>$\ln(\text{Quality}_{\text{KSW}})$ |
|---|---|---|---|
| One Year Lag $\ln(\text{Markdown}_{\text{ACF}})$ | 0.029*** | 0.028*** | 0.030*** |
| | (0.011) | (0.010) | (0.010) |
| Control | No | Yes | Yes |
| Confounding Factors | No | No | Yes |
| Observations | 4,145,783 | 4,145,433 | 4,135,572 |
| Adjusted $R^2$ | 0.394 | 0.394 | 0.394 |

Notes: Robust standard errors clustered at the firm level are in parentheses, ***, **, and * denote significance at the 1%, 5%, 10% level, respectively. Merged data are used for regression. The dependent variable is firm-product-destination country-year-level export product quality (in log). In column (1), we use the one year lag log(markdown) as the explanatory variable. In column (2), we add firm-level covariates. In column (3), we control the confounding factors. In each column, we control for, product-destination country-year fixed effects and firm fixed effects. The TFP is obtained from production function estimation using Ackerberg et al. (2015).

### 5.3 IV Regression

Since quality and markdown are both equilibrium variables, simultaneity bias may exist, which would threaten our estimation. To address this concern more seriously, we use an IV to solve the potential endogeneity problem.

Firms' monopsony power in the labor market is not directly observable. As a result, identifying a good instrument variable is challenging. Inspired by Hau et al. (2020), who proxy the minimum wage as an exogenous competitive shock, we use the county-level minimum wage as the instrument variable for the firm's markdown. The minimum wage data are from the Ministry of Human Resources and Social Security and cover 2000 to 2020. The data contains detailed information on the monthly minimum wage and hourly minimum wage, which vary across counties and time. The validity of the instrument variable relies on two conditions: (1) the relevance condition, and (2) the exogenous condition. First of all, Hau et al. (2020) point out that the minimum wage can reduce labor turnover, which is an important determinant of firms' monopsony power in the labor market (Manning 2003a). Naidu et al. (2018) propose that the minimum wage is the legislative remedy for firms' labor market power and protects low-skill workers from exploitation. In sum, the minimum wage can restrict firms' monopsony power in the labor market, the relevance condition is satisfied. Second, the minimum wage standards are determined by a joint negotiation between provincial, city-level, and county-level governments, with provincial governments playing the key role. Huang et al. (2015) study the determinants of changes in minimum wage and find that economic conditions have limited explanatory power in predicting adjustments to the minimum wage. In sum, the minimum wage can be regarded as an exogenous competitive shock to firms and the exogenous condition is also satisfied.

The empirical results are displayed in Table 8, columns (1) and (2). We use the subsample from 2003 to 2007 to conduct the empirical analysis.[35] Column (1) shows the OLS estimation results. Column (2) shows the IV results, which are in concert with our baseline results and the OLS results in column (1).[36] Several tests are performed to verify the quality of the instruments. Both the *Kleibergen–Paap LM statistic* and the *Kleibergen–Paap F-statistics* demonstrates that there is no weak IV problem. In addition, the t-values of the instrument in the first-stage estimates reported in column (1) in Table B5, in Appendix B, offer strong evidence to justify such instruments.

An alternative instrument variable, the expected number of city-level net immigrants is also used to take care of the possible measurement error and simultaneity problem.[37] We use census data from 2000 and 2005, which recorded the city-level outgoing labor force and the incoming labor force. Following Imbert et al. (2022), we only keep migrants who are ages 15 to 64 years and exclude migrants whose purpose of migration is to study. To identifying the exogenous variation in migration, we adopt the shift-share approach (Adao et al. 2020, Borusyak et al. 2022). Following Jaeger et al. (2018), the shift-share-based expected net immigration is defined as:

$$\Delta \mathrm{M_c} = \sum_{o} \left( \frac{\mathrm{M}^{2000}_{oc}}{\mathrm{M}^{2000}_{o,roc}} \times \Delta \mathrm{M}^{2005}_{o,roc} \right) - \sum_{d} \left( \frac{\mathrm{M}^{2000}_{cd}}{\mathrm{M}^{2000}_{roc,d}} \times \Delta \mathrm{M}^{2005}_{roc,d} \right) \tag{28}$$

where $c$ denotes city; $o$ and $d$ indicate origin city and destination city, respectively; $roc$ denotes the rest of the cities except city $c$ (ROC), and M denotes migration. $\frac{\mathrm{M}^{2000}_{oc}}{\mathrm{M}^{2000}_{o,roc}}$ is the share of immigrants from origin city $o$ to city $c$ at reference year (i.e., 2000 in our case), $\Delta \mathrm{M}^{2005}_{o,roc}$ is the number of incoming immigrants from origin city $o$ to ROC between 2000 and 2005. The migration from origin city $o$ to city $c$ is omitted to following the spirit of Campante et al. (2019). Similarly, $\frac{\mathrm{M}^{2000}_{cd}}{\mathrm{M}^{2000}_{roc,d}}$ is the share of immigrants from city $c$ to destination city $d$ in the reference year and $\Delta \mathrm{M}^{2005}_{roc,d}$ is the number of emigrants from ROC to destination city $d$ between 2000 and 2005. The expected net inflow of migrants $\Delta M_c$ is the weighted average of the net inflow of migration (the "shift"), with weights depending on the past geographical migration structure (the "share").

[35]This is because data on the minimum wage before 2003 has too many missing values. Several papers have studied the impact of the minmum wage using the subsample between 2004 and 2007 because the enforcement of the minimum wage law has improved over time. After March 2004, with the revised minimum wage regulations, the implementation of minimum wage law become more comprehensive and stricter as well. Our results remain the same when we use the subsample between 2004 and 2007. For the detailed background information on the minimum wage in China, please refer to Hau et al. (2020) section 4.

[36]The magnitudes of the coefficients of interest are larger in the IV, compared to the OLS. There are two possible explanations for this. First, the markdown may have measurement error; hence OLS estimation has *attenuation bias* since we assume that the input market is perfectly competitive. Second, better export product quality may help firms escape from fierce competition (Amiti & Khandelwal 2013) and possess more monopsony power in the labor market, which generates positive inverse causality and downward pressure in OLS estimation.

[37]For the empirical regression, we conduct a hyperbolic sine transformation for $\Delta M_c$, that is, we use $\log(\Delta M_c + \sqrt{\Delta {M_c}^2 + 1})$ as the instrument variables. Bellemare & Wichman (2020) points out that this transformation has the following good properties: (1) it is similar to a logarithm, and (2) it allows retaining zero-valued (and even negative-valued) observations.

For the feasibility of expected net immigration as an instrument variable, Manning (2003a) and Brooks et al. (2021b) point out that labor supply elasticity is the key determinants of firms' labor market power, which can be influenced by migration. This verifies the relevance condition. Moreover, we use the shift-share designed predicted migration, which is the exogenous component of real migration, to satisfy the exogeneous condition. The empirical results are also displayed in Table 8. We use the subsample from 2005 to conduct the empirical analysis. Column (3) displays the OLS results, and column (4) shows the IV results. Both columns are in keeping with our baseline results. The IV regression results also pass the aforementioned IV quality tests.

Table 8: Instrument Variable Regression

| Dependent Variables | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | $\ln(\text{Quality}_{\text{KSW}})$ | | $\Delta\ln(\text{Quality}_{\text{KSW}})$ | |
| | Minimum Wage | | Migration | |
| | OLS | IV | OLS | IV |
| ln(markdown) | 0.156*** | 0.699* | | |
| | (0.013) | (0.379) | | |
| $\Delta\ln(\text{markdown}_{\text{ACF}})$ | | | 0.353*** | 1.969* |
| | | | (0.028) | (1.004) |
| Kleibergen-Paap rk LM statistic | | 41.92 | | 9.69 |
| Kleibergen-Paap Wald rk F statistic | | 38.64 | | 8.12 |
| Observations | 3,657,415 | 3,102,277 | 350,880 | 296,950 |
| Adjusted $R^2$ | 0.393 | | 0.173 | |

Notes: Robust standard errors clustered at the firm level are in parentheses, ***, **, and * denote significance at 1%, 5%, 10% level, respectively. Merged data are used for the regression. The dependent variable is firm-product-destination country-year level export product quality (in log). In columns (1) and (2), we use the subsample between 2003 and 2007. Product-destination country-year fixed effects and firm fixed effects are controlled. In columns (3) and (4), we use the subsample in year 2005. Product-destination country fixed effects and CIC 4-digit industry fixed effects are controlled instead. In each column, we add firm's control variables and confounding factors. The TFP is obtained from production function estimation using Ackerberg et al. (2015).

### 5.4 Further Analysis: The Role of Output Expansion

As the model analysis suggested, firms' monopsony power results in increasing the marginal cost of labor and motivates quality upgrading. Firms with greater monopsony power in the labor market face a steeper upward-sloping labor supply curve and hence their marginal cost of labor is more sensitive to output expansion. As a result, firms improve their product quality in response to output expansion. For firms with greater monopsony power and that experience a larger expansion of output, the effect of quality upgrading should be more significant. Following Khandelwal et al. (2013), we use the the removal of Chinese export quotas under the MFA in the textile and clothing industries in 2005 as an exogenous demand shock to test this prediction. We start with a description of the background of the MFA. The MFA and its successor, the Agreement on Textile and Clothing, are institutions that restricted textile and clothing industry exports from developing countries to the United States, the European Union, Canada, and Turkey. The Uruguay Round negotiation in 1995 reached an agreement that the quotas would be phased out on January 1, 1995, 1998, 2002, and 2005, where the Phase IV (i.e., 2005) quotas were most binding.

The MFA quota removal of Chinese textile and clothing industry's exports in 2005 constitutes a relevant and informative case study for two reasons. First, the quota was a quantity-constraint trade policy instrument, which means its removal changed output directly. Second, the agreement on the removal of products and the timeline was determined in 1995, which implied that they would not be influenced by demand and supply conditions in 2005. Together, the MFA case can be viewed as an exogenous demand shock to firms' output.

Using firm-destination country-product-level quotas data provided by Khandelwal et al. (2013), we reexamine the impact of firms' monopsony power on their export product quality according to equation 17, based on refined samples. Table 9 documents the results. Column (1) shows the results of refined sample, that is export from Chinese textile and clothing industry to the United States, the European Union, and Canada, which are in line with our baseline results. Next, we conduct two comparisons. First, columns (2) and (3) shows the results when we use products subject to quotas and not subject to quotas, respectively. The impact of monopsony power is more significant for quota-bound exports, which experiences an output expansion shock and has greater upward pressure on labor costs. Second, columns (4) and (5) displays the results for the quota-bound groups for firms with higher markdowns and firms with lower markdowns, respectively. The impact is significant for firms with markdowns that are greater than the median value. The intuition is that, for firms experiencing an exogenous output expansion shock, greater monopsony power results in more sensitive labor costs and hence quality upgrading effect is more obvious.

Table 9: Case Study: Quota Removal as an Exogenous Supply Shock

| Dependent Variables | (1) ln(Quality$_{KSW}$) Textile Clothing | (2) ln(Quality$_{KSW}$) Quota Bound | (3) Quota Free | (4) ln(Quality$_{KSW}$) Quota Bound | (5) |
|---|---|---|---|---|---|
| | All | All | All | High MD | Low MD |
| ln(Markdown$_{ACF}$) | 0.101*** | 0.108*** | 0.085** | 0.130** | 0.105 |
| | (0.027) | (0.037) | (0.035) | (0.059) | (0.077) |
| Observations | 115,321 | 61,864 | 51,661 | 29,353 | 29,697 |
| Adjusted $R^2$ | 0.435 | 0.495 | 0.462 | 0.540 | 0.524 |

Notes: Robust standard errors clustered at the firm level are in parentheses, ***, **, and * denote significance at the 1%, 5%, 10% level, respectively. Column (1) use the textile and clothing subsample of merged data. Columns (2) and (3) further refine the sample to quota-bound and quota-free subsamples. Columns (4) and (5) use the quota-bound subsample and group firms based on the the median value of the logarithm value of markdown. The data are from 2000 to 2005. The dependent variable is firm-product-destination country-year level export product quality (in log). In all columns, we control firm-level covariate, confounding factors, product-destination country-year fixed effects and firm fixed effects. The TFP is obtained from production function estimation using Ackerberg et al. (2015).

### 5.5 Heterogeneity Analysis

In this subsection, we further analyze the heterogeneous effect of monopsony power on firms' export product quality from the perspective of firm characteristics, export destination, characteristics and export product attributes.

#### 5.5.1 Heterogeneity Analysis 1: Firm Characteristics

As pointed out by Qiu & Yu (2020), managerial efficiency is another important dimension of firms' heterogeneity, and it has a significant impact on firms' product line decisions in response to a cost shock. They point out that efficient firms expand their export product scope in response to foreign tariff cuts, whereas inefficient firms reduce their product scope. Inspired by this, we explore whether the effect of monopsony power on export product quality differs with firms' managerial efficiency. We re-run empirical specification (17) using a subsample of firms with high managerial efficiency and a subsample of firms with low managerial efficiency.

Following Qiu & Yu (2020), we estimate a firm's managerial efficiency by using general and administrative expenses while controlling for firm size, export status, markup and markdown. A low of the general and administrative expenses residual represents a high managerial efficiency. We calculate the average managerial efficiency of each CIC 4-digit sector and year to construct the two subsamples. The high managerial efficiency group includes all firms with a residual lower than the mean value, whereas the high low managerial efficiency group includes all industries with a residual that is higher than the mean value. In Table 10, column (1) reports the regression results for the high managerial efficiency group, and column (2) reports the regression results for the low managerial efficiency group. First, in both groups, firms' monopsony power in the labor market has a positive impact on firms' export product quality. Second, the effect is stronger for firms with low managerial efficiency. The reason behind this finding might be that firms with higher managerial efficiency can better cope with the increasing cost of labor and have lower incentives to upgrade their product quality.

More importantly, with the development of information and communications technology and the reduction in transportation costs, trade in tasks has becoming more and more pervasive (Baldwin & Robert-Nicoud 2014). Thus, we run the same regression according to equation (17) separately on firms with a longer production stage and firms with a shorter production stage. Following Chor et al. (2021), we calculate firms' import upstreamness and export upstreamness and use the difference between them to measure the span of production stages that the firm oversees or coordinates within China. Similarly, we calculate the average span of production stages at the CIC 4-digit sector and year level and assign firms with production stages longer than the mean value to the long group and the others to the short group. The regression results for these two subgroups are displayed in Table 10, columns (3) and (4), respectively. The impact of firms' monopsony power on export product quality is in keeping with our baseline results in both columns, but it is stronger for firms with shorter span of production stages. The reason might be that firms with a shorter span of production stages has lower coordination costs and can easily adjust their product quality.

Table 10: Heterogeneity Analysis: Management Efficiency and Production Stage

| Dependent Variables | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | $\ln(\text{Quality}_{\text{KSW}})$ | | $\ln(\text{Quality}_{\text{KSW}})$ | |
| | Managerial Efficiency | | Production Length | |
| | High | Low | Long | Short |
| $\ln(\text{markdown}_{\text{ACF}})$ | 0.137*** | 0.157*** | 0.144*** | 0.182*** |
| | (0.020) | (0.013) | (0.017) | (0.022) |
| Observations | 939,563 | 3,791,880 | 1,879,448 | 1,592,438 |
| Adjusted $R^2$ | 0.462 | 0.398 | 0.422 | 0.440 |

Notes: Robust standard errors clustered at the firm level are in parentheses, ***, **, and * denote significance at the 1%, 5%, 10% level, respectively. Merged data are used for the regression. The dependent variable is firm-product-destination country-year level export product quality (in log). In each column, we add firm-level control variables and confounding factors, product-destination country-year fixed effects and firm fixed effects. The TFP is obtained from production function estimation using Ackerberg et al. (2015).

There are three main types of firm ownership in China: SOEs, domestic private enterprises (DPEs) and FIEs. They differ from each other in terms of access to land, capital, credit resource, and so on (Chen et al. 2019). In Table 11, columns (1) to column (3) shows the results for SOEs, DPEs and FIEs, respectively. The positive effect among DPEs is the weakest while the positive effect on FIEs is the strongest. SOEs ranks in the middle.

As stressed by Yu (2015), processing trade accounted for a large part of trade in China during our sample period, and firms engaging in processing trade are more labor intensive. As a result, the impact of firms' monopsony power on their export product quality might be stronger for processing trade firms. Moreover, as pointed out by Feenstra & Hanson (2005), the two main types of processing trade firms are pure assembly (PA) and import and assembly (IA). These two regimes differ from each other in terms of the control rights of imported inputs. In the PA regime, processing trade firms have no autonomy in imports and production at all; in the IA regime is, firms have autonomy in imports and production. As a result, our prediction is that the the stronger effect of monopsony power on firms' export product quality only applies to import and assembly type processing trade firms. In Table 11, columns (4) to (6) displays the results, which are in line with our prediction. PA firms refer to firm whose pure assembly processing trade share is larger than 70%, IA firms refer to firm whose import and assembly processing trade share is more than 70% as IA firms, and ordinary firms refer to those with 100% ordinary trade. For a robustness check, we re-run the regressions in columns (4) and (5) using pure PA firms and pure IA firms, and the results still hold.

Table 11: Heterogeneity Analysis: Ownership Type and Trade Mode

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Dependent Variables | $\ln(\text{Quality}_{\text{KSW}})$ | | | $\ln(\text{Quality}_{\text{KSW}})$ | | |
| | Ownership Type | | | Trade Type (Dummy) | | |
| | SOE | DPE | FIE | PA | IA | Ordinary |
| $\ln(\text{markdown}_{\text{ACF}})$ | 0.100* | 0.089*** | 0.166*** | -0.026 | 0.241*** | 0.134*** |
| | (0.060) | (0.019) | (0.012) | (0.028) | (0.025) | (0.013) |
| Observations | 187,666 | 957,348 | 3,290,282 | 138,173 | 1,349,006 | 1,829,974 |
| Adjusted $R^2$ | 0.589 | 0.497 | 0.394 | 0.590 | 0.432 | 0.457 |

Notes: Robust standard errors clustered at the firm level are in parentheses, ***, **, and * denote significance at the 1%, 5%, 10% level, respectively. Merged data are used for the regression. The dependent variable is firm-product-destination country-year level export product quality (in log). In each column, we add firm-level control variables and confounding factors, product-destination country-year fixed effects and firm fixed effects. The TFP is obtained from production function estimation using Ackerberg et al. (2015).

### 5.5.2 Heterogeneity Analysis 2: Firm Export Destination Country and Export Product

Thanks to the detailed information on firms' export destination countries and export products provided by the Customs data, we can detect the heterogeneous impact on monopsony power from the perspective of firm export behavior.

To begin, we conduct heterogeneity analysis based on the income levels in firms' export destination countries. Fajgelbaum et al. (2011) point out that there exists a positive correlation between consumers' income and the quality of products consumed. Hallak (2006) shows that rich countries tend to import relatively more from countries that produce high-quality goods. Brambilla et al. (2012) also show that high-income countries value quality more than low-income countries and firms exporting to high-income countries tend to hire more skilled labor and export high-quality goods.Thus, we divide the firms into groups based on the level of income in their export destination countries. Table 12 shows the results. Columns (1) and (2) denotes the results for high-income countries and low-income countries, respectively, as defined by the World Bank. Apparently, the quality of export products improves more in response to firms' monopsony power in the labor market for firms exporting to high-income countries. We also find the heterogeneous effects from the perspective of whether the export destination country belongs to the Organization for Economic Co-operation and Development (OECD) or Group of Seven (G7) or not, since the member countries of OECD or G7 countries are developed countries and have high income levels. The results are displayed in Table 12. Similarly, the impact of monospony power is more important for firms that export to OECD or G7 countries. Overall, the results in Table 12 further verify our baseline results and indicates that the impact is greater for firms exporting to high-income destination countries.

Table 12: Heterogeneity Analysis: Export Destination Country

| Dependent Variables | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | $\ln(\text{Quality}_{\text{KSW}})$ | | $\ln(\text{Quality}_{\text{KSW}})$ | | $\ln(\text{Quality}_{\text{KSW}})$ | |
| | High Income | Low Income | OECD | Non OECD | G7 | Non G7 |
| $\ln(\text{markdown}_{\text{ACF}})$ | 0.155*** | 0.127*** | 0.164*** | 0.130*** | 0.181*** | 0.131*** |
| | (0.011) | (0.024) | (0.012) | (0.014) | (0.013) | (0.013) |
| Observations | 4,056,801 | 495,851 | 2,630,321 | 1,939,042 | 1,675,715 | 2,893,966 |
| Adjusted $R^2$ | 0.389 | 0.531 | 0.350 | 0.497 | 0.351 | 0.457 |

Notes: Robust standard errors clustered at the firm level are in parentheses, ***, **, and * denote significance at the 1%, 5%, 10% level. Merged data are used for the regression. The dependent variable is firm-product-destination country-year level export product quality (in log). In each column, we add firm-level control variables and confounding factors, product-destination country-year fixed effects and firm fixed effects. The TFP is obtained from production function estimation using Ackerberg et al. (2015).

Next, we analyze the heterogeneous effect from the perspective of product characteristics. First, as noted by Fan et al. (2015b; 2018b), differentiated products and homogeneous products differ from each other in terms of scope for quality differentiation. The scope for quality differentiation governs the difficulty of upgrading product quality. Differentiated products have a large scope for quality differentiation and the cost of quality upgrading is relatively low; for homogeneous product, it is the opposite. Table 13 reports the empirical results for differentiated products and homogeneous products, as defined by Rauch (1999).[38] Columns (1) and (2) display the results based on a conservative classification, and columns (3) and (4) display the results based on a liberal classification; the former classfication has stricter requirement for homogeneous products. In sum, all the results in all the columns are comparable to our baseline estimates. The quality upgrading effect is stronger for differentiated products, which have more scope for quality differentiation and lower cost of upgrading.

Table 13: Heterogeneity Analysis: Product Differentiation

| Dependent Variables | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | $\ln(\text{Quality}_{\text{KSW}})$ | | $\ln(\text{Quality}_{\text{KSW}})$ | |
| | Conservative Classification | | Liberal Classification | |
| | Differentiated | Homogeneous | Differentiated | Homogeneous |
| $\ln(\text{markdown}_{\text{ACF}})$ | 0.154*** | 0.134*** | 0.151*** | 0.147*** |
| | (0.011) | (0.022) | (0.011) | (0.024) |
| Observations | 4,159,291 | 460,526 | 4,031,761 | 586,887 |
| Adjusted $R^2$ | 0.398 | 0.542 | 0.403 | 0.509 |

Notes: Robust standard errors clustered at the firm level are in parentheses, ***, **, and * denote significance at the 1%, 5%, 10% level, respectively. Merged data are used for the regression. The dependent variable is firm-product-destination country-year level export product quality (in log). In each column, we add firm-level control variables and confounding factors, product-destination country-year fixed effects and firm fixed effects. The TFP is obtained from production function estimation using Ackerberg et al. (2015).

Finally, we also explore the heterogeneous effects based on product import demand elasticity. Using data provided by Fontagné et al. (2022), we separate products into two groups, the elastic product group and the inelastic product group based on its import demand elasticity.[39] Products with elasticity above the

[38] Rauch (1999) provides product classification at the Standard International Trade Classification (SITC) 4-digit level (version 2). Homogeneous goods include both goods traded on organized exchanges and reference-priced goods. The remaining goods are classified as differentiated products. The correspondence tables between HS 2002, HS 1996 and SITC 2 come from UN Trade Statistics (https://unstats.un.org/unsd/trade/classifications/correspondence-tables.asp).

[39] Fontagné et al. (2022) estimate trade elasticities at the HS 6-digit product level by exploiting the variation in bilateral tariffs for each product category for the universe of country pairs. Their data can be accessed via https://sites.google.com/view/product-level-trade-elasticity/home.

mean elasticity are assigned to the elastic group and *vice versa*. For the inelastic product group, consumers are insensitive to price increases due to quality upgrading. As a result, firms can improve product quality and increase prices without losing too much demand. Table 14 shows the results, where columns (1) and (2) use tariff-based elasticity while columns (3) and (4) use point estimated elasticity. The results convey the same message: firms' monopsony power in the labor market can improve the quality of the export products to a larger extent when the product is inelastic.

Table 14: Heterogeneity Analysis: Elasticity of Import Demand

| Dependent Variables | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | $\ln(\text{Quality}_{\text{KSW}})$ | | $\ln(\text{Quality}_{\text{KSW}})$ | |
| | Tariff Based | | Point Estimation | |
| | Elasitic | Inelastic | Elasitic | Inelastic |
| $\ln(\text{markdown}_{\text{ACF}})$ | 0.138*** | 0.249*** | 0.131*** | 0.198*** |
| | (0.010) | (0.045) | (0.010) | (0.033) |
| Observations | 4,162,697 | 328,780 | 3,354,859 | 529,669 |
| Adjusted $R^2$ | 0.406 | 0.551 | 0.404 | 0.518 |

Notes: Robust standard errors clustered at the firm level are in parentheses, ***, **, and * denote significance at the 1%, 5%, 10% level, respectively. Merged data are used for the regression. The dependent variable is firm-product-destination country-year level export product quality (in log). In each column, we add firm-level control variables and confounding factors, product-destination country-year fixed effects and firm fixed effects. The TFP is obtained from production function estimation using Ackerberg et al. (2015).

## 6 Conclusion

With renewed interest in imperfect competition in the labor market, this paper studied the impact of firms' monopsony power in the labor market on export product quality. We first uncovered several stylized facts: firms possessing greater labor market power export products with higher prices and their labor costs are more sensitive to output expansion. To rationalize these preliminary empirical findings, we extended the Melitz (2003) model by incorporating monopsonistic competition in the labor market and endogenous product quality choice. Our model shows that, with an upward-sloping labor supply curve and increasing marginal cost of labor stemming from labor market imperfections, firms produce and export high-quality products in response to the rising cost of labor. Our model predicts that, firms with more monopsony power in the labor market produce and export higher quality products. Analogously, this can be viewed as a variant of the "*Washington apple effect*" (Feenstra & Romalis 2014), with the increasing marginal cost of labor playing the role of the specific cost in Feenstra & Romalis (2014). Using detailed, highly disaggregated firm production data and export data from Chinese manufacturing firms during 2000 and 2007, our empirical evidence supports our model predictions. Firms' monopsony power in the labor market has a positive impact on export product quality: greater labor market power leads to higher quality export products. Our empirical results are highly robust across alternative measurements, empirical specifications, regression samples and instrument variables. Using quota cancellation associated with the MFA as an exogeneous demand shock, the results suggest that the impact is more significant for firms experiencing output expansion. This phenomenon is more obvious for firms that are FIEs, engage in import and assembly processing trade, have low managerial efficiency, have shorter production length, firms exporting differentiated products or products with inelastic demand, and export to high-income countries.

Our paper has important implications. It shows that domestic input market competition can influence firms' output market performance and export behavior. In addition to the previous focus on output markets, the antitrust policy should focus on input markets, especially the labor market (Naidu & Posner 2022, Naidu et al. 2018). Moreover, it is not only necessary, but also important to reconsider firms' production and export behavior under the imperfectly competitive labor markets and non-constant marginal cost of production.

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## Appendix A Datails of the Data Processing

Following Cai & Liu (2009), Brandt et al. (2017; 2012; 2014) and Yu (2015), we conduct the following data cleaning process:

- Observations with missing key financial variables (such as total assets, net value of fixed assets, sales, and gross value of the firm's output) are excluded.
- Firms with fewer than 8 workers are dropped from the sample.
- Following the basic rules of the Generally Accepted Accounting Principles (GAAP), we eliminate the observations if any of the following criteria are met:
  - Liquid assets are greater than total assets.
  - Total fixed assets are greater than total assets.
  - The net value of fixed assets is greater than total assets.
  - The firm's identification number is missing.
  - An invalid established time exists (e.g., the opening month is later than December or earlier than January).

It is worth noting that in the ASIF data, there exist some trading companies that do not produce themselves (Ahn et al. 2011). Following Brandt et al. (2017), we delete these trading companies by identifying key words in their firm name. Moreover, the AISF database includes mining industries, manufacturing industries, and electricity, gas, and water production and supply industries. We only retain firms that belong to the manufacturing industry and omit the other two types of firms.

Since the AISF data do not report the actual capital stock of the company, we use the method of Brandt et al. (2012) to convert the book value of capital into a comparable actual capital stock. Meanwhile, the CIC 4-digit code is adjusted to be consistent over time and the nominal variables, such as output value, sales value, and intermediate input value, are converted into real variables using the deflator provided by Brandt et al. (2012).

It is also worth mentioning that we omit observation from tobacco (CIC2, 16) and other manufacturing (CIC2, 43) sectors due to the lack of observations.

Table A1: Merged ASIF Data and Customs Data

| | Customs Data | | ASIF Data | | Merged Data |
|---|---|---|---|---|---|
| | Transactions | Firms | Firms (Raw) | Firms (Filtered) | Firms (Matched) |
| Year | (1) | (2) | (3) | (4) | (5) |
| 2000 | 3812258 | 82063 | 162885 | 134541 | 22118 |
| 2001 | 4161533 | 89660 | 171256 | 143858 | 25743 |
| 2002 | 4934787 | 104245 | 181557 | 153993 | 29607 |
| 2003 | 5828295 | 124299 | 196222 | 170796 | 34616 |
| 2004 | 6909902 | 153779 | 279092 | 242851 | 51537 |
| 2005 | 8184097 | 179666 | 270043 | 241482 | 52075 |
| 2006 | 9411429 | 208425 | 301961 | 269410 | 62376 |
| 2007 | 10635560 | 236505 | 336768 | 303642 | 65876 |

Note: Column (1) reports the number of observations of HS 8-digit monthly transaction-level trade data from China's General Administration of Customs by year. Column (2) reports the number of firms covered in the transaction-level trade data by year. Column (3) reports the number of firms covered in the firm-level production data set compiled by China's National Bureau of Statistics without any filter and cleaning. By contrast, column (4) presents the number of firms covered in the firm-level production data set with careful filtering described above. Accordingly, column (5) reports the number of matched firms using exactly identical company names and exactly identical phone numbers and contact persons in both the trade data set and the filtered production data set.

## Appendix B Figures and Tables

Table B1 reports the average of estimated output elasticities of the production function at the CIC 2-digit (CIC2) sector level by the ACF method (Cobb-Douglas specification). The mean values of the average output elasticity of labor, capital, and intermediate input are around 0.07, 0.04, and 0.85, respectively.

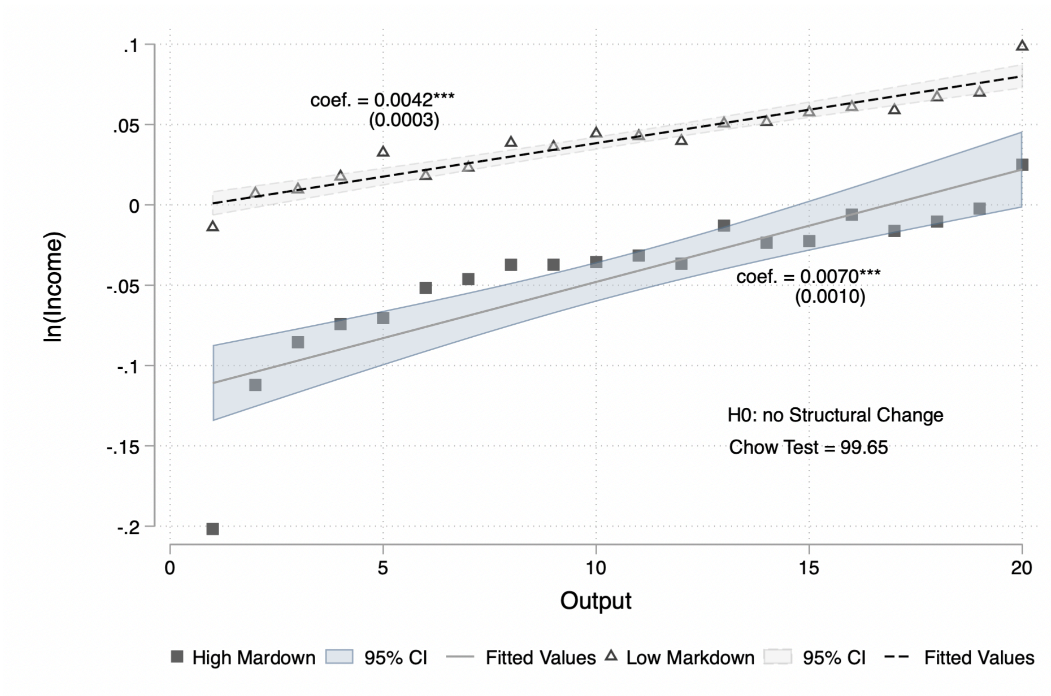
Table B1: Output Elasticity by CIC 2-Digit Sector (ACF, Cobb-Douglas Specification)

| Industry | No.Obs. | $\beta_L$ | $\beta_K$ | $\beta_M$ | Return To Scale |
|---|---|---|---|---|---|
| 13 Food from Agricultural Products | 117337 | 0.06 | 0.04 | 0.85 | 0.95 |
| 14 Foods | 47219 | 0.06 | 0.04 | 0.88 | 0.98 |
| 15 Beverages | 32793 | 0.03 | 0.02 | 0.89 | 0.94 |
| 17 Textile | 162311 | 0.07 | 0.03 | 0.86 | 0.96 |
| 18 Textile and products | 92868 | 0.09 | 0.04 | 0.80 | 0.93 |
| 19 Leather and Products | 46210 | 0.08 | 0.02 | 0.83 | 0.93 |
| 20 Wood, and Products | 41812 | 0.04 | 0.02 | 0.89 | 0.95 |
| 21 Furniture | 22315 | 0.07 | 0.03 | 0.85 | 0.95 |
| 22 Paper and Paper | 57176 | 0.06 | 0.03 | 0.87 | 0.96 |
| 23 Printing and Recording Media | 40234 | 0.04 | 0.02 | 0.83 | 0.89 |
| 24 Culture, Education and Sport | 25481 | 0.08 | 0.04 | 0.81 | 0.93 |
| 25 Petroleum, Coking and Nuclear Fuel | 16827 | 0.05 | 0.03 | 0.87 | 0.96 |
| 26 Chemical and Products | 140435 | 0.07 | 0.04 | 0.86 | 0.97 |
| 27 Medicines | 40905 | 0.09 | 0.06 | 0.82 | 0.97 |
| 28 Chemical Fibers | 9779 | 0.06 | 0.03 | 0.92 | 1.01 |
| 29 Rubber | 23021 | 0.07 | 0.05 | 0.84 | 0.96 |
| 30 Plastics | 89596 | 0.08 | 0.05 | 0.83 | 0.96 |
| 31 Non-metallic Mineral | 165781 | 0.06 | 0.04 | 0.88 | 0.98 |
| 32 Ferrous Metals | 46040 | 0.06 | 0.03 | 0.91 | 1.00 |
| 33 Non-ferrous Metals | 34267 | 0.08 | 0.03 | 0.88 | 0.99 |
| 34 Metal Products | 103756 | 0.07 | 0.04 | 0.86 | 0.97 |
| 35 General Purpose Machinery | 146404 | 0.08 | 0.05 | 0.85 | 0.99 |
| 36 Special Purpose Machinery | 81070 | 0.09 | 0.07 | 0.85 | 1.01 |
| 37 Transport Equipment | 92192 | 0.11 | 0.07 | 0.84 | 1.03 |
| 39 Electrical Machinery | 114855 | 0.08 | 0.04 | 0.86 | 0.98 |
| 40 Communication and Computer | 64512 | 0.17 | 0.08 | 0.80 | 1.05 |
| 41 Measuring Instruments and products | 27326 | 0.12 | 0.04 | 0.81 | 0.97 |
| 42 Artwork and Other Manufacturing | 37422 | 0.08 | 0.03 | 0.84 | 0.95 |

Note: We use ASIF data instead of merged data to estimate the production function. The tobacco industry was dropped due to the lack of observations.

In line with 1, the chow test of the slope for Figure B1 is 99.62, which also suggests that the sensitivities of income with respect to output expansion for the high-markdown subsample and low-markdown subsample are statistically differ from each other.

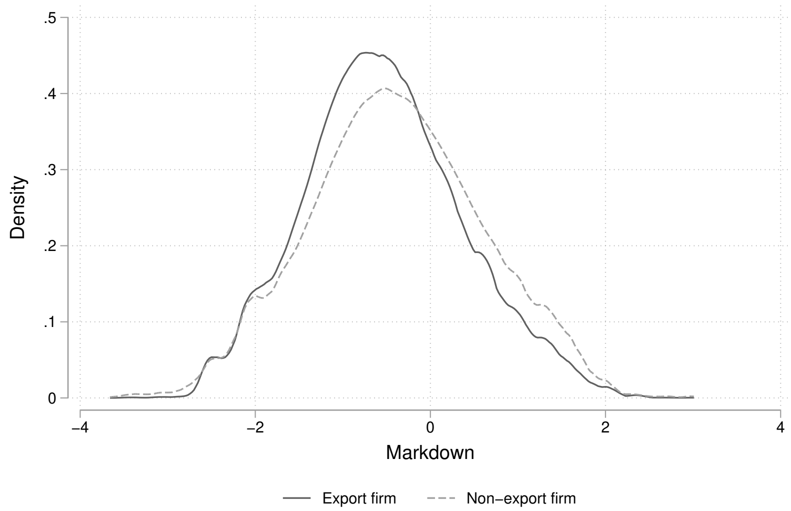
Figure B1: Relationship between Firms' Output and Average Income




Note: Merged data are used. The y-axis denotes the wage (in log), which is the residual obtained by regressing the average income (in log) on domestic output (in log), TFP (in log), firm fixed effects, and year fixed effects. TFP is obtained from production function estimation using Ackerberg et al. (2015). We divide the firms into 20 groups from lowest to highest in terms of output for the high-markdown subsample and the low-markdown subsample, respectively. The x-axis represents the output group number. Firms with markdowns above the CIC2 industry-year-level 75th percentile are designated as "High Markdown" and firms with markdown below the CIC2 industry-year-level 25th percentile are designated as "Low Markdown." The dashed line and triangle scatter refer to firms with monopsony power lower than the 25th percentile, while the solid line and square scatter refer to firms with monopsony power higher than the 75th percentile.

Figure B2 shows the distribution of markdowns for export firms and non-export firms. Clearly, the distribution of non-export firms' markdowns is to the right of the distribution of export firms' markdowns. In turn, this implies that firms with monopsony power in the labor market are more likely to be non-exporters.

Figure B2: Distributions of Markdowns for Exporters and Non-Exporters




Note: ASIF data are used. ASIF data provide information on firms' export value. However, there exist some reporting errors, such as firms' export value is zero in ASIF but positive in the Customs data. We use Customs data to correct this and generate an export dummy variable. The solid line refers to the markdown distribution for export firms, and the dashed refers to the markdown distribution for non-export firms.

To verify this rigorously, we analyze the impact of monopsony power on firms' export probability based on both a Linear Probability Model (LPM) and a Logit model according to the following specification:

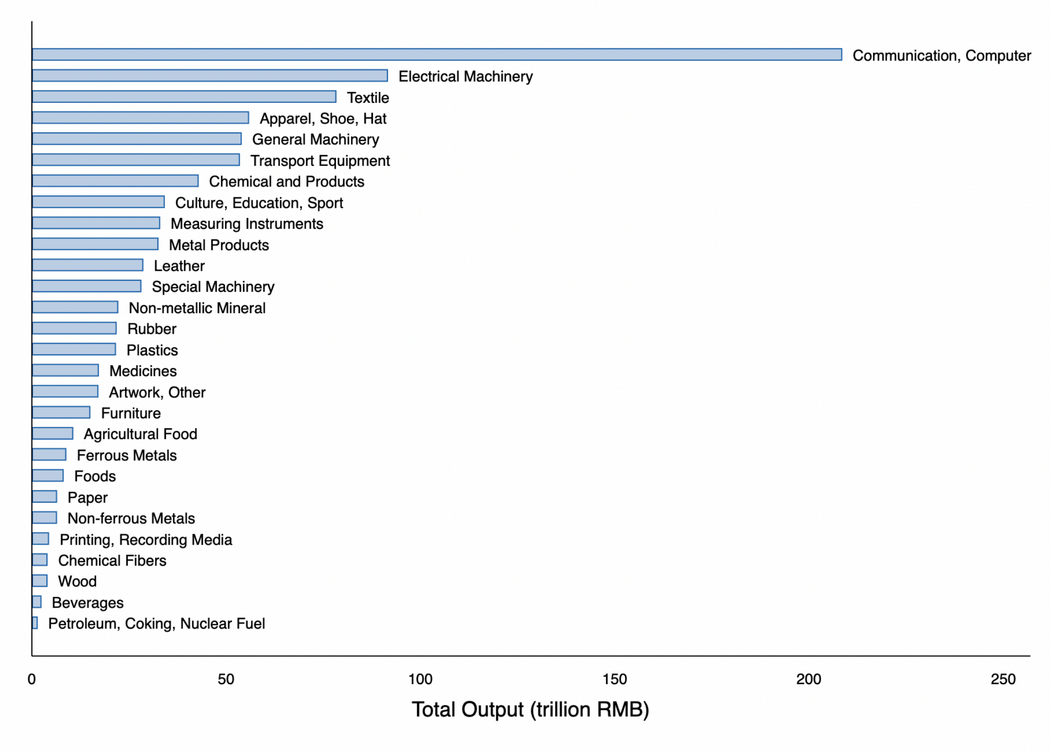
$$\text{Exp}_{ft} = ln(\text{markdown}_{ft}^{\text{ACF}}) + \boldsymbol{\eta}\mathbf{X_{ft}} + \lambda_t + \epsilon_{ft} \tag{B.1}$$

where $\text{EXP}_{ft}$ denotes firm $f$'s export status in year $t$, taking the value 1 if firm $f$ exports in year $t$ and 0 otherwise; $\mathbf{X}$ denotes the control variables, including firms' capital-labor ratio (in log), SOE indicator, FIE indicator, and total factor productivity (TFP) (in log); and $\lambda_t$ denotes year fixed effects.[40]

Table B2 shows the results, where the first two columns refer to the results obtained from LPM estimation, and the last two columns refer to the results obtained from Logit estimation. Apparently, the higher the monopsony power is in the labor market, the lower is firms' export probability.

[40] We do not control for firm fixed effects since the export status of the firm hardly changes over time.

Figure B3: Total Output by CIC 2-Digit Industry




Note: Merged data are used. The “Tobacco” and “Recycling and Disposal of Waste” industries were dropped due to lack of observations.

Table B2: Impact of Monopsony Power on Firms' Export Probability

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | LPM | | Logit | |
| | ASIF | ASIF (corrected) | ASIF | ASIF (corrected) |
| Dependent Variables | Export Dummy | | Export Dummy | |
| $\ln(\text{markdown}_{\text{ACF}})$ | -0.017*** | -0.017*** | -0.099*** | -0.085*** |
| | (0.001) | (0.001) | (0.003) | (0.003) |
| Observations | 1,648,200 | 1,648,078 | 1,648,200 | 1,648,078 |
| Adjusted $R^2$/Pseudo $R^2$ | 0.180 | 0.180 | 0.143 | 0.161 |

Note: Robust standard errors clustered at the firm level are in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively. The dependent variable is the firm-year-level export indicator, which takes the value 1 if the firm exports and 0 if the firm does not export. In columns (1) and (3), we use the ASIF data for identifying exporters and non-exporters. In columns (2) and (4), we use ASIF data corrected by Customs data. In each column, we control log(TFP), firm's capital-labor ratio (in log), and the SOE dummy, FIE dummy, and year fixed effects. TFP is obtained from production function estimation using Ackerberg et al. (2015).

Table B3: Robustness Check: Alternative Measurements of Quality and Markdown

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| | OP | LP | OLS | OLS FE | GNR |
| Dependent Variables | | | ln(Price) | | |
| ln(markdown) | 0.017*** | 0.014*** | 0.015*** | 0.016*** | 0.007*** |
| | (0.004) | (0.003) | (0.003) | (0.003) | (0.003) |
| Observations | 3,062,827 | 4,773,289 | 4,781,560 | 4,938,473 | 4,862,653 |
| Adjusted $R^2$ | 0.819 | 0.819 | 0.820 | 0.831 | 0.831 |

Note: Robust standard errors clustered at the firm level are in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively. The dependent variable is product unit price (in log) at the firm-destination country-HS 6-digit level. From columns (1) to (5), the dependent variable is markdown (in log) obtained from production function estimation using Olley & Pakes (1992), Levinsohn & Petrin (2003), OLS, OLS with fixed effects and Gandhi et al. (2020), respectively. The TFP estimations are the same, with the exception in column (5). In column (5), we use labor productivity instead, measured by value added per worker. In each column, we add firm control variables and confounding factors,product-destination country-year fixed effects and firm fixed effects.

Table B4: Robustness Check: Alternative Fixed Effect

| VARIABLES | (1)<br>ln(Quality$_{KSW}$) | (2)<br>ln(Quality$_{KSW}$) | (3)<br>ln(Quality$_{KSW}$) |
|---|---|---|---|
| ln(markdown$_{ACF}$) | 0.126*** | 0.213*** | 0.212*** |
| | (0.010) | (0.010) | (0.010) |
| Observations | 3,463,545 | 3,463,545 | 3,453,642 |
| Adjusted $R^2$ | 0.805 | 0.806 | 0.806 |

Note: Robust standard errors clustered at the firm level are in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.The dependent variable is firm-product-destination country-year-level export product quality. In column (1), we only use the log(markdown) as the explanatory variable. In column (2), we add firm-level covariates. In column (3), we further control the confounding factors. In each column, we add product-destination country-firm fixed effects and year fixed effects. TFP is obtained from production function estimation using Ackerberg et al. (2015).

Table B5: First-Stage Results of the IV Regression

| VARIABLES | (1)<br>Minimum wage<br>ln(markdown$_{ACF}$) | (2)<br>Migration<br>ln(markdown$_{ACF}$) |
|---|---|---|
| ln(minimumwage) | -0.224*** | |
| | (0.010) | |
| ln(netmigration$_{in}^{expected}$) | | -0.003*** |
| | | (0.001) |
| Observations | 3,102,277 | 296,950 |

Note: Robust standard errors clustered at the firm level are in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively. Merged data are used for the regression. The dependent variable is firm-product-destination country-year-level export product quality. In each (1), we control firm-level covariates, confounding factors, and product-destination country-year fixed effects. In column (2), product-destination country fixed effects and CIC 4-digit industry fixed effects are controlled instead. TFP is obtained from production function estimation using Ackerberg et al. (2015).

## Appendix C Increasing Marginal Cost: The Domestic Product Market and Export Product Market Are Correlated through the Domestic Labor Market

The cornerstone model of trade, Eaton & Kortum (2002) and Melitz (2003) both assume constant marginal production cost and perfect competition in the input market. Under this setup, firms' product markets across different destinations are independent. However, as aforementioned, firms compete with each other monopsonistically in the labor market, which results in an upward-sloping labor supply curve and increasing marginal labor cost. As a result, the export product market and domestic product market are no longer independent as they are in the traditional trade model; instead, they are correlated through the domestic labor market. Export expansion increases firms' domestic labor costs and has a negative impact on their domestic sales.

To verify this, following the method of Ahn & McQuoid (2017), we first examine the relationship between firms' domestic sales and export sales according to the following specification:

$$\begin{aligned} ln(y_{ft}^D) &= \delta_1 ln(y_{ft}^X) + \delta_2 ln(\varphi_{ft}) + \lambda_t + \lambda_f + \epsilon_{ft} \\ \Delta ln(y_{ft}^D) &= \delta_1 \Delta ln(y_{ft}^X) + \delta_2 \Delta ln(\varphi_{ft}) + \lambda_t + \lambda_f + \epsilon_{ft} \end{aligned} \tag{C.1}$$

where $y_{ft}^X$ and $y_{ft}^D$ indicate firm $f$'s export sales value and domestic sales value respectively. $\varphi_{ft}$ refers to firms' total factor productivity (TFP), obtained from production function estimation. $\Delta$ denotes the annual change between adjacent two years, i.e., $\Delta \mathrm{A}_t = \mathrm{A}_t - \mathrm{A}_{t-1}$. We also add firm fixed effects $\lambda_f$ and year fixed effects $\lambda_t$ to control for omitted variables. Standard errors are clustered at the firm level. The parameter of interest, $\delta_1$ is expected to be negative. Table C.1, columns (1) and (2) display the estimation results of equation (C.1). The results suggest that the domestic product market and export product market are not independent. Instead, there exists a negative relationship between them. Moreover, according to Ahn & McQuoid (2017), this also provides evidence of the existence of increasing marginal cost.

Next, we move a step further to examine the relationship between firms' domestic sales, export sales, and wage according to following specification:

$$ln(w_{ft}) = \eta_1 ln(y_{ft}^X) + \eta_2 ln(y_{ft}^D) + \eta_3 ln(\varphi_{ft}) + \lambda_t + \lambda_f + \epsilon_{ft} \tag{C.2}$$

where $w_{ft}$ denotes firm $f$'s average wage in year $t$. The parameters of interest, $\eta_1$ and $\eta_2$, are expected to be positive. Table C.1, columns (3) and (4) display the estimation results of equation (C.2).

Clearly, expansion in both the export product market and the domestic product market raises the average wage of firms, which indicates that these two markets are correlated through the domestic labor market. The results offer suggestive evidence of the increasing marginal labor cost of production at the firm level since the constant marginal labor production cost trade model, such as Melitz (2003) and Eaton & Kortum (2002), supports that output expansion has no effect on the domestic wage.

Table C.1: Interaction between Export and Domestic Product Markets through the Labor Market

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Dependent Variables | ln(domestic sales) | Δln(domestic sales) | ln(wage) | ln(income) |
| ln(export sales) | -0.055*** | | 0.016*** | 0.017*** |
| | (0.002) | | (0.001) | (0.001) |
| Δln(export sales) | | -0.092*** | | |
| | | (0.003) | | |
| ln(domestic sales) | | | 0.029*** | 0.030*** |
| | | | (0.001) | (0.001) |
| Observations | 227,158 | 135,582 | 227,158 | 227,158 |
| Adjusted $R^2$ | 0.852 | 0.243 | 0.732 | 0.758 |

Note: Robust standard errors clustered at the firm level are in parentheses. ***, **, and * denote significance at the 1%, 5%, 10% levels, respectively. Merged data are used for the regression. The dependent variable is at the firm level. In column (1), we use firm domestic sales (in log) as the dependent variable, the domestic sales equal firm total sales minus firm total exports. In column (2), we use the annual change in domestic sales (in log) as the dependent variable. In columns (3) and (4), we use wage per capita (in log) and income (wage plus insurance and housing subsidy) per capita as the dependent variables, respectively. In each column, we control for firm TFP (in log), firm fixed effects, and year fixed effects. TFP is obtained from production function estimation using Ackerberg et al. (2015). To save space, the regression results of the constant terms are not reported in this paper.

## Appendix D Derivation of the Profit Maximization Problem of Non-Exporting Firms

For a non-exporting firm, the gross profit is equals the following:

$$\pi = pq - \frac{w_L + w_M}{\varphi} q \tag{D.1}$$

where $p$ is the price of product $\omega$, $q$ is the quantity of product $\omega$, and $z$ is the quality of product $\omega$. Using equation (2), we solve the inverse demand function as $p = q^{-\frac{1}{\sigma}} z^{\frac{\sigma-1}{\sigma}} P^{\frac{\sigma-1}{\sigma}} E^{\frac{1}{\sigma}}$. According to equation (3) and (8), the labor wage $w_L$ is $\left(\frac{q}{\varphi}\right)^{\rho}$. Moreover, from equations (6) and (9), the price of composite intermediate inputs is $w_M = z^{\alpha}$. Thus, the profit maximization problem of a non-exporting firm is given by:

$$\max_{q,z} q^{\frac{\sigma-1}{\sigma}} z^{\frac{\sigma-1}{\sigma}} P^{\frac{\sigma-1}{\sigma}} E^{\frac{1}{\sigma}} - \left(\frac{q}{\varphi}\right)^{1+\rho} - \frac{q}{\varphi} z^{\alpha} \tag{D.2}$$

The first-order condition w.r.t. $q$ is given by:

$$\frac{\sigma-1}{\sigma} q^{-\frac{1}{\sigma}} z^{\frac{\sigma-1}{\sigma}} P^{\frac{\sigma-1}{\sigma}} E^{\frac{1}{\sigma}} = \frac{z^{\alpha}}{\varphi} + \frac{1+\rho}{\varphi}\left(\frac{q}{\varphi}\right)^{\rho} \tag{D.3}$$

The first-order condition w.r.t. $z$ is given by:

$$\frac{\sigma-1}{\sigma} q^{-\frac{1}{\sigma}} z^{\frac{\sigma-1}{\sigma}} P^{\frac{\sigma-1}{\sigma}} E^{\frac{1}{\sigma}} = \alpha \frac{z^{\alpha}}{\varphi} \tag{D.4}$$

Using equations (D.4) and (D.3), we derive the relationship between product quality and quantity as follows:

$$z = \left[\frac{1+\rho}{\alpha-1}\left(\frac{q}{\varphi}\right)^{\rho}\right]^{\frac{1}{\alpha}} \tag{D.5}$$

Substituting equation (D.5) into equation (D.4), we obtain that the optimal quality and quantity produced by a non-exporting firm are as follows:

$$z = \left[\left(\frac{\sigma-1}{\sigma\alpha}\right)^{\sigma} \varphi^{\sigma-1} P^{\sigma-1} E\right]^{\frac{\rho}{\beta\rho+\alpha}} \left(\frac{1+\rho}{\alpha-1}\right)^{\frac{1}{\beta\rho+\alpha}} \tag{D.6}$$

$$q = \left[\left(\frac{\sigma-1}{\sigma\alpha}\right)^{\sigma} \varphi^{\sigma-1} P^{\sigma-1} E\right]^{\frac{\alpha}{\beta\rho+\alpha}} \left(\frac{1+\rho}{\alpha-1}\right)^{-\frac{\beta}{\beta\rho+\alpha}} \varphi \tag{D.7}$$

where $\beta = \sigma\alpha - \sigma + 1 > 0$ for $\alpha > 1$ and $\sigma > 1$.

From equations (8) and (D.7), the amounts of labor and composite intermediate inputs used by a non-exporting firm are given by:

$$L = M = \left[ \left( \frac{\sigma - 1}{\sigma\alpha} \right)^{\sigma} \varphi^{\sigma-1} P^{\sigma-1} E \right]^{\frac{\alpha}{\beta\rho+\alpha}} \left( \frac{1+\rho}{\alpha-1} \right)^{-\frac{\beta}{\beta\rho+\alpha}} \tag{D.8}$$

According to the inverse labor supply function (3) and equation (D.8), the labor wage faced by a non-exporting firm is

$$w_L = \left[ \left( \frac{\sigma - 1}{\sigma\alpha} \right)^{\sigma} \varphi^{\sigma-1} P^{\sigma-1} E \right]^{\frac{\alpha\rho}{\beta\rho+\alpha}} \left( \frac{1+\rho}{\alpha-1} \right)^{-\frac{\beta\rho}{\beta\rho+\alpha}} \tag{D.9}$$

Moreover, from equations (6) and (D.6), we obtain that the price of composite intermediate inputs is:

$$w_M = \left[ \left( \frac{\sigma - 1}{\sigma\alpha} \right)^{\sigma} \varphi^{\sigma-1} P^{\sigma-1} E \right]^{\frac{\alpha\rho}{\beta\rho+\alpha}} \left( \frac{1+\rho}{\alpha-1} \right)^{\frac{\alpha}{\beta\rho+\alpha}} \tag{D.10}$$

Using equations (2), (D.3), (D.9), and (D.10), the domestic market price set by a non-exporting firm can be written as:

$$\begin{aligned} p &= \frac{\sigma}{\sigma-1} \frac{1}{\varphi} \Big[ (1+\rho) w_L + w_M \Big] \\ &= \frac{\sigma}{\sigma-1} \frac{\alpha}{\varphi} \left[ \left( \frac{\sigma - 1}{\sigma\alpha} \right)^{\sigma} \varphi^{\sigma-1} P^{\sigma-1} E \right]^{\frac{\alpha\rho}{\beta\rho+\alpha}} \left( \frac{1+\rho}{\alpha-1} \right)^{\frac{\alpha}{\beta\rho+\alpha}} \end{aligned} \tag{D.11}$$

Finally, the maximum gross profit of a non-exporting firm is given by:

$$\pi = \frac{\beta\rho+\alpha}{(\sigma-1)(1+\rho)} \left[ \left( \frac{\sigma - 1}{\sigma\alpha} \right)^{\sigma} \varphi^{\sigma-1} P^{\sigma-1} E \right]^{\frac{\alpha(1+\rho)}{\beta\rho+\alpha}} \left( \frac{1+\rho}{\alpha-1} \right)^{\frac{(\alpha-1)(1-\sigma)}{\beta\rho+\alpha}} \tag{D.12}$$

## Appendix E Derivation of the Profit Maximization Problem of Exporting Firms

The profit maximization problem of an exporting firm is

$$\max_{q_r, z_r, r\in\{d,x\}} \left\{ q_d^{\frac{\sigma-1}{\sigma}} z_d^{\frac{\sigma-1}{\sigma}} P^{\frac{\sigma-1}{\sigma}} E^{\frac{1}{\sigma}} - \frac{q_d}{\varphi}\left(\frac{q}{\varphi}\right)^{\rho} - \frac{q_d}{\varphi} z_d^{\alpha} \right. \\ \left. + q_x^{\frac{\sigma-1}{\sigma}} z_x^{\frac{\sigma-1}{\sigma}} P^{\frac{\sigma-1}{\sigma}} E^{\frac{1}{\sigma}} - \tau\frac{q_x}{\varphi}\left(\frac{q}{\varphi}\right)^{\rho} - \tau\frac{q_x}{\varphi} z_x^{\alpha} \right\} \tag{E.1}$$

where $q_r$ is the quantity of product $\omega$ sold in market $r$, $z_r$ is the product quality in market $r$, and $q = q_d + \tau q_x$, which is the total production of an exporting firm.

The first-order condition w.r.t. $q_d$ is given by:

$$\frac{\sigma-1}{\sigma} q_d^{-\frac{1}{\sigma}} z_d^{\frac{\sigma-1}{\sigma}} P^{\frac{\sigma-1}{\sigma}} E^{\frac{1}{\sigma}} = \frac{z_d^{\alpha}}{\varphi} + \frac{1+\rho}{\varphi}\left(\frac{q}{\varphi}\right)^{\rho} \tag{E.2}$$

The first-order condition w.r.t. $q_x$ is given by:

$$\frac{\sigma-1}{\sigma} q_x^{-\frac{1}{\sigma}} z_x^{\frac{\sigma-1}{\sigma}} P^{\frac{\sigma-1}{\sigma}} E^{\frac{1}{\sigma}} = \tau\frac{z_x^{\alpha}}{\varphi} + \tau\frac{1+\rho}{\varphi}\left(\frac{q}{\varphi}\right)^{\rho} \tag{E.3}$$

The first-order condition w.r.t. $z_d$ is given by:

$$\frac{\sigma-1}{\sigma} q_d^{-\frac{1}{\sigma}} z_d^{\frac{\sigma-1}{\sigma}} P^{\frac{\sigma-1}{\sigma}} E^{\frac{1}{\sigma}} = \alpha\frac{z_d^{\alpha}}{\varphi} \tag{E.4}$$

The first-order condition w.r.t. $z_x$ is given by:

$$\frac{\sigma-1}{\sigma} q_x^{-\frac{1}{\sigma}} z_x^{\frac{\sigma-1}{\sigma}} P^{\frac{\sigma-1}{\sigma}} E^{\frac{1}{\sigma}} = \tau\alpha\frac{z_x^{\alpha}}{\varphi} \tag{E.5}$$

Substituting equation (E.4) into equation (E.2), we obtain that the relationship between the optimal domestic quality $z_d$ and the total production $q$ is

$$z_d = \left[\frac{1+\rho}{\alpha-1}\left(\frac{q}{\varphi}\right)^{\rho}\right]^{\frac{1}{\alpha}} \tag{E.6}$$

Similarly, substituting equation (E.5) into equation (E.3), we obtain that the relationship between the optimal export quality $z_x$ and the total production $q$ is

$$z_x = \left[\frac{1+\rho}{\alpha-1}\left(\frac{q}{\varphi}\right)^{\rho}\right]^{\frac{1}{\alpha}} \tag{E.7}$$

Equations (E.6) and (E.7) imply that the optimal domestic and export qualities of an exporting firm are the same, that is

$$z_d = z_x \equiv z \tag{E.8}$$

Using equations (E.4), (E.5), and (E.8), we derive that the optimal quantity of units sold in each market should satisfy the following relationship:

$$q_d = \tau^{\sigma} q_x \tag{E.9}$$

Then, from equations (E.4), (E.6), (E.8), and (E.9), the optimal product quality and total quantity produced by an exporting firm are given by:

$$z = \left[ \left(1+\tau^{1-\sigma}\right) \left(\frac{\sigma-1}{\sigma\alpha}\right)^{\sigma} \varphi^{\sigma-1} P^{\sigma-1} E \right]^{\frac{\rho}{\beta\rho+\alpha}} \left(\frac{1+\rho}{\alpha-1}\right)^{\frac{1}{\beta\rho+\alpha}} \tag{E.10}$$

$$q = \left[ \left(1+\tau^{1-\sigma}\right) \left(\frac{\sigma-1}{\sigma\alpha}\right)^{\sigma} \varphi^{\sigma-1} P^{\sigma-1} E \right]^{\frac{\alpha}{\beta\rho+\alpha}} \left(\frac{1+\rho}{\alpha-1}\right)^{-\frac{\beta}{\beta\rho+\alpha}} \varphi \tag{E.11}$$

where $\beta = \sigma\alpha - \sigma + 1 > 0$ for $\alpha > 1$ and $\sigma > 1$. Hence, $q_d = \frac{1}{1+\tau^{1-\sigma}} q$ and $\tau q_x = \frac{\tau^{1-\sigma}}{1+\tau^{1-\sigma}} q$.

According to equations (8) and (E.11), the total amounts of labor and composite intermediate inputs used by an exporting firm are as follows:

$$L = \left[ \left(1+\tau^{1-\sigma}\right) \left(\frac{\sigma-1}{\sigma\alpha}\right)^{\sigma} \varphi^{\sigma-1} P^{\sigma-1} E \right]^{\frac{\alpha}{\beta\rho+\alpha}} \left(\frac{1+\rho}{\alpha-1}\right)^{-\frac{\beta}{\beta\rho+\alpha}} \tag{E.12}$$

Next, we explore the impact of labor monopsony power on firms' outputs and inputs. We take the derivatives of $\ln q$ and $\ln L$ with respect to $\rho$, which are given by:

$$\frac{\partial \ln q}{\partial \rho} = \frac{\partial \ln L}{\partial \rho} = -\left(\frac{\beta}{\beta\rho+\alpha}\right)\left(\ln L + \frac{1}{1+\rho}\right) < 0 \tag{E.13}$$

Equation (E.13) shows that firms having greater monopsony power hire fewer workers and produce lower quantities of outputs.

From the upward-sloping labor supply in (3) and equation (E.12), we obtain that the labor wage faced by an exporting firm is

$$w_L = \left[ \left(1+\tau^{1-\sigma}\right) \left(\frac{\sigma-1}{\sigma\alpha}\right)^{\sigma} \varphi^{\sigma-1} P^{\sigma-1} E \right]^{\frac{\alpha\rho}{\beta\rho+\alpha}} \left(\frac{1+\rho}{\alpha-1}\right)^{-\frac{\beta\rho}{\beta\rho+\alpha}} \tag{E.14}$$

Using equations (6), (9), and (E.10), the prices of composite intermediate inputs used by an exporting firm to produce for different markets are the same, given by:

$$w_M = \left[ \left(1+\tau^{1-\sigma}\right) \left(\frac{\sigma-1}{\sigma\alpha}\right)^{\sigma} \varphi^{\sigma-1} P^{\sigma-1} E \right]^{\frac{\alpha\rho}{\beta\rho+\alpha}} \left(\frac{1+\rho}{\alpha-1}\right)^{\frac{\alpha}{\beta\rho+\alpha}} \tag{E.15}$$

Moreover, combining equations (2), (E.2), (E.3), (E.14), and (E.15), the prices set by an exporting firm in different markets can be written as:

$$p_x = \tau p_d = \frac{\sigma}{\sigma-1} \frac{\tau}{\varphi} \left[ (1+\rho) w_L + w_M \right] \tag{E.16}$$

$$p_d = \frac{\sigma}{\sigma-1} \frac{\alpha}{\varphi} \left[ \left(1+\tau^{1-\sigma}\right) \left(\frac{\sigma-1}{\sigma\alpha}\right)^{\sigma} \varphi^{\sigma-1} P^{\sigma-1} E \right]^{\frac{\alpha\rho}{\beta\rho+\alpha}} \left(\frac{1+\rho}{\alpha-1}\right)^{\frac{\alpha}{\beta\rho+\alpha}} \tag{E.17}$$

Finally, the maximum total profit of an exporting firm is

$$\pi^T = \frac{\beta\rho+\alpha}{(\sigma-1)(1+\rho)} \left[ \left(1+\tau^{1-\sigma}\right) \left(\frac{\sigma-1}{\sigma\alpha}\right)^{\sigma} \varphi^{\sigma-1} P^{\sigma-1} E \right]^{\frac{\alpha(1+\rho)}{\beta\rho+\alpha}} \left(\frac{1+\rho}{\alpha-1}\right)^{\frac{(\alpha-1)(1-\sigma)}{\beta\rho+\alpha}} \tag{E.18}$$

## Appendix F Cost Minimization Problem and the Washington Apple Effect

Following Feenstra & Romalis (2014), we rearrange the profit maximization problem of an exporting firm in equation (11) as follows:

$$\begin{aligned} &\max_{q_r, z_r, r\in\{d,x\}} \sum_{r=d,x} \left[p_r - \tau_r \frac{w_L + w_M(z_r)}{\varphi}\right] q_r \\ \iff &\max_{Q_r, z_r, r\in\{d,x\}} \sum_{r=d,x} \left[P_r - \frac{w_L + w_M(z_r)}{\varphi z_r}\right] Q_r \end{aligned} \tag{F.1}$$

where $Q_r \equiv \tau_r q_r z_r$, which is the quality-adjusted output produced by the firm for market r, and $P_r \equiv p_r/(\tau_r z_r)$, which is the quality-adjusted, tariff-exclusive price. In the second line, we change the choice variables from $q_r$, $z_r$ to $Q_r$, $z_r$.

Thus, given the quality-adjusted output level $Q_r$, to maximize a firms' profit, we must first choose $z_r$ to minimize the average cost of quality, which is given by:

$$\min_{z_r, r\in\{d,x\}} \sum_{r=d,x} \left(\frac{w_L + w_M(z_r)}{z_r}\right) \frac{Q_r}{\varphi} \tag{F.2}$$

where the labor wage is $w_L = \left(\sum_r \frac{Q_r}{\varphi z_r}\right)^{\rho}$, and the cost of the composite intermediate inputs is $w_M(z_r) = z_r^{\alpha}$. Therefore, the optimal quality should balance between the two costs.

First, the labor wage depends on the amount of labor hired by the firm. Given the quality-adjusted output level $Q_r$, the labor wage is decreasing in $z_r$, because the better the quality of the output is, the less quantity that needs to be produced using labor. Second, the average cost of intermediate inputs per unit of quality equals $z_r^{\alpha-1}$, which is increasing in $z_r$ as $\alpha > 1$. Solving the first order condition with respect to $z_r$, we can obtain that the optimal quality is

$$z_r = \left(\frac{\Psi w_L}{\alpha - 1}\right)^{\frac{1}{\alpha}}, \quad r = d, x \tag{F.3}$$

where the product of markdown $\Psi$ and labor wage $w_L$ is the firms' marginal cost of labor. In equilibrium, the marginal cost of labor is increasing in the firm's markdown. It is immediate that when $\Psi$ is high, $z_r$ is also high, because the high labor costs due to greater monopsony power induce a firm to avoid using too much labor to produce the quantity of outputs, but rather to embed more quality into the per quantity unit. The effect of the monopsony power on the product quality is similar to that of specific trade costs, the so-called Washington apple effect.

## Appendix G Measurement of Markdown

Solving a non-exporting firm's profit maximization problem yields the following first-order condition w.r.t. $q$:

$$\frac{\sigma-1}{\sigma} q^{-\frac{1}{\sigma}} z^{\frac{\sigma-1}{\sigma}} P^{\frac{\sigma-1}{\sigma}} E^{\frac{1}{\sigma}} = \frac{1+\rho}{\varphi}\left(\frac{q}{\varphi}\right)^{\rho} + \frac{1}{\varphi} z^{\alpha} \tag{G.1}$$

Substituting equations (2), (3), (6), and (8) into equation (G.1), we rewrite the first-order condition as:

$$\frac{\sigma-1}{\sigma} p = \frac{w_L L(1+\rho) + w_M M}{q} \tag{G.2}$$

where the left-hand side is the firms' marginal revenue from selling one additional unit of final goods, and the right-hand side is the marginal cost producing the final goods.

From equation (G.2), we obtain the markdown expression as follows:

$$\Psi = 1 + \rho = \frac{1/\mu - \alpha_M}{\alpha_L} \tag{G.3}$$

where $\alpha_M \equiv \frac{w_L L}{pq}$ and $\alpha_L \equiv \frac{w_M M}{pq}$ denote the revenue shares of labor and intermediate inputs, respectively, and $\mu \equiv \frac{\sigma}{\sigma-1}$ denotes a firm's markup. Following De Loecker & Warzynski (2012), we use price-taking intermediate inputs to solve for the markup expression, which is given by:

$$\mu = \mu_M^{DLW} = \frac{\theta_M}{\alpha_M} \tag{G.4}$$

where $\theta_M$ denotes the output elasticity with respect to intermediate inputs.

Due to the property of constant returns to scale in the Leontief production function, the sum of the output elasticities of all inputs is exactly one, by definition; that is:

$$\theta_L + \theta_M = 1 \tag{G.5}$$

Substituting equations (G.4) and (G.5) into equation (G.3), we can rewrite the measurement formula of a firm's markdown as:

$$\Psi = \frac{\theta_L/\alpha_L}{\theta_M/\alpha_M} = \frac{\mu_L^{DLW}}{\mu_M^{DLW}} \tag{G.6}$$

Equation (G.6) shows that we can use the approach given by Brooks et al. (2021b) to estimate a firm's monopsony power in the labor market.

## Appendix H Production Function Combining Leontief and Cobb-Douglas Technology

Following Artuc et al. (2022), we assume that firms produce final goods by using three factors: labor, capital, and intermediate inputs. The production function is a Leontief combination of intermediate inputs with a Cobb-Douglas aggregation of labor and capital, given by:

$$q = \varphi \; min \left\{ \frac{L^{\alpha_L} K^{\alpha_K}}{\alpha_L^{\alpha_L} \alpha_K^{\alpha_K}}, M \right\} \tag{H.1}$$

where $q$ is the quantity of final goods, $\varphi$ is firm productivity, $L$ is the amount of labor, $K$ is the capital stock, and $M$ is the amount of intermediate inputs. The parameters $\alpha_L$ and $\alpha_K$ are the Cobb-Douglas output elasticities, satisfying $\alpha_L + \alpha_K = 1$. The intuition behind the functional form is that there are substitutions between labor and capital, whereas intermediate inputs transform into final goods in a fixed proportion and cannot be substituted for labor or capital.

Thus, the intermediate inputs requirement is given by:

$$M(q) = \frac{q}{\varphi} \tag{H.2}$$

The labor and capital requirements are given by:

$$L(q) = \alpha_L \left[ \frac{w_K}{(1+\rho) w_L} \right]^{\alpha_K} \frac{q}{\varphi} \tag{H.3}$$

$$K(q) = \alpha_K \left[ \frac{(1+\rho) w_L}{w_K} \right]^{\alpha_L} \frac{q}{\varphi} \tag{H.4}$$

where $w_K$ is the price of capital. We assume that the capital market is perfectly competitive, so $w_K$ is a constant for all firms. $w_L$ is the wage of labor paid by the firm, which is increasing with the quantity of final goods. Combining equations (3) and (H.3), we have

$$w_L(q) = \left[ \frac{\alpha_L q}{\varphi} \left( \frac{w_K}{1+\rho} \right)^{\alpha_K} \right]^{\frac{\rho}{1+\rho\alpha_K}} \tag{H.5}$$

Moreover, the quality of final goods depends on the quality of the composite intermediate inputs used in production, given by:

$$z = z_M \tag{H.6}$$

Therefore, the average production cost of $q$ units of final goods with quality $z$ is given by:

$$\bar{c}(q, z) = \frac{\Lambda w_L(q)^{\alpha_L} w_K^{\alpha_K} + w_M(z)}{\varphi} \tag{H.7}$$

where $\Lambda = (1+\rho)^{\alpha_L}(\frac{\alpha_L}{1+\rho} + \alpha_K)$, and $w_M(z)$ is the price of composite intermediate inputs, which equals $z^{\alpha}$ according to equations (6) and (H.6).

For an exporting firm, the total profit equals:

$$\pi^T = \left[p_d - \bar{c}(q, z_d)\right] q_d + \left[p_x - \tau \bar{c}(q, z_x)\right] q_x \tag{H.8}$$

where $p_r$ is the price of product $\omega$ sold in market $r \in \{d, x\}$, $q_r$ is the quantity of product $\omega$ sold in market $r$, and $z_r$ is the product quality chosen by the firm in market $r$. Using equation (2), we solve the inverse demand function as $p_r = q_r^{-\frac{1}{\sigma}} z_r^{\frac{\sigma-1}{\sigma}} P^{\frac{\sigma-1}{\sigma}} E^{\frac{1}{\sigma}}$. Due to the iceberg trade cost $\tau$, the exporting firms' total output is $q = q_d + \tau q_x$. Together with equations (H.3), (H.5), and (H.7), the optimal total employment of an exporting firm is given by:

$$L = \left[\alpha_L \left(\frac{w_K}{1+\rho}\right)^{\alpha_K} \left(\varphi^{\sigma-1} A\right)^{\frac{\alpha}{\beta S+\alpha}} \left(\frac{TR}{\alpha-1}\right)^{-\frac{\beta}{\beta S+\alpha}}\right]^{\frac{1}{1+\rho\alpha_K}} \tag{H.9}$$

where $A \equiv (1+\tau^{1-\sigma})\left(\frac{\sigma-1}{\sigma\alpha}\right)^{\sigma} P^{\sigma-1} E > 0$, $\beta \equiv \sigma\alpha - \sigma + 1 > 0$, $S \equiv \frac{\rho\alpha_L}{1+\rho\alpha_K} > 0$, $R \equiv \frac{1+\rho}{1+\rho\alpha_K} > 0$, and $T \equiv \alpha_L^S w_K^{R\alpha_K} (1+\rho)^{\frac{\alpha_L}{1+\rho\alpha_K}} (\frac{\alpha_L}{1+\rho} + \alpha_K) > 0$, as $\sigma > 1$ and $\alpha > 1$.

In equilibrium, the domestic quality and export quality chosen by an exporting firm are the same, that is, $z_d = z_x$. For convenience, we omit the subscript and denote the optimal quality of an exporting firm by $z$, which is given by:

$$z = \left(\varphi^{\sigma-1} A\right)^{\frac{S}{\beta S+\alpha}} \left(\frac{TR}{\alpha-1}\right)^{\frac{1}{\beta S+\alpha}} \tag{H.10}$$

Next, we explore the impact of labor monopsony power on firms' product quality. The derivative of $\ln z$ with respect to $\rho$ is given by:

$$\frac{\partial \ln z}{\partial \rho} = \frac{\alpha_L}{(\beta S+\alpha)(1+\rho\alpha_K)} \left(\ln L + \frac{1}{1+\rho}\right) > 0 \tag{H.11}$$

with $\ln L > 0$ by assumption. Equation (H.11) shows that firms' product quality $z$ is increasing in the firms' monopsony power, and thus the main conclusion of this paper remains unchanged under the alternative production function combining Leontief and Cobb-Douglas technology.