Superstars or Supervillains? Large Firms in the South Korean Growth Miracle*

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Abstract

We quantify the contribution of the largest firms to South Korea's economic performance since 1970. Using firm-level historical data, we document a novel fact: firm concentration rose substantially during the growth miracle period. To understand whether the increased importance of large firms contributed positively or negatively to the South Korean growth miracle, we build a quantitative heterogeneous firm small open economy model. Our framework accommodates a variety of causes and consequences of (changes in) firm concentration: productivity, distortions, selection into exporting, and oligopolistic and oligopsonistic market power in domestic goods and labor markets. The model is implemented directly on the firm-level data and inverted to recover the drivers of changing concentration. We find that most of the increased concentration is attributable to higher productivity growth of the largest firms. Shutting down differential productivity growth of the top 3 firms within each sector would have decreased firm concentration, but nonetheless would have reduced welfare by 2%. Differential distortions and foreign market access of the largest firms played a more limited role in the trends in concentration and had a smaller welfare impact. Thus, the largest Korean firms were superstars rather than supervillains.

Keywords: large firms, market power, productivity, misallocation, growth miracle
JEL Codes: L11, N15, O40

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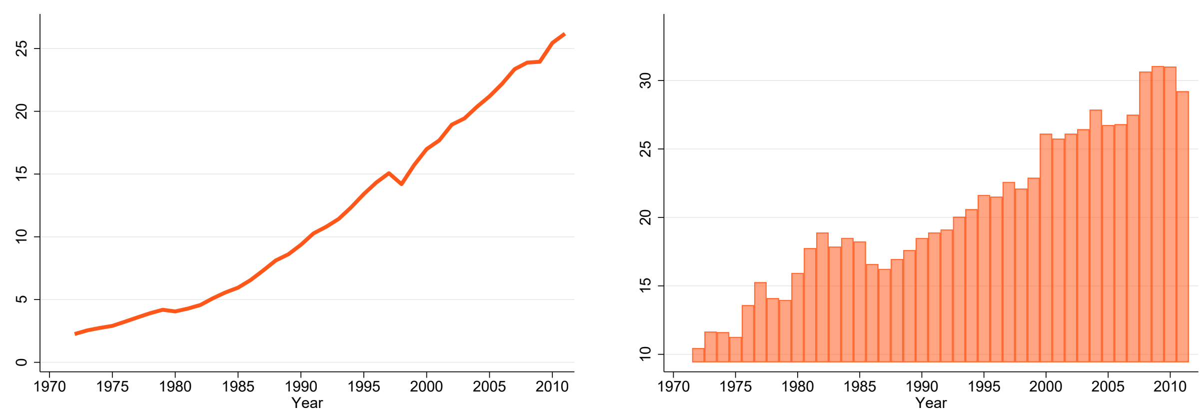
1 Introduction

The rise of "superstar" firms and increased firm concentration have attracted a great deal of recent attention (e.g. Covarrubias et al., 2020; De Loecker et al., 2020; Autor et al., 2020). These trends have been viewed mostly in a negative light, and blamed for rising markups/downs and falling labor share. However, whether concentration is bad for economic performance depends on both the underlying causes and consequences of increased concentration. For example, changes in concentration could be driven by productivity growth differentials, changes in distortions, or selection of large firms into exporting. Markups and markdowns would correspondingly be affected by these trends. All of these forces are not mutually exclusive, and disentangling the drivers of firm concentration is important for understanding how large firms contribute to economic performance.

Figure 1. Real GDP Per Capita and Firm Concentration of South Korea



A. Real GDP per capita (thousands 2010 USD) B. Mfg. Concentration Ratio of the Top 3 (%)

Notes. Panel A illustrates real GDP per capita in thousands 2010 US dollars. Panel B plots the sales shares of the top 3 firms in each manufacturing sector in the total manufacturing gross output.

This paper studies the role of large firms in the economic performance of South Korea between the 1970s and the 2010s. This setting is of particular interest for 2 reasons. On the one hand, this is the growth miracle period (Lucas, 1993). The left panel of Figure 1 documents the well-known rapid growth in South Korean real per capita GDP. Between 1972 and 2011, the real GDP per capita increased nearly 12-fold (the average real GDP per capita growth was a staggering 6.5% per annum). On the other hand, South Korea is famous for the presence of very large firms. While this fact is familiar in levels (see, e.g. di Giovanni and Levchenko, 2012), the right panel of Figure 1 documents the changes in firm concentration over this period. It plots the share of the top 3 firms in each manufacturing sector in total manufacturing gross output. The top-3 share increased from 10.1% to 28.5% between the 1970s and the 2010s.[1] This long-run trend in the South Korean firm concentration has not to our knowledge been previously documented in the literature. Thus, superficially at least, it appears that the rising concentration had not stopped the growth miracle. However, to fully understand the role of concentration in South Korea's macroeconomy, we must quantify the forces that produced this trend.

Our analysis combines a novel panel firm-level dataset spanning 40 years, 1972-2011, with a general equilibrium multi-sector heterogeneous firm small open economy framework. In the model, the firm size distribution is jointly determined by (i) heterogeneous productivity á la Melitz (2003); (ii) heterogeneous idiosyncratic labor and capital distortions á la Hsieh and Klenow (2009); (iii) selection into exporting á la Melitz (2003); (iv) oligopoly in domestic goods markets á la Atkeson and Burstein (2008); and (v) oligopsony labor markets á la Berger et al. (2022). Thus, our framework simultaneously allows for firm market power in both goods and labor markets, distortions, and heterogeneous trade at the firm level. Productivity, market power, distortions, and differential exporting interact with each other and shape firm concentration.

Our theoretical contributions are threefold. First, we derive a system of equations that tightly maps unobservable firm primitives to observable firm market shares in the data. This result allows us to recover the key potential structural determinants of firm concentration – productivity, distortions, and export market access – from data. Second, we provide aggregation results that map micro-level productivities, distortions, and foreign market access into sector-level production functions, TFPs, and markups. These aggregation results generalize existing ones in the literature to our richer setting. Third, we develop a decomposition of the top-3 concentration ratio into the components capturing differential top-3 firms' productivity, foreign market access, entry and exit into the top 3, and sectoral reallocation. This decomposition is quantifiable, and can be used to shed light on the underlying drivers of increased concentration in the data.

Our quantitative contribution is to provide a joint account of the micro (changing concentration) and the macro (long-run economic performance) in South Korea. Importantly, our model is implemented directly on firm-level data, so that actual firms in South Korea correspond to firms in the model. We invert the model to recover firm-level productivity, distortions, and foreign demand from data on domestic sales shares, employment shares, capital shares, and export shares. This information is commonly observed in firm-level data sets. We disentangle the contributions of each of these factors to South Korean concentration and economic growth over this period.

Our results can be summarized as follows. The top-3 firms experienced substantially higher TFP growth over this period. While these firms were about 2.4 times more productive than other firms in the 1970s, they are about 8.5 times more productive in the 2000s. They also experienced a faster increase in foreign demand, whereas the relative labor and capital distortions fluctuated widely over

[1] In the quantification below, it will be convenient to work with the sectoral top-3 firms concentration measure. The increase in concentration is equally evident when using other concentration indices, such as the top 10 firms economywide or the Herfindahl index.

this period but exhibited no long-run trend. When it comes to the underlying drivers of concentration, about 60% of the total is driven by sectoral reallocation – sectors with larger firms growing overall faster than sectors with smaller firms. The remaining 40% is driven by within-sector increases in the top-3 firm shares. Of that, about half is due to the churning of the set of the top-3 firms, indicating quite a bit of dynamism at the top of the firm size distribution over this period.

Thus, it seems that productivity and market access trends are chiefly responsible for the rise in firm concentration, suggesting that the takeoff of the large firms was welfare-improving. To assess the strength of the individual underlying forces, we perform counterfactuals in which we instead endow the top-3 firms with the average within-sector change in productivity, distortions, and market access. These counterfactuals answer the question of what South Korean GDP and welfare would have been had the top-3 Korean firms' productivity/market access/distortions grown at the same rate as the rest of the firms in their sector. Had the top-3 firms not enjoyed a productivity growth advantage, the top-3 concentration ratio would have only increased half as much as it did in the data. But, measured real GDP would have been 10.7% lower by 2010, and the present discounted welfare would have been 2.3% lower. This is in spite of the fact that higher concentration leads to higher markups and markdowns. Indeed, notwithstanding the measured increase in concentration, changes in aggregate markups and wage markdowns has been quite modest in our calibration, and barely change in the counterfactuals. Differential foreign market access and distortions had a more modest welfare impact.

To illustrate these findings further, we examine the contributions of individual firms to the long-term aggregate growth. We focus on South Korea's two largest firms, Samsung Electronics and Hyundai Motors. We find that had Samsung Electronics and Hyundai Motors' productivity evolved at the same rate of the rest of the firms', the top 3 concentration ratio in 2011 would have been 3.2 and 1.3 percentage points lower, respectively, and real 2011 GDP would have been 4.1% and 0.1% lower. The corresponding welfare losses are 0.6% and 0.3% for Samsung and Hyundai, respectively. These counterfactual results indicate that even one large firm can exert a noticeable influence on the aggregate long-run outcomes.

We examine the welfare effects of oligopolistic and oligopsonistic market structures by comparing our baseline with counterfactuals featuring alternative market structures. Specifically, we consider their constant-markup counterparts while maintaining the same firm-level shocks. We find modest welfare gains (0.97%) when removing oligopolistic (goods market) power, whereas the welfare effects of removing oligopsonistic (wage setting) market power were negligible.

Related literature This paper contributes to several strands of the literature. The first is the work on large firms and their role in the macroeconomy (see among many others, Atkeson and Burstein, 2008; Eaton et al., 2012; Amiti et al., 2014; Freund and Pierola, 2015; Amiti et al., 2019; Edmond et al., 2015; Carvalho and Grassi, 2019; Autor et al., 2020; Covarrubias et al., 2020; De Loecker et al., 2020; Burstein et al., 2021; Gaubert and Itskhoki, 2021; Kehrig and Vincent, 2021; Rossi-Hansberg et al., 2021; Berger et al., 2022; Deb et al., 2022a,b; Edmond et al., 2023; Yeh et al., 2022; Akcigit and

Ates, 2023; Alviarez et al., 2023; Eslava et al., 2023; Felix, 2023; Hsieh and Rossi-Hansberg, 2023; Kwon et al., 2023). Several of these papers study the causes and consequences of rising concentration. While most research in this area has focused on the US and developed countries, we turn attention to a relatively underexplored setting: South Korea's growth miracle. Lee and Shin (2023) document a number of stylized facts about average plant size, misallocation, and business dynamism in South Korea over this period. We provide a full-fledged model-based quantification of the sources of rising firm concentration and its consequences for real GDP and welfare.

Second, we contribute to the literature on the aggregate implications of microeconomic shocks (see among many others, Gabaix, 2011; Acemoglu et al., 2012; di Giovanni and Levchenko, 2012; di Giovanni et al., 2014; Carvalho and Gabaix, 2013; Atalay, 2017; Grassi, 2017; di Giovanni et al., 2018; Cravino and Levchenko, 2017; Huneeus, 2018; Baqaee, 2018; Baqaee and Farhi, 2019b, 2020; Bui et al., 2022; Bonadio et al., 2023; Huo et al., 2023b; di Giovanni et al., 2024). Most of the previous work has focused on the impact of individual firms on macroeconomic volatility and shock transmission. By contrast, we turn attention to the role of individual firms in long-run growth.

Third, we apply the insights of the literature on large firms to growth accounting, and in particular on the Asian growth experience (see among many others, Solow, 1956; Domar, 1961; Hulten, 1978; Lucas, 1988; Young, 1995; Mankiw et al., 1992; Klenow and Rodríguez-Clare, 1997; Barro, 1999; Hsieh, 2002; Gourinchas and Jeanne, 2013; Fernald and Neiman, 2011; Ohanian et al., 2018; Baqaee and Farhi, 2019a; Baqaee et al., 2023). The growth accounting literature has not widely used firm-level data to quantitatively assess the importance of individual firms in aggregate growth. Methodologically, we contribute to this line of research by breaking down aggregate economic growth into components associated with changes in factor inputs, productivity, distortions, and market power at the firm level.

The rest of this paper is organized as follows. Section 2 builds the quantitative framework. Section 3 discusses the calibration strategy and the data. Section 4 presents the quantitative results. Section 5 concludes.

2 Quantitative Framework

This section presents a heterogeneous-firm small-open-economy model and states three propositions that shape our quantification. The first proposition maps the model primitives to firm-level shocks, the second details how we aggregate firm-level shocks to speak to growth and real income, and the third provides a model-based decomposition of changes in concentration.

2.1 Setup

Environment The world is divided into Home and Foreign, corresponding to South Korea and the rest of the world. Home is a small open economy that takes the world demands and prices as exogenously given. There is a continuum of sectors, indexed by $i, j \in [0, 1]$. In manufacturing sectors $\mathcal{J}^{\mathrm{M}} \subset [0, 1]$, there is a finite number of heterogeneous firms and one fringe firm, indexed by $f \in \mathcal{F}_j = \{1, \ldots, F_j - 1, \tilde{f}\}$ where $\mathcal{F}_j$ is the set of sector j firms and $\tilde{f}$ denotes the fringe firm.

F_j denotes the number of firms in sector j ($F_j = |\mathcal{F}_j|$). Heterogeneous firms have oligopolistic and oligopsonistic market power in domestic goods and labor markets, but fringe firms do not have market power.[2] In the remaining commodity and service sectors $\mathcal{J}_{\text{NM}} = [0,1]/\mathcal{J}_{\text{M}}$, there are only fringe firms. Firm entry and export status are exogenous, with $\mathcal{F}_j^x \subset \mathcal{F}_j$ denoting the set of sector j exporters. In describing the within-period equilibrium, we omit time subscripts in order to de-clutter notation.

Households A representative household supplies labor, and owns the country's capital stock and all the firms. It maximizes a GHH objective (Greenwood et al., 1988):

$$\begin{aligned}
&\max_{\{C,L\}} U\left(C - \bar{\psi}\frac{L^{1+\frac{1}{\psi}}}{1+\frac{1}{\psi}}\right)\\
&s.t.\\
&PC = WL + \varrho K + \Pi + T,
\end{aligned}$$

where C is consumption whose price is P, L is composite labor earning the wage index W, K and ϱ are the capital stock and the price of capital, Π is aggregate profits, and T is the lump sum transfer from the government.

The household provides differentiated workers to firms and sectors, with the composite labor L taking a constant-elasticity-of-substitution (CES) form with two nests (Berger et al., 2022):

$$L = \left(\int_0^1 L_j^{\frac{\theta+1}{\theta}} \mathrm{d}j\right)^{\frac{\theta}{\theta+1}}, \qquad L_j = \left(F_j^{\frac{1}{\eta}} \sum_{f\in\mathcal{F}_j} l_{fj}^{\frac{\eta+1}{\eta}}\right)^{\frac{\eta}{\eta+1}},$$

where L_j is sectoral employment and l_{fj} is employment in firm f. This formulation allows for imperfect substitution of workers both within and across sectors, with the elasticities of substitution η and θ subsequently shaping firms' labor market power. Guided by existing evidence, we assume that jobs within sectors are more substitutable than jobs across sectors, $\eta > \theta$. The wage index W_j is normalized by the number of firms to neutralize the love-of-variety effects:

$$W = \left(\int_0^1 W_j^{1+\theta} \mathrm{d}j\right)^{\frac{1}{1+\theta}} \qquad \text{and} \qquad W_j = \left(\frac{1}{F_j} \sum_{f\in\mathcal{F}_j} w_{fj}^{1+\eta}\right)^{\frac{1}{1+\eta}},$$

where w_{fj} is wage paid by firm f. Aggregate labor supply is given by

$$L = \left(\frac{1}{\bar{\psi}}\frac{W}{P}\right)^{\psi}. \tag{2.1}$$

[2] Fringe firms can be interpreted as a continuum of atomistic homogeneous firms, whose mass is normalized to one.

Sectors Using a CES technology, an aggregating firm within each sector j combines the output of individual firms into a sectoral Home good Y_j^H that is sold at price P_j^H:

$$Y_j^H = \Big[F_j^{-\frac{1}{\sigma_j}} \sum_{f\in\mathcal{F}_j} (y_{fj}^d)^{\frac{\sigma_j-1}{\sigma_j}}\Big]^{\frac{\sigma_j}{\sigma_j-1}} \quad \text{and} \quad P_j^H = \Big[\frac{1}{F_j} \sum_{f\in\mathcal{F}_j} (p_{fj}^d)^{1-\sigma_j}\Big]^{\frac{1}{1-\sigma_j}},$$

where y_{fj}^d is the quantity of firm f output demanded in domestic markets, p_{fj}^d is firm's domestic price, and σ_j is the elasticity of substitution across firms within a sector. Note that the Home sector j output is also normalized by the number of firms to neutralize the love-for-variety effects.

Each Home sector faces competition from abroad so that Y_j, the final output of sector j, is a CES amalgam of the Home and Foreign sector j outputs and is sold at price P_j:

$$Y_j = \Big[(Y_j^H)^{\frac{\rho_j-1}{\rho_j}} + (Y_j^F)^{\frac{\rho_j-1}{\rho_j}}\Big]^{\frac{\rho_j}{\rho_j-1}} \quad \text{and} \quad P_j = \Big[(P_j^H)^{1-\rho_j} + (P_j^F)^{1-\rho_j}\Big]^{\frac{1}{1-\rho_j}},$$

where Y_j^F is the quantity of Foreign sector j output demanded by Home, P_j^F is the Foreign sector j price that Home takes as exogenous, and ρ_j is the elasticity of substitution between Home and Foreign sectoral outputs. The share of imports to total sector j expenditure is $\lambda_j^F = (P_j^F/P_j)^{1-\rho_j}$. The share of expenditures on domestic goods is correspondingly $\lambda_j^H = 1 - \lambda_j^F$.

Sectoral output has two uses: consumption for households and intermediate inputs for firms. Both the final consumption and the intermediate input markets are perfectly competitive. The producers in those markets use constant-returns-to-scale Cobb-Douglas technologies to produce C at price P:

$$C = \exp\Big(\int_0^1 \alpha_j \ln Y_j^C \mathrm{d}j\Big) \quad \text{and} \quad P = \exp\Big(\int_0^1 \alpha_j \ln P_j \mathrm{d}j\Big) \text{ where } \int_0^1 \alpha_j \mathrm{d}j = 1,$$

and to produce intermediate inputs M_i for use in sector i at price P_i^M:

$$M_i = \exp\Big(\int_0^1 \gamma_j^i \ln Y_j^{i,M} \mathrm{d}j\Big) \quad \text{and} \quad P_i^M = \exp\Big(\int_0^1 \gamma_j^i \ln P_j \mathrm{d}j\Big) \text{ where } \int_0^1 \gamma_j^i \mathrm{d}j = 1, \quad \forall i \in [0,1].$$

Parameters α_i and γ_j^i are the Cobb-Douglas cost shares, and Y_j^C and $Y_j^{i,M}$ are sectoral outputs demanded, respectively, by final consumption and for intermediate use in sector i.

Firms Firms face downward-sloping CES demand:

$$y_{fj}^d = \frac{1}{F_j}(p_{fj}^d)^{-\sigma_j}(P_j^H)^{\sigma_j-\rho_j}P_j^{\rho_j-1}E_j, \qquad y_{fj}^x = (p_{fj}^x)^{-\sigma_j}D_{fj}^x, \tag{2.2}$$

where y_{fj}^d is domestic demand, E_j is total domestic expenditure on sector j goods, and y_{fj}^x is export demand. Firms are potentially oligopolistic in the domestic goods market: they internalize the impact of their own price p_{fj}^d on P_j^H and P_j, but take E_j as given. In the foreign market, we assume firms are infinitesimally small and are monopolistically competitive. The firm charges price p^x_{fj} and faces a firm-specific exogenous foreign demand shifter D^x_{fj}, inclusive of any iceberg trade costs. For non-exporters, $D^x_{fj} = 0$. Firms allocate their output to domestic and foreign markets subject to the following resource constraint:

$$y_{fj} = y^d_{fj} + y^x_{fj}. \tag{2.3}$$

With CES structure for the household's allocation of labor, each firm faces an upward-sloping labor supply curve, potentially allowing the firm to exercise two forms of labor market power:

$$l_{fj} = \frac{1}{F_j} w^{\eta}_{fj} W_j^{\theta-\eta} W^{-\theta} L. \tag{2.4}$$

By internalizing how its labor demand affects the wage w_{fj}, a firm can exercise monopsonistically competitive power. Additionally, by internalizing how its labor demand affects the sectoral wage W_j, a firm can exercise oligopsony power. All firms take the aggregate wage index W as given.

Firms maximize their profits

$$\pi_{fj} = \max_{\{y^d_{fj}, y^x_{fj}, l_{fj}, k_{fj}, m_{fj}\}} \Big\{ p^d_{fj} y^d_{fj} + p^x_{fj} y^x_{fj} - (1+\tau^L_{fj}) w_{fj} l_{fj} - (1+\tau^K_{fj}) \varrho k_{fj} - P^M_j m_{fj} \Big\}, \tag{2.5}$$

subject to the resource constraint (2.3) and demand and labor supply functions (2.2) and (2.4). In hiring labor and capital firms potentially face exogenous distortions, τ^L_{fj} and τ^K_{fj}, which are interpreted as taxes or subsidies to labor and capital inputs. ϱ is rental rate of capital common across all firms.

The domestic goods and labor market structure is Cournot. Firms set their quantities to maximize their own profits, taking as given foreign quantity supplied Y^F_j, and the vectors of domestic quantities supplied $\mathbf{y}^d_{-fj}$, and of labor employed $\mathbf{l}_{-fj}$, by all the other firms in the sector.

Since firms can exercise market power in both domestic product and labor markets, they face endogenous, firm-specific elasticities of demand ϵ_{fj} and of labor supply ϵ^L_{fj}. These elasticities help the firm balance marginal revenue against the marginal cost of hiring labor, as reflected in the first-order conditions with respect to l_{fj}, y^d_{fj}, and y^x_{fj}:

$$p^d_{fj}\Big(1 - \frac{1}{\epsilon_{fj}}\Big)\frac{\partial y_{fj}}{\partial l_{fj}} = p^x_{fj}\Big(1 - \frac{1}{\sigma_j}\Big)\frac{\partial y_{fj}}{\partial l_{fj}} = (1+\tau^L_{fj})\Big(1 + \frac{1}{\epsilon^L_{fj}}\Big) w_{fj}. \tag{2.6}$$

The first two terms are the marginal revenue products of labor in domestic and in foreign markets; the third term is marginal cost of labor. Profit maximization implies that the marginal revenues should be equal to the marginal costs of labor. The two elasticities can be written as functions of exogenous model parameters and endogenous shares s^d_{fj}, λ^H_j, and s^L_{fj}:

$$\epsilon_{fj} = -\bigg(\frac{\partial \ln p^d_{fj}}{\partial \ln y^d_{fj}}\bigg|_{\mathbf{y}^d_{-fj}, Y^F_j}\bigg)^{-1} = \bigg[\frac{1}{\sigma_j} + \Big(\frac{1}{\rho_j} - \frac{1}{\sigma_j}\Big) s^d_{fj} + \Big(1 - \frac{1}{\rho_j}\Big)\lambda^H_j s^d_{fj}\bigg]^{-1} \tag{2.7}$$

and

$$\epsilon^L_{fj} = \left(\frac{\partial \ln w_{fj}}{\partial \ln l_{fj}}\bigg|_{\mathbf{l}_{-fj}}\right)^{-1} = \left[\frac{1}{\eta} + \left(\frac{1}{\theta} - \frac{1}{\eta}\right)s^L_{fj}\right]^{-1}. \tag{2.8}$$

The firm-specific elasticities lead to firm-specific domestic price markups μ^d_{fj} and firm-specific wage markdowns μ^L_{fj}. Expressed as functions of elasticities, the markups (domestic and exporting) and wage markdowns are:

$$\mu^d_{fj} = \frac{\epsilon_{fj}}{\epsilon_{fj} - 1}, \qquad \mu^x_{fj} = \frac{\sigma_j}{\sigma_j - 1}, \qquad \mu^L_{fj} = \frac{\epsilon^L_{fj} + 1}{\epsilon^L_{fj}}, \tag{2.9}$$

The firm-specific elasticities for domestic demand ϵ_{fj} and labor supply ϵ^L_{fj} are given by (2.7) and (2.8). When size is measured by within-sector sales shares s^d_{fj}, larger firms face more inelastic demand and charge higher domestic markups over marginal cost. This size-elasticity correlation is mediated by foreign competition (as in, e.g. Edmond et al., 2015): when foreign competition is greater—captured here by a lower expenditure share on domestic goods λ^H_j—all firms face more elastic demand and all markups are lower. Moreover, when size is measured by within-sector wage bill shares s^L_{fj}, larger firms face more inelastic labor supply and impose higher wage markdowns.

Note that the export market markup μ^x_{fj} is common across firms, consistent with our assumption that these firms are globally small and monopolistically competitive. Homogeneous fringe firms face the same demand and labor supply functions. However, because they do not exert oligopolistic and oligopsonistic power, they charge constant markups and markdowns as in the standard monopolistically competitive models: $\mu^d_{\tilde{f}j} = \mu^x_{\tilde{f}j} = \sigma_j/(\sigma_j - 1)$ and $\mu^L_{\tilde{f}j} = (\eta + 1)/\eta$.

Each heterogeneous firm produces a unique variety using the Cobb-Douglas production function:

$$y_{fj} = a_{fj} l_{fj}^{\gamma^L_j} k_{fj}^{\gamma^K_j} m_{fj}^{\gamma^M_j}, \qquad \gamma^L_j + \gamma^K_j + \gamma^M_j = \gamma_j.$$

Production is subject to returns to scale γ_j, with γ^L_j, γ^K_j, and γ^M_j denoting the shares of costs spent on labor, capital, and intermediate inputs, and with a_{fj} as exogenous productivity. The first-order conditions show that the firm trades off the marginal revenue product of any input in each market against the marginal cost of that input. For each $e \in \{d, x\}$:

$$\begin{aligned} mrpl_{fj} &:= \frac{\gamma^L_j p^e_{fj} y_{fj}}{\mu^e_{fj} l_{fj}} = \mu^L_{fj}(1 + \tau^L_{fj}) w_{fj}, \\ mrpk_{fj} &:= \frac{\gamma^K_j p^e_{fj} y_{fj}}{\mu^e_{fj} k_{fj}} = (1 + \tau^K_{fj})\varrho, \\ mrpm_{fj} &:= \frac{\gamma^M_j p^e_{fj} y_{fj}}{\mu^e_{fj} m_{fj}} = P^M_j. \end{aligned} \tag{2.10}$$

Combining these first order conditions, we see that firms set prices as the aforementioned markups over marginal cost:

$$p_{fj}^e = \mu_{fj}^e \left[\frac{y_{fj}^{1-\gamma_j}}{a_{fj}} \left(\frac{mrpl_{fj}}{\gamma_j^L} \right)^{\gamma_j^L} \left(\frac{mrpk_{fj}}{\gamma_j^K} \right)^{\gamma_j^K} \left(\frac{mrpm_{fj}}{\gamma_j^M} \right)^{\gamma_j^M} \right]^{\frac{1}{\gamma_j}} \qquad e \in \{d, x\}. \tag{2.11}$$

Marginal cost—the term in brackets—is decreasing in productivity and increasing in different input distortions. Moreover, when returns to scale γ_j are different from one, marginal cost varies with the scale of production (i.e., when returns to scale are decreasing, marginal cost goes up with each unit of output produced, and vice versa).

2.2 Equilibrium

Market clearing conditions For notational convenience, denote firm sales in domestic and foreign markets by $r_{fj}^e = p_{fj}^e y_{fj}^e$ for $e \in \{d, x\}$, and total sales as $r_{fj} = r_{fj}^e + r_{fj}^x$. Goods market clearing implies

$$\sum_{f \in \mathcal{F}_j} r_{fj}^d = \lambda_j^H \left[\alpha_j (WL + \varrho K + \Pi + T) + \int_0^1 \gamma_i^{\mathrm{M}} \gamma_j^i \Big(\sum_{f \in \mathcal{F}_i} \sum_{e \in \{d,x\}} (\mu_{fi}^e)^{-1} r_{fi}^e \Big) \mathrm{d}i \right],$$

where $\Pi = \int_0^1 \big(\sum_{f \in \mathcal{F}_i} \pi_{fi} \big) \mathrm{d}i$. The labor and capital market clearing conditions are

$$L = \int_0^1 \sum_{f \in \mathcal{F}_i} l_{fi} \mathrm{d}i \qquad \text{and} \qquad K = \int_0^1 \sum_{f \in \mathcal{F}_i} k_{fi} \mathrm{d}i.$$

The government budget is balanced:

$$T = (1 - \zeta) \int_0^1 \Big(\sum_{f \in \mathcal{F}_i} \tau_{fi}^L w_{fi} l_{fi} + \tau_{fi}^K \varrho k_{fi} \Big) \mathrm{d}i,$$

where $\zeta \in [0, 1]$ is a parameter that governs how much resources are wasted due to distortions. Market clearing conditions imply balanced trade.

We formally define an equilibrium as follows.

Definition 1. *An equilibrium is a set of prices* $\{p_{fj}^d, p_{fj}^x, w_{fj}\}_{f \in \mathcal{F}_j, j \in [0,1]}$, $\{P_j^H, P_j, P_j^M\}_{j \in [0,1]}$, ϱ, P, *and goods and factor allocations* $\{y_{fj}^d, y_{fj}^x, l_{fj}, k_{fj}, m_{fj}\}_{f \in \mathcal{F}_j, j \in [0,1]}$, $\{Y_j^H, Y_j^F, Y_j, Y_j^{i,M}, Y_j^C\}_{i,j \in [0,1]}$ *such that (i) consumers maximize utility; (ii) firms maximize profits; (iii) all goods and factor markets clear; (iv) the government budget is balanced; and (v) trade is balanced.*

We now state a proposition that details a tight mapping between the unobservable firm primitives and observable data, allowing us to back out firm-specific shocks in a computationally simple manner.

We focus on four within-sector shares:

$$s_{fj}^d = \frac{r_{fj}^d}{\sum_{g\in\mathcal{F}_j} r_{gj}^d}, \quad s_{fj}^L = \frac{w_{fj} l_{fj}}{\sum_{g\in\mathcal{F}_j} w_{gj} l_{gj}}, \quad s_{fj}^K = \frac{k_{fj}}{\sum_{g\in\mathcal{F}_j} k_{gj}}, \quad s_{fj}^x = \frac{r_{fj}^x}{\sum_{g\in\mathcal{F}_j^x} r_{gj}^x},$$

spanning respectively domestic sales s_{fj}^d, wage bills s_{fj}^L, capital s_{fj}^K, and export revenues s_{fj}^x.[3] In establishing mappings between the model primitives and the observables, the approach is similar to Hsieh and Klenow (2009), Berger et al. (2022), and Deb et al. (2022a).

Proposition 1. ***(Market Shares)*** *For each sector, given sectoral domestic shares* $\{\lambda_j^H\}_{j\in\mathcal{J}^M}$ *and firm sales in domestic and foreign markets* $\{r_{fj}^d, r_{fj}^x\}$*, the shares* $\{s_{fj}^d, s_{fj}^L, s_{fj}^K, s_{fj}^x\}_{f\in\mathcal{F}_j}$ *satisfy the following* $3\times|\mathcal{F}_j| + |\mathcal{F}_j^x|$ *system of equations:*

$$s_{fj}^d = \frac{\left(a_{fj}^{-\frac{1}{\gamma_j}} \mu_{fj}^d \left(\mu_{fj}^L (1+\tau_{fj}^L)(s_{fj}^L)^{\frac{1}{\eta+1}}\right)^{\frac{\gamma_j^L}{\gamma_j}} (1+\tau_{fj}^K)^{\frac{\gamma_j^K}{\gamma_j}} (\Lambda_{fj}^d)^{\frac{\gamma_j-1}{\gamma_j}}\right)^{-\frac{\gamma_j}{\frac{\sigma_j}{\sigma_j-1}-\gamma_j}}}{\sum_{g\in\mathcal{F}_j}\left(a_{gj}^{-\frac{1}{\gamma_j}} \mu_{gj}^d \left(\mu_{gj}^L (1+\tau_{gj}^L)(s_{gj}^L)^{\frac{1}{\eta+1}}\right)^{\frac{\gamma_j^L}{\gamma_j}} (1+\tau_{gj}^K)^{\frac{\gamma_j^K}{\gamma_j}} (\Lambda_{gj}^d)^{\frac{\gamma_j-1}{\gamma_j}}\right)^{-\frac{\gamma_j}{\frac{\sigma_j}{\sigma_j-1}-\gamma_j}}}, \tag{2.12}$$

$$s_{fj}^L = \frac{s_{fj}^d (\Lambda_{fj}^d)^{-1} \left(\mu_{fj}^d (1+\tau_{fj}^L)\mu_{fj}^L\right)^{-1}}{\sum_{g\in\mathcal{F}_j} s_{gj}^d (\Lambda_{gj}^d)^{-1} \left(\mu_{gj}^d (1+\tau_{gj}^L)\mu_{gj}^L\right)^{-1}}, \tag{2.13}$$

$$s_{fj}^K = \frac{s_{fj}^d (\Lambda_{fj}^d)^{-1} \left(\mu_{fj}^d (1+\tau_{fj}^K)\right)^{-1}}{\sum_{g\in\mathcal{F}_j} s_{gj}^d (\Lambda_{gj}^d)^{-1} \left(\mu_{gj}^d (1+\tau_{gj}^K)\right)^{-1}}, \tag{2.14}$$

$$s_{fj}^x = \frac{s_{fj}^d (\mu_{fj}^x/\mu_{fj}^d)^{1-\sigma_j} D_{fj}^x}{\sum_{g\in\mathcal{F}_j^x} s_{gj}^d (\mu_{gj}^x/\mu_{gj}^d)^{1-\sigma_j} D_{gj}^x}, \tag{2.15}$$

where the markups μ_{fj}^d *and* μ_{fj}^L *are given by* (2.9) *and*

$$\Lambda_{fj}^d = \frac{r_{fj}^d/\mu_{fj}^d}{r_{fj}^d/\mu_{fj}^d + r_{fj}^x/\mu_{fj}^x} = \frac{y_{fj}^d}{y_{fj}}.$$

Proof. See Appendix A. ◻

The key implication of Proposition 1 is that to back out firm-level shocks only requires solving the system of nonlinear equations (2.12)–(2.15) sector-year by sector-year; we do not have to solve the full model. Solving the full model can be computationally costly because we would have to solve for the Nash equilibrium with many firms and sectors jointly. Instead, note that each of the shares

[3] We also note that—using the nested CES labor aggregation—the wage bill share s_{fj}^L can be expressed in terms of only labor: $s_{fj}^L = l_{fj}^{(\eta+1)/\eta}/L_j^{(\eta+1)/\eta}$.

in (2.12)–(2.15) depends only on other shares and firm-level parameters of firms in the same sector, allowing us to solve the system separately for each sector-year.

In addition to its computational convenience, Proposition 1 highlights the drivers of the cross-sectional dispersion in the different market shares and provides some intuition for the identification of key parameters. For instance, domestic sales shares in (2.12) reflect productivity a_{fj} as well as price markups μ_{fj}, wage markdowns μ^L_{fj}, and factor-market distortions τ^L_{fj} and τ^K_{fj}. Moreover, firm-specific exporting opportunities can potentially shape domestic market shares through Λ^d_{fj}, the ratio of quantity demanded by the domestic market relative to the firm's total output. The impact of this open-economy margin depends on the returns to scale parameter γ_j. Under decreasing returns, for instance, foreign demand drives up a firm's marginal cost for all production, increasing its domestic price and decreasing its domestic market share relative to an otherwise identical firm that only serves the domestic market. Note that our model nests benchmarks like Melitz (2003): without market power, distortions, and differential foreign demand, higher domestic sales shares would reflect only differences in productivity.

Similarly, correlations between different market shares help identify different factor distortions and firm-specific foreign demand. For instance—conditioning on productivity and foreign demand—if there were no distortions in hiring labor and capital, there would be a one-to-one mapping between the domestic sales shares in equation (2.12) and the labor or capital shares in (2.13) and (2.14). Using the same intuition as Hsieh and Klenow (2009), we can then measure the factor distortions faced by a firm in terms of deviations from this one-to-one mapping.[4] Furthermore, we can identify firm-specific foreign demand from the export shares in (2.15). Conditioning on other primitives, we would deduce that a firm with a higher export share faces a higher foreign demand.

2.3 Aggregation and National Accounting

Having shown how to back out firm-specific primitives sector by sector, this section states a proposition relating sectoral and aggregate objects of interest—output, productivity, markups—to firm primitives. To start, we define the sectoral producer price index (PPI) as:

$$PPI_j = \left(\frac{1}{F_j}\sum_{f\in\mathcal{F}_j}\tilde{p}_{fj}^{1-\sigma_j}\right)^{\frac{1}{1-\sigma_j}}, \qquad \text{with} \qquad \tilde{p}_{fj} = p^d_{fj}\frac{y^d_{fj}}{y_{fj}} + p^x_{fj}\frac{y^x_{fj}}{y_{fj}}, \tag{2.16}$$

where $\tilde{p}_{fj}$ is the firm-level quantity-weighted average of domestic and export prices. The definition of PPI_j can be viewed as a generalization of the CES welfare-relevant price index in a closed economy.[5] A first-order approximation of (2.16) is simply the total-sales-weighted average firm price, and thus mimics the notion of PPI as constructed by the national statistical agencies. Note that PPI_j is not

[4] Our model nests the Hsieh and Klenow (2009) formulas for identifying labor and capital distortions when we eliminate exporting ($\Lambda^d_{fj} = 1 \forall f$) and restrict firms to monopolistic competition and perfectly competitive labor markets.

[5] In the closed economy case, which is the limiting case that can be achieved by letting $D^x_{fj} \to 0$ and $P^F_{jt} \to \infty$, PPI_j converges to the welfare-relevant price index.

the welfare-relevant price index as it does not include foreign import prices. Next define real gross sectoral output as the ratio between nominal gross output and the PPI_j:

$$Y_j^r = \frac{R_j}{PPI_j},$$

where R_j is sectoral nominal gross output: $R_j = \sum_{f \in \mathcal{F}_j} r_{fj}$.

We now show that these definitions allow us to derive useful analytical aggregation formulas. We characterize two notions of productivity at both the firm and the sectoral level: the productivity for generating physical output—denoted by a_{fj} and A_j—and the productivity for generating revenue—denoted by $tfpr_{fj}$ and $TFPR_j$:

$$a_{fj} = \frac{y_{fj}}{l_{fj}^{\gamma_j^L} k_{fj}^{\gamma_j^K} m_{fj}^{\gamma_j^M}}, \quad A_j = \frac{Y_j^r}{L_j^{\gamma_j^L} K_j^{\gamma_j^K} M_j^{\gamma_j^M}}, \quad tfpr_{fj} = \frac{r_{fj}}{l_{fj}^{\gamma_j^L} k_{fj}^{\gamma_j^K} m_{fj}^{\gamma_j^M}}, \quad TFPR_j = \frac{R_j}{L_j^{\gamma_j^L} K_j^{\gamma_j^K} M_j^{\gamma_j^M}},$$

where $L_j = \left(F_j^{\frac{1}{\eta}} \sum_{f \in \mathcal{F}_j} l_{fj}^{\frac{\eta+1}{\eta}} \right)^{\frac{\eta}{\eta+1}}$, $K_j = \sum_{f \in \mathcal{F}_j} k_{fj}$, and $M_j = \sum_{f \in \mathcal{F}_j} m_{fj}$ represent sectoral aggregates of labor, capital, and material inputs. From these expressions, our notion of sectoral production function $Y_j^r = A_j L_j^{\gamma_j^L} K_j^{\gamma_j^K} M_j^{\gamma_j^M}$ holds by definition.

In defining sectoral markups and markdowns we rely on the notion that revenue shares of flexible inputs are characterized by a ratio of output elasticities, markups and markdowns (see De Loecker and Warzynski, 2012; Yeh et al., 2022). To that effect—following Edmond et al. (2023) and Yeh et al. (2022)—we can back out sectoral markups $\mathcal{M}_j$ and markdowns $\mathcal{M}_j^L$ by comparing sectoral factor shares to output elasticities γ_j^M and γ_j^L:

$$\mathcal{M}_j = \gamma_j^M \left(\frac{P_j^M M_j}{R_j} \right)^{-1} \quad \text{and} \quad \mathcal{M}_j \mathcal{M}_j^L = \gamma_j^L \left(\frac{(1+\tau_j^L) W_j L_j}{R_j} \right)^{-1}, \tag{2.17}$$

where $W_j L_j = \sum_{f \in \mathcal{F}_j} w_{fj} l_{fj}$ and the sectoral labor distortion is a wage-bill-weighted average of firm-level distortions: $(1+\tau_j^L) = \sum_{f \in \mathcal{F}_j} s_{fj}^L (1+\tau_{fj}^L)$. The sectoral markup $\mathcal{M}_j$ is the wedge between the sectoral output elasticity of a flexible input—materials—and its revenue shares. The sectoral markdown $\mathcal{M}_j^L$ is the part of the wedge between the sectoral output elasticity of labor inputs and the labor shares that is not accounted for by the sectoral markup and the sectoral labor distortion.

Building on these definitions, we show in Proposition 2 that sectoral markups, markdowns, productivity, and output can all be expressed as functions of firm-level primitives.

Proposition 2. ***(Aggregation)***
(i) The sectoral markup $\mathcal{M}_j$ and markdown $\mathcal{M}_j^L$ can be expressed as weighted averages of firm-level

markups $\widetilde{\mu}_{fj}$ *and markdowns* μ^L_{fj}*:*

$$\mathcal{M}_j = \Big(\sum_{f\in\mathcal{F}_j} \tilde{\mu}_{fj}^{-1} s_{fj}\Big)^{-1} \qquad \textit{and} \qquad \mathcal{M}^L_j = \frac{\Big(\sum_{f\in\mathcal{F}_j} (\tilde{\mu}_{fj}\mu^L_{fj})^{-1} s_{fj}\Big)^{-1}}{\Big(\sum_{f\in\mathcal{F}_j} \tilde{\mu}_{fj}^{-1} s_{fj}\Big)^{-1}}, \tag{2.18}$$

where s_{fj} *is firm* f*'s total sectoral revenue share and* $\widetilde{\mu}_{fj}$ *is the within-firm average of domestic and foreign markups:*

$$s_{fj} = \frac{r_{fj}}{R_j} \qquad \textit{and} \qquad \widetilde{\mu}_{fj} = \mu^d_{fj}\frac{y^d_{fj}}{y_{fj}} + \mu^x_{fj}\frac{y^x_{fj}}{y_{fj}}.$$

(ii) Real gross output of each sector can be expressed in terms of a sectoral production function:

$$Y^r_j = A_j L_j^{\gamma^L_j} K_j^{\gamma^K_j} M_j^{\gamma^K_j} \quad \textit{with} \quad A_j = \left[\frac{1}{F_j}\sum_{f\in\mathcal{F}_j}\left(a_{fj}\frac{TFPR_j}{tfpr_{fj}}\right)^{\sigma_j-1}\right]^{\frac{1}{\sigma_j-1}}, \tag{2.19}$$

where the ratio of relative revenue productivities $TFPR_j/tfpr_{fj}$ *reflects within-sector variation in firm size* s_{fj} *and in firm marginal revenue products:*

$$\frac{TFPR_j}{tfpr_{fj}} = s_{fj}^{\gamma_j-1}\left(\frac{\widetilde{MRPL}_j}{\widetilde{mrpl}_{fj}}\right)^{\gamma^L}\left(\frac{\widetilde{MRPK}_j}{\widetilde{mrpk}_{fj}}\right)^{\gamma^K}\left(\frac{\widetilde{MRPM}_j}{\widetilde{mrpm}_{fj}}\right)^{\gamma^M}.$$

The relevant marginal revenue products, defined by equation (2.10), are adjusted by the markup $\widetilde{\mu}_{fj}$ *so that* $\widetilde{mrpv}_{fj} = \widetilde{\mu}_{fj} mrpv_{fj}$ *for* $v \in \{l,k,m\}$*. The sectoral counterparts of these marginal products are:*

$$\widetilde{MRPL}_j = \left[F_j^{\frac{1}{\eta}}\sum_{f\in\mathcal{F}_j}\left(s_{fj}\widetilde{mrpl}_{fj}\right)^{\frac{\eta+1}{\eta}}\right]^{\frac{\eta}{\eta+1}},\ \widetilde{MRPK}_j = \sum_{f\in\mathcal{F}_j} s_{fj}\widetilde{mrpk}_{fj}$$

$$\textit{and} \qquad \widetilde{MRPM}_j = \sum_{f\in\mathcal{F}_j} s_{fj}\widetilde{mrpm}_{fj}.$$

Proof. See Appendix A. □

The aggregation results in Proposition 2 are open-economy generalizations of existing aggregation results. For instance, the definition of the sectoral markup $\mathcal{M}_j$ in part (i) is similar to the aggregation in Edmond et al. (2015) and Edmond et al. (2023), with the difference being the use of $\widetilde{\mu}_{fj}$, the within-firm average of domestic and foreign markups. Similarly, the result that the product of the sectoral markup $\mathcal{M}_j$ and markdown $\mathcal{M}^L_j$ can be expressed as the sales-weighted harmonic weighted average of the product of μ^L_{fj} and $\tilde{\mu}_{fj}$ parallels the closed-economy case in Yeh et al. (2022).[6] Analogously for (ii), our expressions for sectoral productivity generalize those in Hsieh and Klenow (2009) and Ruzic and Ho (2023) by including a role for the open economy through the global sales shares s_{fj} and the markup $\widetilde{\mu}_{fj}$.

National accounts and aggregate productivity From now onwards let t index years. National accounting conventions define aggregate real GDP at year t as output evaluated at base prices (prices at the base year $t-1$) minus real inputs also evaluated at the base year input prices:

$$Y^r_t = \int_0^1 (PPI_{j,t-1} Y^r_{jt} - P^M_{j,t-1} M_{jt}) \mathrm{d}j, \tag{2.20}$$

The change in aggregate real GDP between t_0 and t is then:

$$\hat{Y}^r_t = \int_0^1 S^D_{j,t-1} (\hat{Y}^r_{jt} - S^M_{j,t-1} \hat{M}_{jt}) \mathrm{d}j,$$

where the hat notation denotes time-series changes, $S^M_{j,t-1} = \frac{P^M_{j,t-1} M_{j,t-1}}{R_{j,t-1}}$ denotes the shares of material expenditures in nominal gross output, and $S^D_{j,t-1}$ is the Domar weight:[7]

$$S^D_{j,t-1} = \frac{R_{j,t-1}}{\sum_i (\gamma^L_i + \gamma^K_i) R_{i,t-1}}.$$

Aggregate productivity A_t is then a Domar aggregation of sectoral productivities (Hulten, 1978):

$$A_t = \int_0^1 S^D_{j,t-1} A_{jt} \mathrm{d}j. \tag{2.21}$$

We define the aggregate markup $\mathcal{M}$ and markdown $\mathcal{M}^L$ as sales-weighted averages of their sectoral counterparts:

$$\mathcal{M}_t = \Big(\int_0^1 \mathcal{M}^{-1}_{jt} S_{j,t-1} \Big)^{-1} \mathrm{d}j, \qquad \mathcal{M}^L_t = \frac{\Big(\int_0^1 (\mathcal{M}_{jt} \mathcal{M}^L_{jt})^{-1} S_{j,t-1} \Big)^{-1} \mathrm{d}j}{\Big(\int_0^1 \mathcal{M}^{-1}_{jt} S_{j,t-1} \Big)^{-1} \mathrm{d}j}, \tag{2.22}$$

where $S_{j,t-1} = \frac{R_{j,t-1}}{\int_0^1 R_{i,t-1} \mathrm{d}i}$ are sectoral revenue shares.

[6] We nest the closed economy case by letting $D^x_{fj} \to 0$ and $P^F_j \to \infty$; our expressions for sectoral markups and markdowns in equation (2.18) are then identical to those in Edmond et al. (2023) and Yeh et al. (2022). Edmond et al. (2015) also studies the open economy setup. However, our expression for the sectoral markup differs slightly from theirs: our within-firm markup is quantity weighted while theirs is revenue weighted, with the difference arising from the way we define PPI_j and real gross output.

[7] See, e.g. Burstein and Cravino (2015), Huo et al. (2023a), and di Giovanni et al. (2024).

2.4 Concentration Ratio (CR)

With a view of explaining the concentration growth from Figure 1 through firm primitives, we next derive a proposition that summarizes a firm's role in concentration growth using two terms: one term captures productivity and domestic distortions, and the other term captures export demand. The first term, $\tilde{a}_{fjt}$, combines a firm's Hicks-neutral productivity a_{fjt} with the marginal productivities of the firm's different inputs:

$$\tilde{a}_{fjt} = a_{fjt} \left(\frac{\widetilde{MRPL}_{jt}}{\widetilde{mrpl}_{fjt}} \right)^{\gamma^L} \left(\frac{\widetilde{MRPK}_{jt}}{\widetilde{mrpk}_{fjt}} \right)^{\gamma^K} \left(\frac{\widetilde{MRPM}_{jt}}{\widetilde{mrpm}_{fjt}} \right)^{\gamma^M}.$$

The relative marginal revenue product ratios summarize the product and factor market distortions across firms in a sector. Within-sector concentration is shaped by a firm's $\tilde{a}_{fjt}$ relative to the sectoral average $\tilde{A}_j = (F_j)^{\frac{1}{\sigma_j - 1}} A_j$, defined as sectoral productivity A_j adjusted for the number of firms F_j.

The second term, ϕ_{fjt}, captures the role of international trade. It takes the value one for non-exporting firms; otherwise it reflects two distinct channels through which firm-specific export demand shapes sectoral concentration:

$$\phi_{fjt} = \frac{(\tilde{D}^{x,MA}_{fjt})^{\frac{\sigma_j}{\sigma_j - 1} - \gamma_j}}{(\tilde{D}^{x,RTS}_{fjt})^{1-\gamma_j}}.$$

In turn, $\tilde{D}^{x,MA}_{fjt}$ captures the importance of export market access for firm size and $\tilde{D}^{x,RTS}_{fjt}$ captures the extent to which export demand can change marginal costs through returns-to-scale:

$$\tilde{D}^{x,MA}_{fjt} = \left(\frac{\tilde{\mu}_{fjt}}{\mu^d_{fjt}} \right)^{\sigma_j - 1} + \left(\frac{\tilde{\mu}_{fjt}}{\mu^x_{fjt}} \right)^{\sigma_j - 1} \tilde{D}^x_{fjt}, \qquad \text{and} \qquad \tilde{D}^{x,RTS}_{fjt} = \left(\frac{\tilde{\mu}_{fjt}}{\mu^d_{fjt}} \right)^{\sigma_j} + \left(\frac{\tilde{\mu}_{fjt}}{\mu^x_{fjt}} \right)^{\sigma_j} \tilde{D}^x_{fjt}.$$

The importance of each channel reflects firm-specific demand from the rest of the world, $\tilde{D}^x_{fjt} = \frac{D^x_{fjt}}{\frac{1}{F_j}(P^H_j)^{\sigma_j - \rho_j} P_j^{\rho_j - 1} E_j}$, and the firm's differential market power domestically and abroad $\tilde{\mu}_{fjt}/\mu^d_{fjt}$. Like the other forces in the model, within-sector concentration will be shaped by a firm's ϕ_{fjt} compared to the sectoral average Φ_{jt}:

$$\Phi_{jt} = \Big(\sum_{f \in \mathcal{F}_{jt}} s_{fjt} \phi_{fjt}^{1-\sigma_j} \Big)^{\frac{1}{1-\sigma_j}}.$$

Proposition 3 then decomposes the rise in concentration along two dimensions: (i) the differential role of continuing firms, and (ii) the differential roles of productivity-cum-distortions, and export demand. While the decomposition is more general, we focus on the sales share of the top 3 firms within a sector, denoted by CR^3_{jt}. Aggregating the sales of the top 3 firms in each sector, we denote by CR_t^3 the manufacturing-wide sales concentration ratio for the top-3 firms:

$$CR_{jt}^3 = \frac{\sum_{f\in\mathcal{F}_{jt}^3} r_{fjt}}{\sum_{f\in\mathcal{F}_{jt}} r_{fjt}} \qquad \text{and} \qquad CR_t^3 = \frac{\sum_{j\in\mathcal{J}_M}\sum_{f\in\mathcal{F}_{jt}^3} r_{fjt}}{\sum_{j\in\mathcal{J}_M}\sum_{f\in\mathcal{F}_{jt}} r_{fjt}},$$

where $\mathcal{F}_{jt}^3$ is the set of top 3 firms in sector j at time t. Between any two periods t and $t-p$, the set of top-3 firms might change. To understand the differential contribution of continuing top-3 firms, we also define $S_{j,t-p}^{3,cont}$ and $S_{jt}^{3,cont}$ to be the sales shares of the set of firms $\mathcal{F}_{j,t,t-p}^{3,cont} = \mathcal{F}_{jt}^{3,cont} \cap \mathcal{F}_{j,t-p}^{3,cont}$ that are in the top 3 in both t and $t-p$:

$$S_{j,t-p}^{3,cont} = \frac{\sum_{f\in\mathcal{F}_{j,t,t-p}^{3,cont}} r_{fj,t-p}}{\sum_{f\in\mathcal{F}_{j,t-p}^3} r_{fj,t-p}} \qquad \text{and} \qquad S_{jt}^{3,cont} = \frac{\sum_{f\in\mathcal{F}_{j,t,t-p}^{3,cont}} r_{fjt}}{\sum_{f\in\mathcal{F}_{jt}^3} r_{fjt}}.$$

Proposition 3. ***(Concentration Ratio)***
(i) Changes in CR_{jt}^3 between $t-p$ and t reflect the contributions of continuing top-3 firms and the differential contribution of entering top-3 firms compared to firms no longer in the top 3:

$$\ln\frac{CR_{jt}^3}{CR_{j,t-p}^3} = \underbrace{\frac{1}{\frac{\sigma_j}{\sigma_j-1}-\gamma_j}\left[\sum_{f\in\mathcal{F}_{j,t,t-p}^{3,cont}} \omega_{fjt,t-p}\left(\ln\frac{\tilde{a}_{fjt}/\tilde{A}_{jt}}{\tilde{a}_{fj,t-p}/\tilde{A}_{j,t-p}} + \ln\frac{\phi_{fjt}/\Phi_{jt}}{\phi_{fj,t-p}/\Phi_{j,t-p}}\right)\right]}_{\textit{Continuing top-3 firms}} - \underbrace{\ln\frac{S_{jt}^{3,cont}}{S_{j,t-p}^{3,cont}}}_{\textit{Entry/exit}}. \tag{2.23}$$

The weights $\omega_{fjt,t-p}$ are defined as

$$\omega_{fjt,t-p} = \frac{\frac{s_{fjt}^{3,cont}-s_{fj,t-p}^{3,cont}}{\ln s_{fjt}^{3,cont}-\ln s_{fj,t-p}^{3,cont}}}{\sum_{g\in\mathcal{F}_{jt,t-p}^{3,cont}}\frac{s_{gjt}^{3,cont}-s_{gj,t-p}^{3,cont}}{\ln s_{gjt}^{3,cont}-\ln s_{gj,t-p}^{3,cont}}}, \quad \textit{where} \quad s_{fj\tilde{t}}^{3,cont} = \frac{r_{fj\tilde{t}}}{\sum_{g\in\mathcal{F}_{jt,t-p}^{3,cont}} r_{gj\tilde{t}}}, \quad \tilde{t}\in\{t-p,t\}.$$

(ii) Changes in CR_t^3 between $t-p$ and t can be approximated as follows:

$$\begin{aligned}
\ln\frac{CR_t^3}{CR_{t-p}^3} &\approx \sum_{j\in\mathcal{J}_M}\omega_{j,t-p}^3\left(\ln\frac{CR_{jt}^3}{CR_{j,t-p}^3} + \ln\frac{S_{jt}}{S_{j,t-p}}\right)\\
&= \underbrace{\sum_{j\in\mathcal{J}_M}\omega_{j,t-p}^3\frac{1}{\frac{\sigma_j}{\sigma_j-1}-\gamma_j}\left(\sum_{f\in\mathcal{F}_{jt,t-p}^{3,cont}}\omega_{fjt,t-p}\left(\ln\frac{\tilde{a}_{fjt}/\tilde{A}_{jt}}{\tilde{a}_{fj,t-p}/\tilde{A}_{j,t-p}} + \ln\frac{\phi_{fjt}/\Phi_{jt}}{\phi_{fj,t-p}/\Phi_{j,t-p}}\right)\right)}_{\textit{Continuing top 3 firms}}\\
&\qquad - \underbrace{\sum_{j\in\mathcal{J}_M}\omega_{j,t-p}^3\ln\frac{S_{jt}^{3,cont}}{S_{j,t-p}^{3,cont}}}_{\textit{Entry/exit}} + \underbrace{\sum_{j\in\mathcal{J}_M}\omega_{j,t-p}^3\ln\frac{S_{jt}}{S_{j,t-p}}}_{\textit{Sectoral reallocation}},
\end{aligned} \tag{2.24}$$

where $\omega^3_{j,t-p} = \frac{\sum_{f\in\mathcal{F}^3_{j,t-p}} r_{fj,t-p}}{\sum_{i\in\mathcal{J}_M}\sum_{f\in\mathcal{F}^3_{i,t-p}} r_{fi,t-p}}$ *and* $S_{jt} = \frac{R_{jt}}{\sum_{i\in\mathcal{J}_M} R_{it}}$.

Proof. See Appendix A. $\square$

Equation (2.23) attributes growth in concentration separately to continuing top 3 firms and to the turnover among top 3 firms. The continuing firms contribute to growing concentration either through differential productivity growth, $\tilde{a}_{fjt}/\tilde{A}_{jt}$—encompassing both higher productivity and lower domestic distortions—or through differential access to exporting, ϕ_{fjt}/Φ_{jt}. The turnover between entering and exiting firms, $\ln S^{3,cont}_{jt}/S^{3,cont}_{j,t-p}$, captures the same two forces but now compares the firms entering the top 3 in period t to those firms that were only in the top 3 at time $t-p$. When the new entrants to the top-3 are, for instance, disproportionaly productive compared to the firms exiting the top 3, then this turnover term contributes positively to the rise in concentration. The effects of the turnover are captured by the differential market shares of the entering and exiting firms, in a manner similar to the Feenstra (1994) correction for entry and exit of new product varieties.[8]

As we relate within-sector concentration to manufacturing-wide concentration, equation (2.24) emphasizes the additional importance of sectoral reallocation. To that effect, the first two terms are familiar: they reflect aggregation of within-sector concentration growth. The first term aggregates the importance of continuing firms within each sector; the second term aggregates the importance of turnover in the top 3 for each sector. The third term captures the changes in the aggregate CR^3_t due to changes in reallocation; specifically, it captures changes in sector size holding within-sector concentration ratios constant. This intersectoral reallocation between periods t and $t-p$ could, for instance, be due to increases in foreign market size, to the evolution of the economy's input-output structure, or to changes in the household's demand for different goods.

3 Data and Model Implementation

This section provides an overview of our firm-level and sectoral data for South Korea, and describes the calibration and estimation of the parameters and shocks. Appendix B elaborates in detail on both the underlying data and the calibration/estimation procedures.

3.1 Data

Our analysis utilizes a novel firm-level panel dataset covering the period from 1972 through 2011. Firm balance sheet data from 1972 to 1982 come from digitizing the historical Annual Reports of Korean Companies published by the Korea Productivity Center. Data for the 1982-2011 period come from KIS-VALUE, which covers firms with assets above 3 billion Korean Won, for whom reporting balance sheet data has been mandatory since the introduction of the 1981 Act on External Audit of

[8] Note that $S^{3,cont}_{jt}$ compares the sales of the continuing firms to the full set of top-3 firms, and hence defines the contribution of entering firms by omission. When $S^{3,cont}_{jt}$ is small and $S^{3,cont}_{j,t-p}$ is large, we learn that the entering firms are disproportionately more productive compared to the exiting firms.

Joint-Stock Corporations.[9] We merge these two data sets based on firm names. We treat each firm within a business group (chaebol) as a separate entity.

To ensure the comparability of the two data sets across time, we impose the KIS-VALUE inclusion criterion on the data from the earlier period. That is, while the 1972-1982 data have broader coverage, we include in the firm-level analysis only those firms that would have been required to report their balance sheets had the 1981 Act on External Audit been in force prior to 1982. The resulting data set comprises of 23,464 unique firms, with the number of firm-year observations increasing from 731 in 1972 to 18,761 in 2011 (Appendix Figure B1).

The dataset has information on sales, exports, fixed assets, employment, wage bill, and firm age. However, wage bill data are only available after 1983, so we use the wage bill data only for the estimation of the production functions, but not for the quantitative exercises. While our firm-level data cover most of South Korea's economic activity, to capture the entire economy we complement the firm-level data with sector-level data from KLEMS and from the IO tables from the Bank of Korea. The sectoral data cover imports, exports, gross output, producer price indexes (PPI), capital, and employment. Our final data set consists of 19 sectors. Among these 19 sectors, 11 are in manufacturing and have firm-level information (Appendix Table B1).

Concentration ratios Figure 1 displays the concentration ratio of the top 3 firms within each sector, defined as the sum of these firms's sales divided by the total manufacturing gross output. Additionally, Appendix Figure B2 reports concentration ratios for alternative variables, including domestic sales, exports, fixed assets, employment. Over time, both domestic sales and export concentration ratios increased, with a more pronounced increase in export concentration. Furthermore, concentration in employment and fixed asset also increased, although the magnitudes were smaller compared to the increase in the sales concentration ratio. Appendix Figures B3 and B4 also explore the concentration ratios for the top 1 and the top 5 firms, and consider selecting top firms based on their sales among all manufacturing firms, regardless of sector. These two exercises re-confirm the trend increase in concentration. Appendix Table B2 reports a list of the top 3 firms across the sample period.

3.2 Structural Parameters

Externally calibrated parameters Table 1 presents the summary of the calibration. In our baseline, we externally calibrate the elasticity of substitution σ_j to 5, which aligns with the existing estimates of 4 from Broda and Weinstein (2006), 5.8 from De Loecker et al. (2021), and 7 from Burstein et al. (2021). We set the elasticity of substitution between Home and Foreign composites ρ_j to 2 (Boehm et al., 2023). We externally calibrate these elasticities because—as in most firm-level data sets—we observe firms' sales but not their prices and quantities separately. We later conduct

[9] The threshold is roughly 2.3 million USD in 2023. The data structure of KIS-VALUE is similar to Compustat. However, unlike Compustat, it covers medium-sized firms that are not publicly traded.

Table 1: Calibration

Param.	Value	Description	Moment	Source
	Elasticities			
σ_j	5	Elast. subst. firms		Literature
ρ_j	2	Elast. subst. Home vs. Foreign		Boehm et al. (2023)
η	4	Labor supp. elast. firms		Card et al. (2018)
θ	1.89	Labor supp. elast. sectors		Deb et al. (2022b)
ψ	0.5	Agg. labor supp. elast.		Chetty et al. (2013)
	Production, Consumption & Government Revenue			
γ_j^L	0.07–0.50, avg. 0.24	Prod. ftn. labor share	eq. (3.1)	Own estimate
γ_j^K	0.08–0.29, avg. 0.17	Prod. ftn. capital share	eq. (3.1)	Own estimate
γ_j^M	0.42–0.65, avg. 0.57	Prod. ftn. material share	eq. (3.1)	Own estimate
γ_j^i	0–0.75	Intermediate input shares	IO tables	IO tables
α_j	0–0.26	Consumption share	IO tables	IO tables
ζ	1	Gvnt. revenue waste		
	Shocks			
a_{fjt}		Productivity	Dom. sales sh., eq. (2.12)	Data
D_{fjt}^x		Foreign demand	Export sh., eq. (2.15)	Data
$1+\tau_{fjt}^L$		Labor distortion	Emp. sh, eq. (2.13)	Data
$1+\tau_{fjt}^K$		Capital distortion	Cap. sh., eq. (2.14)	Data
P_{jt}^F		Import price shock	Import shares	Data
ψ_t		Labor supp. pref. shock	Working hours per worker	Data

Notes. This table presents the summary of the calibration.

robustness checks for these parameter values.

We set the across-firm labor supply elasticity $\eta = 4$ following Card et al. (2018) who pick 4 as their preferred value in their calibration exercises based on their review of the previous literature.[10] We set the across-sector labor supply elasticity θ to 1.89 following Deb et al. (2022b) who estimate the elasticity across sectors in the US using state-level variation in corporate income tax rates.[11] We set the Frisch aggregate labor supply elasticity ψ to 0.5, a value advocated by Chetty et al. (2013).

We use the Bank of Korea input-output tables to obtain the final consumption shares α_j and the input-output shares of material inputs γ_j^i. We allow both α_j and γ_j^i vary across years to capture structural change. We set $\zeta = 1$ implying that there is no loss of resources due to distortions beyond their misallocation effects.

[10] The value of 4 is also broadly consistent with estimates from other recent contributions. Deb et al. (2022b) estimate the across-firm labor supply elasticity of 3.1 in the US; Lamadon et al. (2022) 4.6 in the US; Kroft et al. (2023) 4 in the US construction industry; Dhyne et al. (2022) 3.5 in Belgium; and Huneeus et al. (2022) the range of 3–6 in Chile.

[11] Our choices for the values of η and θ are based on the studies that employed exogenous variation at the US state or commuting zone levels. We view these setting to be suitable for application to South Korea,as it is a small country comparable in geographic size to the state of Indiana.

Production function estimation We combine the firm-level production function with the demand curve faced by the firms to derive an estimable regression model (see, e.g. De Loecker, 2011). For non-exporters,

$$\ln \frac{r^d_{fjt}}{P^H_{jt}} = \beta^M_j \ln m_{fjt} + \beta^L_j \ln l_{fjt} + \beta^K_j \ln k_{fjt} + \frac{1}{\sigma_j} \ln Y^H_{jt} + \beta^A_j \ln a_{fjt} + \ln u_{fjt}. \tag{3.1}$$

The estimating equation relates deflated firm sales to production inputs (m_{fjt}, l_{fjt}, and k_{fjt}), firm productivity a_{fjt} and industry size Y^H_{jt} through a series of revenue elasticities β.[12] We also allow for measurement error u_{fjt}. The revenue elasticities on the production inputs are a combination of demand and production parameters, $\beta^v_j = \frac{\sigma_j - 1}{\sigma_j}\gamma^v_j$ for $v \in \{L, K, M\}$. Using the calibrated σ_j and the revenue elasticities β^v_j, we can back out the production parameters γ^L_j, γ^K_j, and γ^M_j, whose sum γ_j constitutes the returns to scale.

The dependent variable is log nominal sales deflated by sectoral PPIs, k_{fjt} is fixed assets deflated by the investment deflators, and m_{fjt} is constructed by deflating expenditures on material inputs, $P^M_{jt} m_{fjt}$, by input deflators. We construct the input deflators using sectoral PPIs and intermediate input shares from the IO tables. We measure Y^H_{jt} by the real gross output obtained from KLEMS. Because material expenditures are available only after 1983 from KIS-VALUE, we restrict the estimation sample to observations after 1983.

Our estimation proceeds in two steps. In the first step, using the sample of never-exporters, we pin down the revenue elasticity of material inputs using the following relationship for each sector[13]:

$$\hat{\beta}^M_j = \frac{\sigma_j - 1}{\sigma_j} \frac{1}{N} \sum_t \sum_{f \in \mathcal{F}_{jt}} \mu^d_{fj} \frac{P^M_{jt} m_{fjt}}{r^d_{fj}}, \tag{3.2}$$

Given the calibrated values of σ_j and ρ_j, μ^d_{fj} can be computed from the data using the domestic sales shares and the expenditure share on domestic inputs (equations (2.7) and (2.9)). In addition to reducing the set of parameters to be estimated, this first step is one way of dealing with the identification challenges to control-function approaches of estimating (gross output) production functions, using firms' first order conditions, which have been highlighted by Ackerberg et al. (2015), Gandhi et al. (2020), and Bond et al. (2021). In short, flexibly chosen variable inputs—as materials are often assumed to be—cannot generally be expected both to proxy for productivity through the control function and to estimate the revenue elasticity with respect to itself.

For the second estimation step, we net out material inputs and domestic real gross output from

[12] For exporters, we can derive the following regression model: $\ln \frac{r^d_{fjt}}{P^H_{jt}} = \beta^M_j \ln m_{fjt} + \beta^L_j \ln l_{fjt} + \beta^K_j \ln k_{fjt} + \frac{1}{\sigma_j} \ln Y^H_{jt} + \frac{\sigma_j - 1}{\sigma_j} \ln \Lambda^d_{fjt}(r^d_{fjt}, r^x_{fjt}, s^d_{fjt}; \sigma_j) + \beta^A_j \ln a_{fjt} + \ln u_{fjt}$, where Λ^d_{fjt} now appears due to exporting.

[13] We closely follow Ruzic and Ho (2023) who proceeds in these two steps to recover the revenue elastiticities. Note that the relationship does not hold for exporters due to differential markups in domestic and foreign markets

the initial expression in equation (3.1). Then we estimate the following modified estimating equation for the sample of never-exporters:

$$\ln \frac{r^d_{fjt}}{P^H_{jt}} - \hat{\beta}^M_j \ln m_{fjt} - \frac{1}{\sigma_j} \ln Y^H_j = \beta^L_j \ln l_{fjt} + \beta^K_j \ln k_{fjt} + \beta^A_j \ln a_{fjt} + \ln u_{fjt}. \tag{3.3}$$

OLS estimates of (3.3) suffer from an endogeneity problem arising from the fact that firms make input decisions after observing productivity, which is unobservable to researchers. To deal with the endogeneity issue, we estimate (3.3) using the control function approach (Olley and Pakes, 1996; Levinsohn and Petrin, 2003). We assume that productivity follows the following flexible first-order Markov process, $\ln a_{fjt} = \iota_0 + \iota_1 \ln a_{fj,t-1} + \iota_2 (\ln a_{fj,t-1})^2 + \iota_3 (\ln a_{fj,t-1})^3 + \xi_{fjt}$, where ξ_{fjt} is an innovation to productivity. Following the literature, we also assume that firms can adjust their variable inputs—labor and materials—after observing a_{fjt}, but that the capital stock cannot be adjusted contemporaneously.

Using the timing of input choices, we can invert productivity as a function of material inputs conditional on markups, markdowns, and aggregate demand in both markets (Doraszelski and Jaumandreu, 2021; De Ridder et al., 2021). Because markups and markdowns are functions of s^d_{fjt}, λ^H_{jt}, and s^L_{fjt}, it is sufficient to invert productivity conditional on these observable shares:

$$\ln a_{fjt} = m^{-1}(\ln m_{fjt}, \ln k_{fjt}, \ln l_{fjt}, s^d_{fjt}, \lambda^H_{jt}, s^L_{fjt}, \ln Y^H_{jt}).$$

Following Ackerberg et al. (2015), we first purge out measurement errors by nonparametrically estimating the following function:

$$\ln \frac{r^d_{fjt}}{P^H_{jt}} - \hat{\beta}^M_j \ln m_{fjt} - \frac{1}{\sigma_j} \ln Y^H_{jt} = h(\ln l_{fjt}, \ln k_{fjt}, \ln m_{fjt}, s^d_{fjt}, \lambda^H_{jt}, s^L_{fjt}, \ln Y^H_{jt}) + u_{fjt}$$

and obtaining the estimated fit $\hat{h}$. Then, the parameters $\boldsymbol{\kappa} = (\beta^L_j, \beta^K_j, \iota_0, \iota_1, \iota_2, \iota_3)$ are identified by the following moment conditions based on the timing structure:

$$\mathbb{E}_t[\mathbf{Z}_{fjt} \xi_{fjt}(\boldsymbol{\kappa})] = 0,$$

where $\mathbf{Z}_{fjt} = [\ln k_{fj,t-1}, \ln l_{fj,t-1}, 1, \ln a_{fj,t-1}, (\ln a_{fj,t-1})^2, (\ln a_{fj,t-1})^3]'$ is a set of instrumental variables. For a given guess of $\boldsymbol{\kappa}$, we obtain $\ln a_{fjt}$ as

$$\ln a_{fjt} = \frac{1}{\beta^A_j} \left(\ln \frac{r^d_{fjt}}{P^H_{jt}} - \hat{\beta}^M_j \ln m_{fjt} - \frac{1}{\sigma_j} \ln Y^H_{jt} - \beta^L_j \ln l_{fjt} - \beta^K_j \ln k_{fjt} \right)$$

and calculate $\xi_{fjt}(\boldsymbol{\kappa})$ as the residual of the Markov process.[14]

A firm f's profit share relative to its revenue can be expressed as $\frac{\pi_{fjt}}{r_{fjt}} = 1 - \frac{1}{\tilde{\mu}_{fjt}}(\frac{\gamma_j^L}{\mu_{fjt}^L} + \gamma_j^K + \gamma_j^M)$.[15] We impose a constraint on the parameter space that guarantees fringe firms' profit shares to be positive. Because fringe firms charge constant markups and markdowns, this constraint becomes $\frac{\sigma_j - 1}{\sigma_j}(\gamma_j^L \frac{\eta}{\eta+1} + \gamma_j^K + \gamma_j^M) \leq 1$. Because fringe firms have the lowest profit shares within sectors, this constraint guarantees all firms to earn positive profits. This parameter restriction is sensible, as firms earning negative profits would exit. Once we obtain β_j^L, β_j^K, and β_j^M sector-by-sector, we can obtain γ_j^L, γ_j^K, and γ_j^M by multiplying the estimated coefficients by $\frac{\sigma_j}{\sigma_j - 1}$.[16]

Appendix Table B3 reports the estimation results. The mean of returns to scale γ_j is 0.96.[17] The mean of labor share of primary factor costs $\gamma_j^L/(\gamma_j^L + \gamma_j^K)$ is 0.57.

For commodity and service sectors in which firm-level data are not available, we use the averages of γ_j^L, γ_j^K, and γ_j^M across manufacturing sectors.

3.3 Inverting the Model to Recover Shocks

To back out the firm-level shocks, our calibration proceeds in two steps. In our quantification, each firm observed in the data is an object in the model, and we take the model to the data year by year. The first step of the calibration identifies each firm's productivity, distortions and foreign demands relative to fringe firms. Using data on domestic sales, employment, capital, and export shares, we solve for $\{a_{fjt}, D_{fjt}^x, 1+\tau_{fjt}^L, 1+\tau_{fjt}^K\}_{j\in\mathcal{F}_{jt}}$ for each sector and time. Productivity a_{fjt} can be identified from equation (2.12); labor distortions τ_{fjt}^L from equation (2.13); capital distortions τ_{fjt}^K from equation (2.14); and foreign demand D_{fjt}^x from equation (2.15).

In the second step—given these identified shocks relative to fringe firms—we pin down fringe firms' productivity, foreign demands, and distortions $\{a_{\tilde{f}jt}, D_{\tilde{f}jt}^x, 1+\tau_{\tilde{f}jt}^K, 1+\tau_{\tilde{f}jt}^L\}_{j\in[0,1]}$, the sectoral foreign import price shocks $\{P_{jt}^F\}_{j\in[0,1]}$, and the aggregate preference shock to the disutility of labor $\bar{\phi}_t$. We calibrate fringe firms' productivity by fitting sectoral PPI changes and aggregate real GDP growth. We use changes in PPI (relative to a reference sector) to pin down each sector's fringe firms' productivity changes relative to the reference sector. We then pin down the reference sector fringe firms' productivity using aggregate real GDP growth. We calibrate fringe firms' foreign demand by fitting aggregate exports. The sectoral import price shocks are identified by sectoral imports shares λ_{jt}^F and $\bar{\phi}_t$ from changes in aggregate hours per worker. To pin down fringe firms' distortions, we set $1+\tau_{\tilde{f}jt}^L$

[14]Specifically, $\xi_{fjt}(\beta_j^L, \beta_j^K, \rho_j) = \ln a_{fjt} - \iota_0 - \iota_1 \ln a_{fj,t-1} - \iota_2(\ln a_{fj,t-1})^2 - \iota_3(\ln a_{fj,t-1})^3$.

[15]Basu and Fernald (1997) showed that under very general assumptions on functional forms for demand and production, profits drive a wedge between returns to scale and markup. Unlike their setup, because of firms' labor market power, μ_{fjt}^L additionally enters into the formula.

[16]Due to the small number of observations in petrochemical sector, we combine firms in petrochemical and chemical sectors when estimating the production function parameters.

[17]This value is consistent with the existing estimates in the literature. For example, Basu and Fernald (1997) estimate the returns to scale around 1.1–1.3 using the US sectoral data; Gao and Kehrig (2021) around 0.9–1.0 for manufacturing firms in the US Census; Eslava et al. (2023) around 0.9–1.2 using the Colombian plant data; and Huo et al. (2023a) around 1.05–1.17 for manufacturing sectors using the KLEMS data.

and $1+\tau^K_{fjt}$ to satisfy $\sum_{f\in\mathcal{F}_{jt}} s_{fjt}(1/(1+\tau^L_{fjt})\tilde{\mu}_{fjt}\mu^L_{fjt}) = 1$ and $\sum_{f\in\mathcal{F}_{jt}} s_{fjt}(1/(1+\tau^K_{fjt})\tilde{\mu}_{fjt} = 1$, respectively. By doing so, we set the capital income share $\sum_{f\in\mathcal{F}_j} \varrho k_{fjt}/R_{jt}$ equal to γ^K_j, and the labor income share $\sum_{f\in\mathcal{F}_{jt}} w_{fjt}l_{fjt}/R_{jt}$ to γ^L_j. We truncate the top and bottom 1% for $1+\tau^L_{fjt}$ and $1+\tau^K_{fjt}$, the top 1% for D^F_{jt}, and the top and bottom 0.1% for A_{fjt}. Then, we take the 5-year rolling moving averages for the recovered firm-level shocks.

We do not have firm-level information in commodity and service sectors, so we assume homogeneous fringe firms in these sectors and their shocks are matched to the sectoral data. We treat trade deficits as exogenous as standard in the trade literature.

4 Quantitative Results

This section presents the quantitative results on the role of large firms on South Korea's growth miracle.

Shocks Figure 2 displays the trends in the 4 shocks since the 1970s. Panel A illustrates the rapid increase in productivity for the manufacturing sectors. Average productivity is normalized to 1 in 1972. During the sample period, the sales-weighted average manufacturing productivity increased by 230%.[18] Panel B plots the export-weighted average of foreign demand. Its evolution tracks closely the global demand conditions and the real exchange rate movements. Notably, foreign demand dropped in the late 1970s due to the global recession induced by the oil crisis. During the mid-1980s, a depreciated real exchange rate and low oil prices drove an increase in foreign demand. Around 1997, foreign demand surged as the real exchange rate depreciated in the midst of the Asian financial crisis.

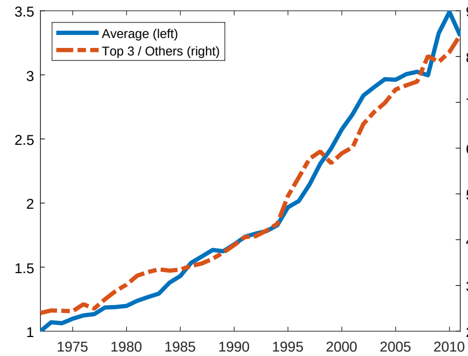
Panels C and D report the dispersions of log labor and capital distortions, a widely used measure of the degree of resource misallocation (e.g. Hsieh and Klenow, 2009). We compute standard deviations of firm-level log distortions within sectors and then take sales-weighted averages of these standard deviations across sectors. The dispersion of labor distortions exhibited a declining trend from the 1970s to the early 1990s, before reversing somewhat. The dispersion in capital distortions initially decreased until the mid 1990s but saw a peak around the 1997-1998 Asian financial crisis. This is in line with financial frictions being exacerbated during the crisis (e.g. Midrigan and Xu, 2014). Since then, it has remained elevated, hovering around the levels seen in the early 1970s.

Figure 2 also plots the divergent evolution of shocks for the top 3 largest firms by sales in each sector compared to the others. We allow for the set of the top-3 firms to vary across years. We calculate the unweighted average of shocks of the top 3 firms, divide it by the unweighted average of shocks of all firms within sectors, and then take the sales-weighted average of these ratios across sectors.[19] Panel A shows that the top-3 firms experienced faster productivity growth. In 1972, their

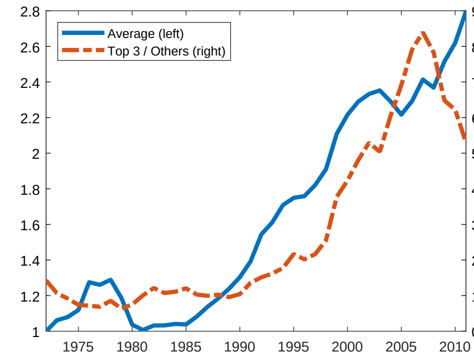
[18] Choi and Shim (2022, 2023) document that these productivity increases are driven by the adoption of foreign advanced technologies and innovation.

[19] Specifically, we calculate $\sum_{j\in\mathcal{J}} S_{jt}\frac{\sum_{f\in\mathcal{F}^3_{jt}} X_{fjt}}{\sum_{f\in\mathcal{F}_{jt}} X_{fjt}}$, for $X_{fjt}\in\{a_{fjt}, D^x_{fjt}, 1+\tau^L_{fjt}, 1+\tau^K_{fjt}\}$.

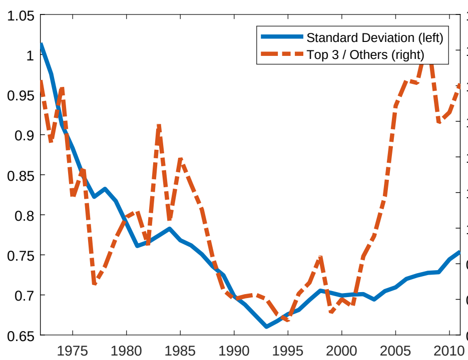
Figure 2. Shocks



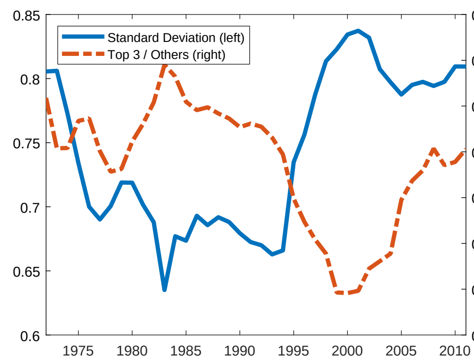
A. a_{fjt}



B. D^x_{fjt}



C. $1 + \tau^L_{fjt}$

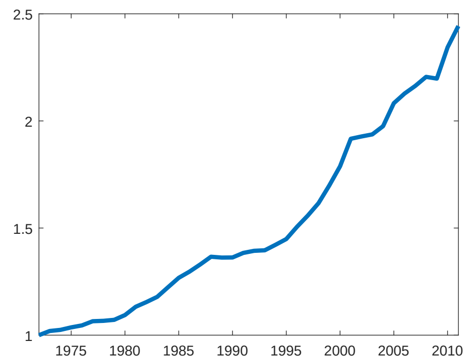


D. $1 + \tau^K_{fjt}$

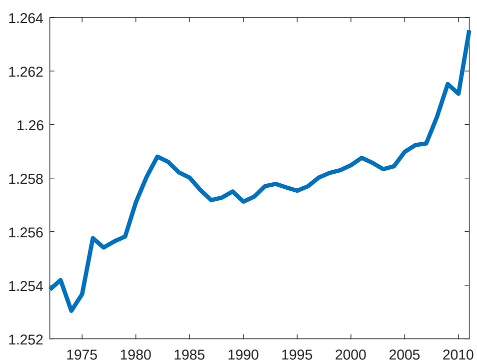
Notes. This figure illustrates the trends in the shocks. Panels A and B plot the sales-weighted average of all firms and the unweighted average of top 3 firms divided by that of other firms of productivity and foreign demand shocks, respectively. Sales-weighted averages of both productivity and foreign demand shocks are normalized to 1 in 1972. Panels C and D plot the standard deviation and the unweighted average of top 3 firms divided by that of other firms of labor and capital distortions, respectively. All results are computed within manufacturing sectors and then aggregated by taking the sales-weighted averages across sectors.

average productivity was 2.4 times higher than that of the other firms; by 2011, it had surged to 8.5 times higher. The top-3 firms' foreign demands—plotted in panel B—remained stable and similar to those of the other firms until the early 1990s. However, in the mid-1990s, their foreign demands sharply increased around the Asian financial crisis and have remained elevated since. At their 2007 peak, they were 8.3 times higher than those of other firms. Panels C and D display the top 3 firms' relative labor and capital distortions. In the 1970s, there were drops in both distortions and rebounds

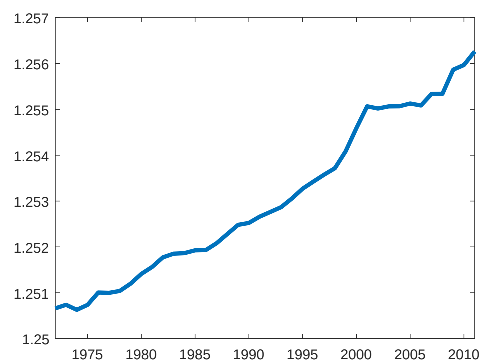
Figure 3. Aggregate Productivity, Markup, and Markdown



A. Aggregate productivity A_t



B. Aggregate markup $\mathcal{M}_t$



C. Aggregate markdown $\mathcal{M}_t^L$

Notes. This figure plots the aggregate productivity, markup, and markdown defined in equations (2.21) and (2.22).

after the early 1980s. These drops are potentially due to large-scale industrial policy that subsidized large-sized heavy manufacturing firms (Choi and Levchenko, 2021; Kim et al., 2021). However, that trend reversed after the end of large-scale industrial policy. Large firms' relative distortions fell again from the late 1980s to about 2000, before increasing back to the early 1970s levels by 2010. Overall, there is no long-run net change in the top-3 firms' relative distortions between 1970 and 2010.

Figure 3 plots the aggregate productivity, markup, and markdown, defined in equations (2.21) and (2.22). Note that the weights and expressions are consistent with theoretical aggregation. The aggregate productivity increased around 140%. However, despite the increased concentration, the

Table 2: Decomposition of the Aggregate Top-3 Concentration Ratio

Period	1972–1982	1982–1992	1992–2002	2002-2011	1972-2011
△ Agg. Top 3 CR (pp)	4.23	2.86	7.15	1.96	16.19
Within-sector Component	−0.43	1.43	4.22	1.59	6.74
Cont. Top 3 – Productivity	−3.71	1.33	1.56	2.12	1.19
Cont. Top 3 – Exports	−0.25	0.43	2.98	-0.91	2.00
Entry & exit	3.53	−0.33	−0.32	0.38	3.55
Across-sector component	4.66	1.43	2.93	0.37	9.45

Notes. This table presents the decomposition results of the aggregate top-3 concentration ratio based on equation (2.24). All units are percentage points.

aggregate markup and markdown increased by less than 1%.

Decomposing the concentration ratio We decompose the observed increase in the aggregate top 3 concentration ratio into the three components following Proposition 3(ii) (equation 2.24): relative improvement of firms that were continuously in the top 3, entry and exit margins, and sectoral reallocation.[20] Table 2 reports the decomposition results.[21] Over the entire 40-year period, 58% of the increase in concentration (9.45 out of 16.19) was driven by the reallocation towards sectors with the largest firms. The remaining 42% (6.74 out of 16.19) is split essentially 50/50 between the better performance by the continuing top-3 firms, and by the extensive margin of new firms entering the top-3.

The long run hides some interesting heterogeneity across periods. Almost half of the cross-sectoral reallocation component (4.66 out of 9.45) came in the first decade on the sample, the period of large-scale industrial policy and dramatic transformation of South Korea into a heavy manufacturing powerhouse. The sectoral reallocation force weakened by the 2000s. The 1970s was also the period responsible for the majority of the churning in and out of the top-3 set (3.53 out of the total of 3.55). In fact, in the 1970s the continuing top-3 firms underperformed, contributing negatively to the rise in concentration.

For the rest of the period structural change and new entry into the top-3 become less important.

[20] Due to approximation errors, we apply the decomposition year-to-year and sum each component over years within each sub-period. Specifically, between $t-p$ and t, we apply the decomposition to $\ln \frac{CR^3_\tau}{CR^3_{\tau-1}}$ between $\tau-1$ and τ, and then sum each component from $t+1-p$ to t as $\ln \frac{CR^3_t}{CR^3_{t-p}} = \sum_{\tau=t+1-p}^{t} \ln \frac{CR^3_\tau}{CR^3_{\tau-1}}$.

[21] The reason why the numbers of the changes in aggregate top 3 concentration ratio do not exactly align with Figure 1 is that we truncate some outliers and take the 5-year rolling moving averages.

Instead, the continuing top-3 firms enjoy a productivity growth advantage, and an expansion in the relative foreign market access in the 1990s.

Large firms We next examine the quantitative importance of the differential microeconomic shocks faced by the largest firms for aggregate growth, market concentration, and welfare. We compare the baseline economy with a series of counterfactual economies in which we set various shocks of the top 3 firms to the unweighted average shocks in their sector, while other firms' shocks remain the same as the baseline. This exercise is motivated by Figure 2, which showed that the large firms experienced shocks with different trends relative to those of other firms.

The spirit of the counterfactual exercise is to ask, what would the economy have looked like had the top-3 firms productivity, market access, and distortions grew at the same rate as the "typical" firm in the sector? Defining "typical" is not completely straightforward in our dataset, which exhibits a great deal of firm entry over this period. Younger firms are known to grow faster than older ones, and the top-3 firms tend to be older on average. To address this compositional effect, we adopt the following procedure to calculate the "typical" firm average to apply to the top-3 firms in the counterfactuals.

Denote by a $\widehat{X}$ the unweighted average DHS growth rate (Davis et al., 1998) of a variable among a subset of firms:

$$\widehat{X}^a_{jt} = \sum_{f\in\mathcal{F}^a_{jt}\cap\mathcal{F}^{cont,nz}_{jt}} \underbrace{\frac{X_{fjt}-X_{fj,t-1}}{2(X_{fjt}+X_{fj,t-1})}}_{=\widehat{X}_{fjt}}, \tag{4.1}$$

for $X_{fjt} \in \{a_{fjt}, D^x_{fjt}, 1+\tau^L_{fjt}, 1+\tau^K_{fjt}\}$. $\mathcal{F}^a_{jt}$ is the set of sector j firms of age bin a. When computing the unweighted average, we restrict the set of firms to satisfy two conditions denoted by $\mathcal{F}^{cont,nz}_{jt} := \{f|t^{\text{entry}}_f < t, X_{fj,t-1} \neq 0, X_{fjt} \neq 0\}$, where t^{entry}_f is firm f's entry year.[22] We impose the two conditions that firms consecutively operated in $t-1$ and t ($t^{\text{entry}}_f < t$) and their values of X_{fjt} were non-zero in $t-1$ and t ($X_{fj,t-1} \neq 0$, $X_{fjt} \neq 0$). The latter condition only applies to foreign demand shocks, because $\{a_{fjt}, 1+\tau^L_{fjt}, 1+\tau^K_{fjt}\}$ are almost surely non-zero for operating firms. This condition implies that when computing the average growth for foreign demand shocks, we restrict the set of firms to be exporters consecutively in $t-1$ and t ($D^x_{fj,t-1} > 0$, $D^x_{fjt} > 0$). We compute the unweighted average within age bins to account for the fact that young firms exhibit different growth patterns compared with older firms (e.g., Decker et al., 2014, 2016), and that shock processes may differ depending on firm age (e.g., Luttmer, 2007; Arkolakis, 2016; Sterk et al., 2021).

Using these computed unweighted averages, for the top-3 firm f in sector j of age bin a, we

[22] Note that firms that exit in t are dropped when calculating the average growth rates.

construct sequences of the counterfactual shocks:

$$X^c_{fjt} = \begin{cases} X_{fjt} & \text{if} \quad f \notin \mathcal{F}^{cont,nz}_{jt} \\ (1+\widehat{X}^a_{jt})X^c_{fj,t-1} & \text{if} \quad f \in \mathcal{F}^{cont,nz}_{jt} \cap \mathcal{F}^3_{jt} \\ (1+\widehat{X}_{fjt})X^c_{fj,t-1} & \text{if} \quad f \in \mathcal{F}^{cont,nz}_{jt} \cap (\mathcal{F}_{jt}/\mathcal{F}^3_{jt}). \end{cases} \tag{4.2}$$

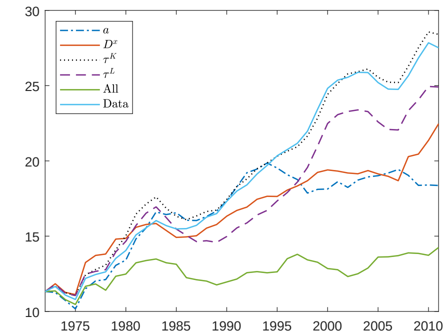
The first line implies that we assign the factual values of shocks for firms entering the top-3 in t or firms that have zero values of X_{fjt} in either $t-1$ or t ($f \notin \mathcal{F}^{cont,nz}_{jt}$). For example, we apply the factual values of foreign demand shocks in levels in t when a firm starts exporting in t regardless of its top-3 status. The second line implies that for the top-3 firms ($f \in \mathcal{F}^3_{jt}$), we apply the unweighted average $\widehat{X}^a_{jt}$. By applying $(1+\widehat{X}^a_{jt})X^c_{fj,t-1}$, we make the top-3 firms grow at the same rate as the other firms within the same sector and age bin. The exercises that feed the counterfactual shocks to these top-3 firms can be viewed as removing the "granular residual" studied in Gabaix (2011).[23] In the third line, for firms that are not in the top 3 group in t ($f \in \mathcal{F}_{jt}/\mathcal{F}^3_{jt}$), we apply the factual growth rate $\widehat{X}_{fjt}$.

Figure 4 presents the quantitative results. Panel A displays results for the top-3 concentration ratio. The light blue solid line displays the concentration ratio in the data. In the data the concentration ratio rose from 11.32% in 1972 to 27.51% in 2011, a 143% increase.The solid green line shows what would happen if all 4 shocks to the top-3 firms were replaces with the corresponding unweighted averages. In this case, the top 3 concentration ratio would have increased only to 14.25% in 2011 – a 26% increase. Thus, in this counterfactual the growth in the concentration ratio is 5.5 times smaller than in the data. The rest of the lines display concentration for one shock at a time. Productivity shocks (dashed-dotter blue line) had the most significant impact on firm concentration, with the elimination of the top 3 productivity shocks reducing the concentration ratio to 18.37% in 2011. The foreign demand shock had the second largest impact, bringing the concentration ratio down to 22.46% in 2011. In contrast, labor and capital distortions had more limited impacts.

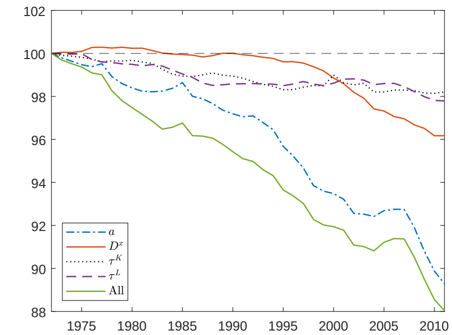
Panel B shows the real GDP per capita of the counterfactuals relative to that of the baseline. Replacing the top 3 shocks with the averages would have led to a nearly 12% lower real GDP per capita by 2011. Notably, the productivity shock emerges as the primary driver, with other shocks playing a more restrained role. It is noteworthy that foreign demand shocks significantly contribute to explaining the concentration ratio, while their impacts on real GDP is much smaller. This discrepancy is attributed to general equilibrium effects. The reduction in export demand by the top-3 firms results in lower wages, stimulating production by other firms. The decreased production due to lower foreign demand shocks from the top 3 firms is largely offset by the increased production from other firms due

[23] According to Gabaix (2011), the granular residual of the top 3 firms within sectors are defined as $\sum_{f\in\mathcal{F}^3_{jt}} \frac{r_{fjt}}{GDP_t}(\widehat{X}_{fjt} - \widehat{X}^a_{jt})$. In the counterfactuals, because we are replacing $\widehat{X}_{fjt}$ with $\widehat{X}^a_{jt}$, we are removing the the top-3 firm granular residual.

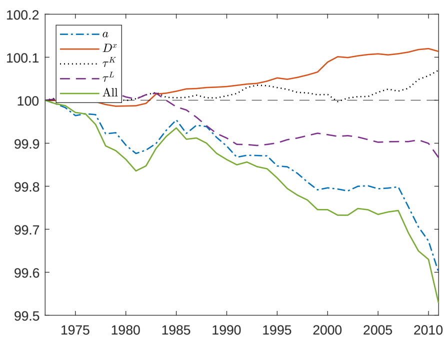
Figure 4. The Impact of the Top 3 Micro Shocks



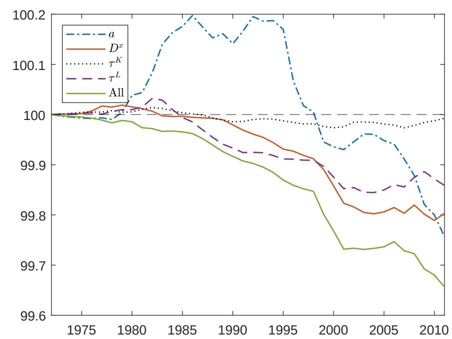
A. Top 3 Mfg. CR (%)



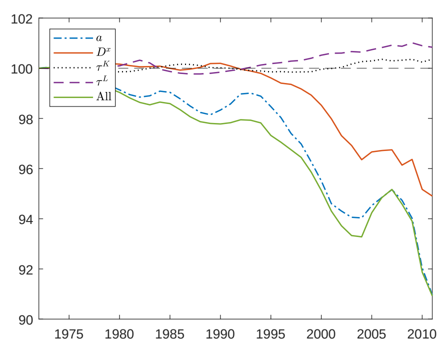
B. Real GDP Relative to Data (%)



C. $\mathcal{M}_t$ Relative to Baseline (%)



D. $\mathcal{M}_t^L$ Relative to Baseline (%)



E. A_t Relative to Baseline (%)

Notes. This figure illustrates counterfactual top-3 concentration ratio (Panel A), real GDP per capita (B), aggregate markup (C), markdown (D), and productivity (E) relative to the baseline, under the counterfactual sequences of the top 3-firms' shocks defined in equation (4.2).

Table 3: Welfare Effects of the Top-3 Micro Shocks

Shocks	All shocks	Productivity a_{fjt}	Foreign demand D^f_{fjt}	Labor distortion $1+\tau^L_{fjt}$	Capital distortion $1+\tau^K_{fjt}$
	(1)	(2)	(3)	(4)	(5)
	Panel A. Top 3 firms within sectors				
△ Welfare (%)	−3.60	−2.30	−0.60	−0.81	−0.72
	Panel B. Samsung Electronics				
△ Welfare (%)	−0.70	−0.55	−0.36	−0.04	−0.15
	Panel C. Hyundai Motor				
△ Welfare (%)	−0.34	−0.27	−0.07	−0.03	−0.03

Notes. Panels A, B, and C report the welfare effects when we replace sequences of shocks of the top-3 firms, Samsung Electronics, and Hyundai Motors with the counterfactual sequences of shocks defined in equation (4.2).

to lower wages.

In Panels C, D, and E, we examine the theory-based aggregate productivity, markups, and markdowns. Substituting the top 3 shocks with the averages would reduce the aggregate productivity by 9.07%. However, its impacts on the markup and the markdown are essentially negligible, resulting in only about a 0.47% and 0.34% decrease, respectively. Shutting down the top-3 foreign demand increases the markup but decreases the markdown. Higher foreign demand induces the top-3 firms to charge lower markup on average due to a constant markup in the foreign market. Nevertheless, higher foreign demand also increases their demand for labor, which in turn lead to higher employment shares and higher markdown. These results echo the finding in Figure 3 that in spite of the large increase in concentration, the aggregate markup and markdown changes over this 40-year period have been quite small.

Table 3 reports the welfare effects in these counterfactuals. Welfare is measured in consumption equivalent variation. We compute λ that equates the discounted welfare of the baseline to that of the counterfactual: $\sum_{t=1972}^{2011} \beta^{t-1972} U((1+\lambda)C_t, L_t) = \sum_{t=1972}^{2011} \beta^{t-1972} U(C_t^c, L_t^c)$, where C_t^c and L_t^c are the counterfactual consumption and labor supply. We find that replacing all of the top-3 firms' shocks with the averages would have decreased welfare by as much as 3.60%. Consistent with the concentration ratio and real GDP, productivity had the largest welfare effects, decreasing welfare by 2.30%, followed by labor (−0.81%) and capital (−0.72%) distortions. Foreign demand had negligible welfare effects. If we replace the top 3's growth in distortions with the unweighted average, the top-3 firms' levels of $1+\tau^L_{fjt}$ and $1+\tau^K_{fjt}$ rose above 1, making them face higher costs of labor and capital

Table 4: Counterfactual. Welfare Effects of Market Structure

Goods market Labor market	Oligopoly Monopsonistic compet.	Monopolistic compet. Oligopsony	Monopolistic compet. Monosonistic compet.
	(1)	(2)	(3)
$\triangle$ Welfare (%)	-0.01	0.97	0.97

Notes. This table reports the welfare effects of market structure.

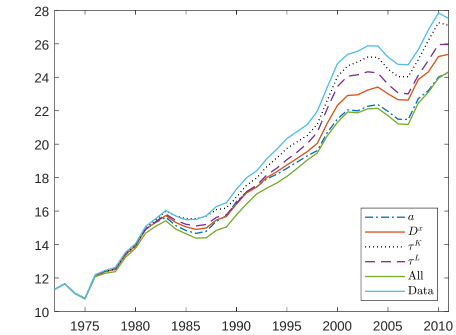
and therefore decreasing welfare.

In the previous counterfactual exercises, we showed that micro shocks experienced by the top-3 firms have different macroeconomic implications. We now push this finding further and examine how one large firm contributes to the aggregate economy. We focus on South Korea's two largest firms, Samsung Electronics and Hyundai Motors. In 2011, they accounted for 7.1% and 2.5% of total manufacturing gross output, respectively. For these two firms, we construct hypothetical sequences of shocks under the assumption that the shocks grew at the rate of the unweighted averages, similar to the previous top-3 counterfactual exercises. Staring from the initial 1972 level, we sequentially multiply the unweighted average growth to the previous levels of shocks of these two firms.

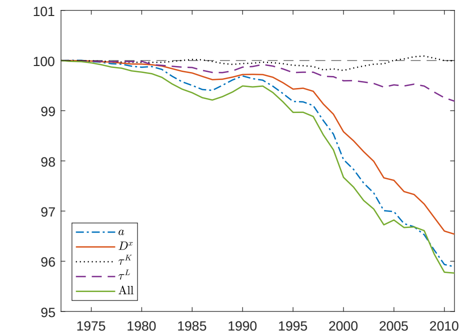
Figure 5 reports the results for this counterfactual. Restricting Samsung's productivity in this way would have reduced concentration. Without Samsung's productivity growth, the top 3 firms' concentration ratio would have decreased by 3.2 percentage points in 2011. While concentration would have declined, so too would have real output: the real GDP in 2011 would have been 4.1% below that of the baseline (Panel B of Figure 5). Also, without Samsung's idiosyncratic productivity growth, the welfare would have been 0.70% lower (Panel B of Table 3). Thus, Samsung alone is responsible for 34% of the GDP and 20% of the welfare impact of the differential trends of the set of the top firms.

Figure 6 reports the same results for Hyundai Motors. Overall, the effects are smaller, reflecting Hyundai's smaller size compared to Samsung. At the peak of its impact around 2000, removing Hyundai's relatively favorable shocks would have decreased real GDP by about 0.75%. Interestingly, by the end of the period, GDP would have been modestly higher had Hyundai been more "typical." This is accounted for by Hyundai's relatively poor productivity performance in the 2000s, and by the relatively unfavorable labor distortions that characterized it in that period. Setting Hyundai's labor distortions to the average level would have actually raised South Korean GDP in the 2000s. Panel C of Table 3 reports that over the whole period, however, the NPV of South Korean welfare would

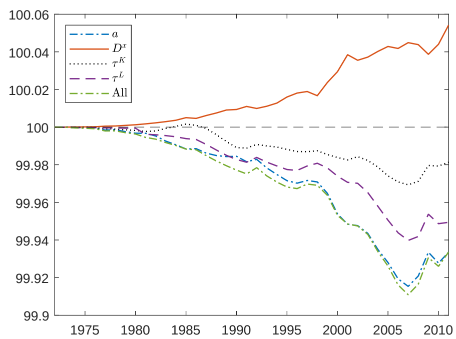
Figure 5. The Impact of the Micro Shocks of Samsung Electronics



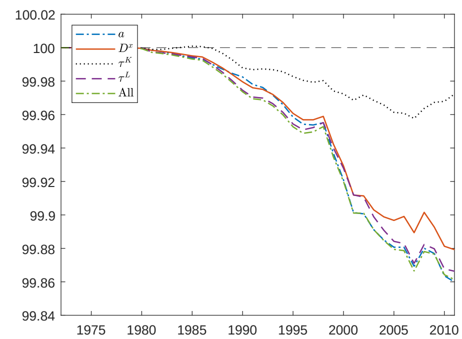
A. Top 3 Mfg. CR (%)



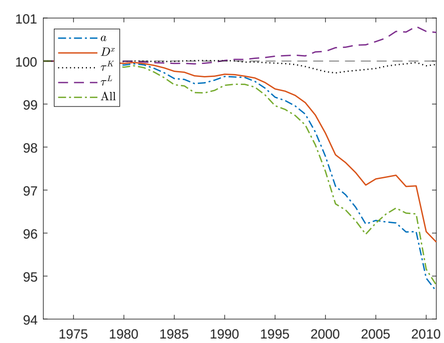
B. Real GDP Relative to Data (%)



C. $\mathcal{M}_t$ Relative to Baseline (%)



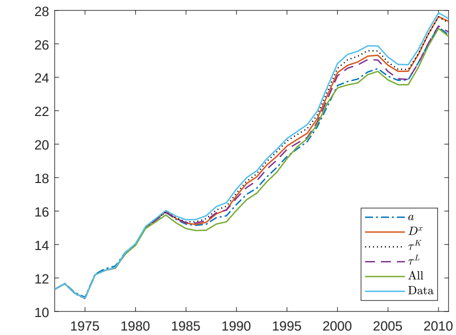
D. $\mathcal{M}_t^L$ Relative to Baseline (%)



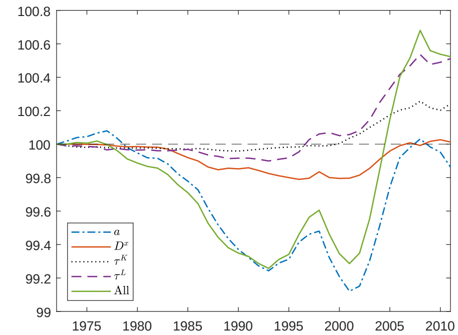
E. A_t Relative to Baseline (%)

Notes. This figure illustrates counterfactual top-3 concentration ratio (Panel A), real GDP per capita (B), aggregate markup (C), markdown (D), and productivity (E) relative to the baseline, when we replace the sequences of shocks of Samsung Electronics with the hypothetical sequences of shocks defined in equation (4.2).

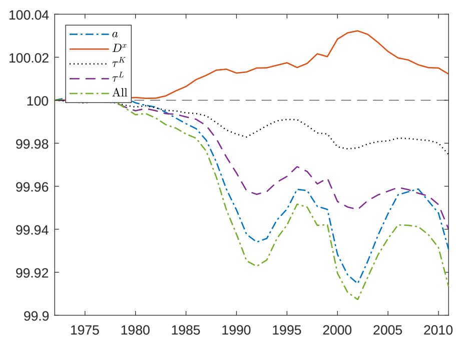
Figure 6. The Impact of the Micro Shocks of Hyundai Motors



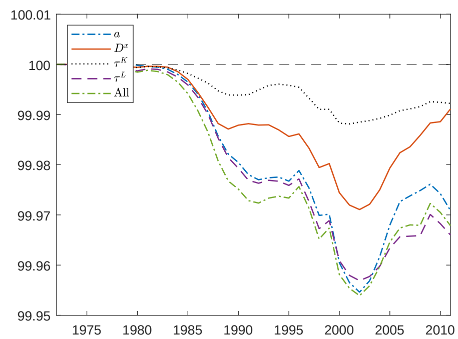
A. Top 3 Mfg. Concentration Ratio (%)



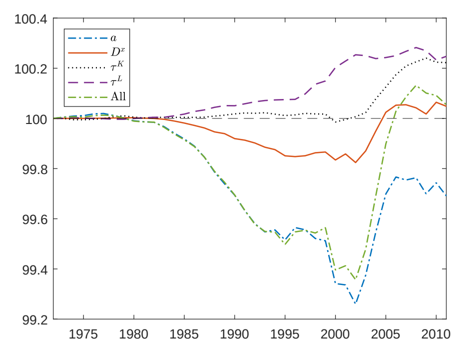
B. Real GDP Relative to Data (%)



C. $\mathcal{M}_t$ Relative to Baseline (%)



D. $\mathcal{M}_t^L$ Relative to Baseline (%)



E. A_t Relative to Baseline (%)

Notes. This figure illustrates counterfactual top-3 concentration ratio (Panel A), real GDP per capita (B), aggregate markup (C), markdown (D), and productivity (E) relative to the baseline, when we replace replace the sequences of shocks of Hyundai Motor with the hypothetical sequences of shocks defined in equation (4.2).

have been 0.34% lower had Huyndai been a "typical" firm.

Market structure We examine the welfare effects of oligopolistic and oligopsonistic market power by re-solving the model under different market structures, while maintaining the same firm-level shocks. In particular, we adopt the monopolistic and monopsonistic competition frameworks, in which large firms' markups and markdowns are the same as other firms'. Table 4 reports the differences in welfare compared to the baseline under three alternative market structures. Without oligopolistic market power, the welfare increases by around 0.97%, while the removal of oligopsonistic market power has negligible welfare impacts. The concentration ratio increases by about 3.2% under monopolistic competition in goods markets because under oligopoly, firms charge higher prices and produce less, leading to lower revenues (Appendix Figure B5).

Robustness We perform robustness checks on the main counterfactual exercise using different sets of parameter values. For each set, we reestimate production function parameters and recalibrate the shocks to exactly fit the baseline model to the data. First, instead of the baseline σ, we use the estimates from Broda and Weinstein (2006) and estimate production function parameters based on these alternative values. We find larger magnitudes because some sectors that include large firms, such as Electronics, had lower σ_j, making large firms less substitutable. We consider an alternative lower value of 2 for ρ_j (Boehm et al., 2023). With a lower ρ_j, foreign goods become less substitutable than domestic varieties, making it more challenging to substitute the loss of the top-3 firms' production, resulting in smaller magnitudes of the effects. We consider alternative values of 3 and 6 for η, which are the lower and the upper range of the previous estimates in the literature. Lastly, we consider alternative values of 0 and 0.5 for ζ. The results remain robust to these alternative values. The detailed results are reported in Appendix Table B4.

5 Conclusion

Using the novel historical data, we document a novel fact about South Korea's growth miracle periodo: a dramatic increase in firm concentration. To understand the driving forces and macro consequences this trend, we build a quantitative small open economy heterogeneous firm model in which firms have oligopolistic and oligopsonistic market power in domestic goods and labor markets, and firms are subject to idiosyncratic distortions and foreign demand. The model allows us to disentangle which factors drove the increase in concentration. We find roles for betwee- and within-sector churning and for productivity and market access in the overall concentration increase. Our counterfactual exercises show that productivity growth of a few large firms had a sizable impact on real GDP, firm concentration, and the average markup and markdown levels of the economy. Our findings highlight the importance of large firms' contributions to economic growth. They also show that an increase in concentration need not be a symptom of economic malaise. Indeed, in South Korea the rise of large firms has been quite a positive phenomenon: it was driven by productivity growth but accompanied by only a limited increase in markups and markdowns.

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ONLINE APPENDIX

(NOT FOR PUBLICATION)

Appendix A Proofs and Derivations

Derivation of equation (2.6) Lagrangian for the profit maximization problem is

$$\max_{y_{fj}^d, y_{fj}^x, l_{fj}, k_{fj}, m_{fj}} p_{fj}^d y_{fj}^d + p_{fj}^x y_{fj}^x - (1+\tau_{fj}^L) w_{fj} l_{fj} - (1+\tau_{fj}^K) R k_{fj} - P_j^M m_{fj} + \lambda(y_{fj} - y_{fj}^d - y_{fj}^x),$$

where λ is the Lagrangian multiplier of the resource constraint. Taking the first order conditions with respect to y_{fj}^d, y_{fj}^x, and l_{fj},

$$p_{fj}^d + y_{fj}^d \frac{\partial p_{fj}^d}{\partial y_{fj}^d} = p_{fj}^d \Big(1 + \frac{\partial \ln p_{fj}^d}{\partial \ln y_{fj}^d}\Big) = \lambda, \qquad p_{fj}^x + y_{fj}^x \frac{\partial p_{fj}^x}{\partial y_{fj}^x} = p_{fj}^x \Big(1 + \frac{\partial \ln p_{fj}^x}{\partial \ln y_{fj}^x}\Big) = \lambda,$$

$$\lambda \frac{\partial y_{fj}}{\partial l_{fj}} = (1+\tau_{fj}^L)\Big(w_{fj} + \frac{\partial w_{fj}}{\partial l_{fj}} l_{fj}\Big) = (1+\tau_{fj}^L) w_{fj} \Big(1 + \frac{\partial \ln w_{fj}}{\partial \ln l_{fj}}\Big),$$

where $-\frac{\partial \ln p_{fj}^d}{\partial \ln y_{fj}^d} = -\epsilon(s_{fj}^d, \lambda_j^H)^{-1}$ and $-\frac{\partial \ln p_{fj}^x}{\partial \ln y_{fj}^x} = -\frac{1}{\sigma_j}$, and $\frac{\partial \ln w_{fj}}{\partial \ln l_{fj}} = \epsilon^L(s_{fj}^L)$. Combining the above three first order conditions gives the expression in equation (2.6).

Derivation of equation (2.7) We show that ϵ_{fj} can be written as domestic sale and import shares. The inverse demand function is expressed as $p_{fj}^d = F_j^{-\frac{1}{\sigma_j}} (y_{fj}^d)^{-\frac{1}{\sigma_j}} (Y_j^H)^{\frac{1}{\sigma_j} - \frac{1}{\rho_j}} (Y_j)^{\frac{1}{\rho_j} - 1} E_j$. From this, we can derive that

$$\epsilon_{fj}^{-1} = -\frac{\partial \ln p_{fj}^d}{\partial \ln y_{fj}^d} = \frac{1}{\sigma_j} + \Big(\frac{1}{\rho_j} - \frac{1}{\sigma_j}\Big) \frac{\partial \ln Y_j^H}{\partial \ln y_{fj}^d} + \Big(1 - \frac{1}{\rho_j}\Big) \frac{\partial \ln Y_j}{\partial \ln y_{fj}^d}. \tag{A.1}$$

Note that $\frac{\partial \ln Y_j^H}{\partial \ln y_{fj}^d} = s_{fj}^d$ and that $\frac{\partial \ln Y_j}{\partial \ln y_{fj}^d} = \underbrace{\frac{\partial \ln Y_j}{\partial \ln Y_j^H}}_{=\lambda_j^H} \underbrace{\frac{\partial \ln Y_j^H}{\partial \ln y_{fj}^d}}_{=s_{fj}^d}$. Substituting these two expressions into equation (A.1) gives

$$\epsilon_{fj}^{-1} = \frac{1}{\sigma_j} + \Big(\frac{1}{\rho_j} - \frac{1}{\sigma_j}\Big) s_{fj}^d + \Big(1 - \frac{1}{\rho_j}\Big) \lambda_j^H s_{fj}^d.$$

Note that if firms take Y_j as given, $\epsilon_{fj}^{-1} = \frac{1}{\sigma_j} + \Big(\frac{1}{\rho_j} - \frac{1}{\sigma_j}\Big) s_{fj}^d$. In a closed economy, $\lambda_j^H = 1$ and therefore $\epsilon_{fj}^{-1} = \frac{1}{\sigma_j} + \Big(\frac{1}{\rho_j} - \frac{1}{\sigma_j}\Big) s_{fj}^d$. If $\sigma_j = \rho_j$, $\epsilon_{fj}^{-1} = \frac{1}{\sigma_j} + \Big(\frac{1}{\rho_j} - \frac{1}{\sigma_j}\Big) \lambda_j^H s_{fj}^d$ holds.

Derivation of equation (2.8) The inverse labor supply function can be written as

$$w_{fj} = F_j^{\frac{1}{\eta}} l_{fj}^{\frac{1}{\eta}} L_j^{\frac{1}{\theta} - \frac{1}{\eta}} W,$$

where firms internalize l_{fj} and L_j and take W as given. From this inverse labor supply function, we can derive that

$$(\epsilon^L_{fj})^{-1} = \frac{\partial \ln w_{fj}}{\partial \ln l_{fj}} = \frac{1}{\eta} + \left(\frac{1}{\theta} - \frac{1}{\eta}\right) \underbrace{\frac{\partial \ln L_j}{\partial \ln l_{fj}}}_{=s^L_{fj}}$$

Derivation of equation (2.11) Using equation (2.10), we obtain

$$l_{fj} = \frac{\gamma^L_j p^e_{fj} y_{fj}}{\mu^e_{fj} \mu^L_{fj} (1+\tau^L_{fj}) w_{fj}}, \quad k_{fj} = \frac{\gamma^K_j p^e_{fj} y_{fj}}{\mu^e_{fj} R (1+\tau^K_{fj})}, \quad m_{fj} = \frac{\gamma^M_j p^e_{fj} y_{fj}}{P^M_j \mu^e_{fj}},$$

for $e \in \{d, x\}$. Substituting the above expressions into production function $y_{fj} = a_{fj} l_{fj}^{\gamma^L_j} k_{fj}^{\gamma^K_j} m_{fj}^{\gamma^M_j}$, we obtain

$$y_{fj} = a_{fj} (\mu^e_{fj})^{-\gamma_j} (p^e_{fj} y_{fj})^{\gamma_j} \left(\mu^L_{fj}(1+\tau^L_{fj})\right)^{-\gamma^L_j} (1+\tau^K_{fj})^{-\gamma^K_j} \left(\frac{w_{fj}}{\gamma^L_j}\right)^{-\gamma^L_j} \left(\frac{R}{\gamma^K_j}\right)^{-\gamma^K_j} \left(\frac{P^M_j}{\gamma^M_j}\right)^{-\gamma^M_j}.$$

Rearranging the above expression, we obtain

$$p^e_{fj} = \mu^e_{fj} \left(\mu^L_{fj}(1+\tau^L_{fj})\right)^{\frac{\gamma^L_j}{\gamma_j}} (1+\tau^K_{fj})^{\frac{\gamma^K_j}{\gamma_j}} c_{fj} a_{fj}^{-1/\gamma_j}.$$

Proof of Proposition 1

Proof. Because price differences in domestic and export markets come from variation in market power, a share of quantities produced for domestic to total quantities produced can be written as

$$\Lambda^d_{fj} = \frac{y^d_{fj}}{y_{fj}} = \frac{y^d_{fj}}{y^d_{fj} + y^x_{fj}} = \frac{r^d_{fj}/p^d_{fj}}{r^d_{fj}/p^d_{fj} + r^x_{fj}/p^x_{fj}} = \frac{r^d_{fj}/\mu^d_{fj}}{r^d_{fj}/\mu^d_{fj} + r^x_{fj}/\mu^x_{fj}},$$

where a_{fj} and c_{fj} are canceled out in the last equality. Using the above expression, total quantity produced can be expressed as

$$y_{fj} = (\Lambda^d_{fj})^{-1} y^d_{fj} = (1-\Lambda^d_{fj})^{-1} y^x_{fj}. \tag{A.2}$$

We first derive a formula in equation (2.12). Using that $y^d_{fj} = \frac{1}{F_j}(p^d_{fj})^{-\sigma_j} (P^H_j)^{\sigma_j - \rho_j} P_j^{\rho_j - 1} E_j$ and equation (A.2), we can rewrite equation (2.11) as

$$p^d_{fj} = \left(\mu^d_{fj} \left(\mu^L_{fj}(1+\tau^L_{fj})\right)^{\frac{\gamma^L_j}{\gamma_j}} (1+\tau^K_{fj})^{\frac{\gamma^K_j}{\gamma_j}} \left(\frac{w_{fj}}{W_j}\right)^{\frac{\gamma^L_j}{\gamma_j}} (\Lambda^d_{fj})^{\frac{\gamma_j - 1}{\gamma_j}} a_{fj}^{-\frac{1}{\gamma_j}} B_j W_j^{\frac{\gamma^L_j}{\gamma_j}}\right)^{\frac{\gamma_j}{(1-\sigma_j)\gamma_j + \sigma_j}}, \tag{A.3}$$

where B_j is a collection of R, F_j, P^M_j, P^H_j, P_j, E_j, and the Cobb-Douglas production parameters common across firms within sectors. From the CES property, we can obtain that

$$\frac{w_{fj}}{W_j} = \left(\frac{l_{fj}}{L_j}\right)^{\frac{1}{\eta}} \quad \Rightarrow \quad s^L_{fj} = \frac{w_{fj} l_{fj}}{W_j L_j} = \left(\frac{l_{fj}}{L_j}\right)^{\frac{\eta+1}{\eta}} \quad \Rightarrow \quad \frac{w_{fj}}{W_j} = (s^L_{fj})^{\frac{1}{\eta+1}}.$$

Substituting the above expression into equation (A.3),

$$(p^d_{fj})^{1-\sigma_j} \propto \left(\mu^d_{fj} \big(\mu^L_{fj}(1+\tau^L_{fj})\big)^{\frac{\gamma^L_j}{\gamma_j}} (1+\tau^K_{fj})^{\frac{\gamma^K_j}{\gamma_j}} (s^L_{fj})^{\frac{\gamma^L_j}{\gamma_j(\eta+1)}} a_{fj}^{-\frac{1}{\gamma_j}} (\Lambda^d_{fj})^{\frac{\gamma_j - 1}{\gamma_j}}\right)^{-\frac{\gamma_j}{\frac{\sigma_j}{\sigma_j - 1} - \gamma_j}}. \tag{A.4}$$

Domestic sales shares are

$$s^d_{fj} = \frac{p^d_{fj} y^d_{fj}}{\sum_{g \in \mathcal{F}_j} p^d_{gj} y^d_{gj}} = \frac{\frac{1}{F_j}(p^d_{fj})^{1-\sigma_j} (P^H_j)^{\sigma_j - \rho_j} P_j^{\rho_j - 1} E_j}{\sum_{g \in \mathcal{F}_j} \frac{1}{F_j} (p^d_{gj})^{1-\sigma_j} (P^H_j)^{\sigma_j - \rho_j} P_j^{\rho_j - 1} E_j} = \frac{(p^d_{fj})^{1-\sigma_j}}{\sum_{g \in \mathcal{F}_j} (p^d_{gj})^{1-\sigma_j}}.$$

Substituting equation (A.4) into the above expression gives the desired results.

Second, we derive the expression for wage bill shares in equation (2.13). Substituting $y_{fj} = (\Lambda^d_{fj})^{-1} y^d_{fj}$ into the FOC with respect to labor $w_{fj} l_{fj} = (\mu^d_{fj} \mu^L_{fj}(1+\tau^L_{fj}))^{-1} (\Lambda^d_{fj})^{-1} \gamma^L_j p^d_{fj} y_{fj}$ gives

$$w_{fj} l_{fj} = \left(\mu^d_{fj} \mu^L_{fj} (1+\tau^L_{fj}) \Lambda^d_{fj}\right)^{-1} \gamma^L_j p^d_{fj} y^d_{fj} = \left(\mu^d_{fj} \mu^L_{fj}(1+\tau^L_{fj})\right)^{-1} (\Lambda^d_{fj})^{-1} \gamma^L_j s^d_{fj} (\sum_{g \in \mathcal{F}_j} p^d_{gj} y^d_{gj}),$$

where the last equality comes from dividing and multiplying $\sum_{g \in \mathcal{F}_j} p^d_{gj} y^d_{gj}$. Substituting the above expression into wage bill shares $s^L_{fj} = \frac{w_{fj} l_{fj}}{\sum_{g \in \mathcal{F}_j} w_{gj} l_{gj}}$ gives the desired result, because $\sum_{g \in \mathcal{F}_j} p^d_{gj} y^d_{gj}$ is canceled out in the numerator and the denominator of the wage bill shares.

Third, we derive the expression for capital shares in equation (2.14). We proceed similarly to the wage bill shares. Substituting $k_{fj} = (\mu^d_{fj}(1+\tau^K_{fj}))^{-1} \varrho^{-1} \gamma^K_j p^d_{fj} y_{fj}$ from the first order conditions and $y_{fj} = (\Lambda^d_{fj})^{-1} y^d_{fj}$ into capital shares and dividing both numerator and the denominator by $\sum_{g \in \mathcal{F}_j} p^d_{gj} y^d_{gj}$ give the desired result.

Finally, using equation (2.11) and that $r^x_{fj} = (p^x_{fj})^{1-\sigma_j} D^x_{fj}$ and $r^d_{fj} = (p^d_{fj})^{1-\sigma_j} \frac{1}{F_j} (P^H_j)^{\sigma_j - \rho_j} P_j^{\rho_j - 1} E_j$, we obtain that $s^x_{fj} \propto (\mu^x_{fj}/\mu^d_{fj})^{1-\sigma_j} s^d_{fj} D^x_{fj}$ because domestic demand and total exports and gross output are common across firms, which gives the desired results.

$\square$

Proof of Proposition 2(i) We first derive the expression for the aggregate markup $\mathcal{M}_j$. From the FOC with respect to material inputs (equation (2.10)),

$$P^M_j m_{fj} = (\mu^d_{fj})^{-1} \gamma^M_j p^d_{fj} y_{fj} = (\mu^d_{fj})^{-1} \gamma^M_j \frac{y_{fj}}{y^d_{fj}} \times \frac{p^d_{fj} y^d_{fj}}{p^d_{fj} y^d_{fj} + p^x_{fj} y^x_{fj}} \times \underbrace{(p^d_{fj} y^d_{fj} + p^x_{fj} y^x_{fj})}_{= r_{fj}} = \gamma^M_j (\tilde{\mu}_{fj})^{-1} r_{fj},$$

where the second equality comes from the fact that

$$\mu^d_{fj}\frac{y^d_{fj}}{y_{fj}}\left(\frac{p^d_{fj}y^d_{fj}}{p^d_{fj}y^d_{fj}+p^x_{fj}y^x_{fj}}\right)^{-1}=\mu^d_{fj}\frac{y^d_{fj}}{y_{fj}}\left(\frac{\mu^d_{fj}\frac{y^d_{fj}}{y_{fj}}}{\mu^d_{fj}\frac{y^d_{fj}}{y_{fj}}+\mu^x_{fj}\frac{y^x_{fj}}{y_{fj}}}\right)^{-1}=\mu^d_{fj}\frac{y^d_{fj}}{y_{fj}}+\mu^x_{fj}\frac{y^x_{fj}}{y_{fj}}=\tilde{\mu}_{fj}. \tag{A.5}$$

From the above expressions, we obtain that

$$P^M_jM_j=\sum_{f\in\mathcal{F}_j}P^M_jm_{fj}=\gamma^M_j\Big(\sum_{f\in\mathcal{F}_j}(\tilde{\mu}_{fj})^{-1}\frac{r_{fj}}{R_j}\Big)R_j=\gamma^M_j\Big(\sum_{f\in\mathcal{F}_j}(\tilde{\mu}_{fj})^{-1}s_{fj}\Big)R_j,$$

Plugging in the above expression into equation (2.17), we obtain that $\mathcal{M}_j=(\sum_{f\in\mathcal{F}_j}\tilde{\mu}^{-1}_{fj}s_{fj})^{-1}$.

We now turn our focus on the expression for sectoral markdown $\mathcal{M}^L_j$. From the FOC with respect to labor,

$$(1+\tau^L_{fj})w_{fj}l_{fj}=(\mu_{fj}\mu^L_{fj})^{-1}\gamma^L_jp^d_{fj}y_{fj}=(\tilde{\mu}_{fj}\mu^L_{fj})^{-1}\gamma^L_jr_{fj}=(\tilde{\mu}_{fj}\mu^L_{fj})^{-1}\gamma^L_js_{fj}R_j,$$

where the second equality holds due to equation (A.5) and the third equality comes from the fact that $s_{fj}=r_{fj}/R_j$. Summing both sides across firms,

$$\sum_{f\in\mathcal{F}_j}(1+\tau^L_{fj})w_{fj}l_{fj}=\Big(\sum_{f\in\mathcal{F}_j}(1+\tau^L_{fj})s^L_{fj}\Big)W_jL_j=\gamma^L_j\Big(\sum_{f\in\mathcal{F}_j}(\tilde{\mu}_{fj}\mu^L_{fj})^{-1}s_{fj}\Big)R_j,$$

where the equality comes from that $\sum_{f\in\mathcal{F}_j}w_{fj}l_{fj}=W_jL_j$. Plugging the above expression into the definition of the aggregate markdown (equation (2.17)), we obtain the desired results. □

Proof of Proposition 2(ii) We first show that $\Big[\sum_{f\in\mathcal{F}_j}F^{-1}_j\Big(a_{fj}\frac{\widetilde{TFPR}_j}{\widetilde{tfpr}_{fj}}\Big)^{\sigma_j-1}\Big]^{\frac{1}{\sigma_j-1}}$ holds. By definition, because $R_j=\text{PPI}_j\times Y^r_j$, $\widetilde{TFPR}_j=\text{PPI}_j\times A_j$ holds. Similarly, at firm-level, because $r_{fj}=\tilde{p}_{fj}y_{fj}$, $\widetilde{tfpr}_{fj}=\tilde{p}_{fj}a_{fj}$ also holds. From these relationships,

$$A_j=\widetilde{TFPR}_j(\text{PPI}_j)^{-1}=\widetilde{TFPR}_j\Big(\sum_{f\in\mathcal{F}_j}F^{-1}_j\tilde{p}^{1-\sigma_j}_{fj}\Big)^{\frac{-1}{1-\sigma_j}}=\Big(\sum_{f\in\mathcal{F}_j}F^{-1}_j\Big(a_{fj}\frac{\widetilde{TFPR}_j}{\widetilde{tfpr}_{fj}}\Big)^{\sigma_j-1}\Big)^{\frac{1}{\sigma_j-1}},$$

where the second equality comes from the fact that $\tilde{p}_{fj}=\widetilde{tfpr}_{fj}/a_{fj}$.

Next, we turn our focus on $\widetilde{tfpr}_{fj}$. From the FOC with respect to labor, we obtain that

$$(\gamma^L_j)^{-1}\mu^d_{fj}\mu^L_{fj}(1+\tau^L_{fj})w_{fj}l_{fj}=p^d_{fj}y_{fj}=\frac{p^d_{fj}y^d_{fj}}{p^d_{fj}y^d_{fj}+p^x_{fj}y^x_{fj}}\frac{y_{fj}}{y^d_{fj}}r_{fj}.$$

Using equation (A.5), we can re-express as $l_{fj}=\gamma^L_j\frac{r_{fj}}{\tilde{\mu}_{fj}\mu^L_{fj}(1+\tau^L_{fj})w_{fj}}$. Using the fact that $\frac{w_{fj}}{W_j}=$

$(s^L_{fj})^{\frac{1}{\eta+1}}$,

$$l_{fj} = \gamma_j^L \frac{r_{fj}}{\tilde{\mu}_{fj}\mu^L_{fj}(1+\tau^L_{fj})(s^L_{fj})^{\frac{1}{\eta+1}}W_j}. \tag{A.6}$$

Similarly for other inputs, we obtain the following relationships

$$k_{fj} = \gamma_j^K \frac{r_{fj}}{\tilde{\mu}_{fj}(1+\tau^K_{fj})\varrho} \qquad \text{and} \qquad m_{fj} = \gamma_j^M \frac{r_{fj}}{\tilde{\mu}_{fj}P^M_j}. \tag{A.7}$$

Substituting the above three expressions into the definition of $\widetilde{tfpr}_{fj} = \frac{r_{fj}}{l_{fj}^{\gamma_j^L} k_{fj}^{\gamma_j^K} m_{fj}^{\gamma_j^M}}$, we obtain that

$$\widetilde{tfpr}_{fj} = r_{fj}^{1-\gamma_j}\Big((\tilde{\mu}_{fj}(1+\tau^L_{fj})\mu^L_{fj}(s^L_{fj})^{\frac{1}{\eta+1}}\Big)^{\gamma_j^L}\Big((\tilde{\mu}_{fj}(1+\tau^K_{fj})\Big)^{\gamma_j^K}\Big(\tilde{\mu}_{fj}\Big)^{\gamma_j^M}$$
$$\times (W_j/\gamma_j^L)^{\gamma_j^L}(\varrho/\gamma_j^K)^{\gamma_j^K}(P^M_j/\gamma_j^M)^{\gamma_j^M}. \tag{A.8}$$

Lastly, we turn our focus on $\widetilde{TFPR}_j$. From equation (A.6) and $L_j = (F_j^{\frac{1}{\eta}}\sum_{f\in\mathcal{F}_j} l_{fj}^{\frac{\eta+1}{\eta}})^{\frac{\eta}{\eta+1}}$,

$$\begin{aligned} L_j &= \gamma_j^L\Bigg(F_j^{\frac{1}{\sigma_j}}\sum_{f\in\mathcal{F}_j}\Big(r_{fj}(\tilde{\mu}_{fj}\mu^L_{fj}(1+\tau^L_{fj})(s^L_{fj})^{\frac{1}{\eta+1}}W_j)^{-1}\Big)^{\frac{\eta+1}{\eta}}\Bigg)^{\frac{\eta}{\eta+1}} \\ &= \gamma_j^L\Bigg(F_j^{\frac{1}{\sigma_j}}\sum_{f\in\mathcal{F}_j}\Big(s_{fj}(\tilde{\mu}_{fj}\mu^L_{fj}(1+\tau^L_{fj})(s^L_{fj})^{\frac{1}{\eta+1}}W_j)^{-1}\Big)^{\frac{\eta+1}{\eta}}\Bigg)^{\frac{\eta}{\eta+1}}R_j, \end{aligned} \tag{A.9}$$

where the second equality comes from that $s_{fj} = r_{fj}/R_j$. Similarly, we can obtain

$$K_j = \gamma_j^K\Bigg(\sum_{f\in\mathcal{F}_j} s_{fj}(\tilde{\mu}_{fj}(1+\tau^K_{fj})R^K_j)^{-1}\Bigg)R_j \tag{A.10}$$

and

$$M_j = \gamma_j^M\Bigg(\sum_{f\in\mathcal{F}_j} s_{fj}(\tilde{\mu}_{fj}P^M_j)^{-1}\Bigg)R_j \tag{A.11}$$

Substituting equations (A.9), (A.10), and (A.11) into $\widetilde{TFPR}_j = \frac{R_j}{L_j^{\gamma_j^L}K_j^{\gamma_j^K}M_j^{\gamma_j^M}}$, we obtain

$$\widetilde{TFPR}_j = R_j^{1-\gamma_j}\Bigg[F_j^{\frac{1}{\sigma_j}}\sum_{f\in\mathcal{F}_j}\Big(s_{fj}\big(\tilde{\mu}_{fj}(1+\tau^L_{fj})\mu^L_{fj}(s^L_{fj})^{\frac{1}{\eta+1}}\big)^{-1}\Big)^{\frac{\eta+1}{\eta}}\Bigg]^{-\gamma_j^L\frac{\eta}{\eta+1}}$$
$$\times\Bigg[\sum_{f\in\mathcal{F}_j}s_{fj}\Big(\tilde{\mu}_{fj}(1+\tau^K_{fj})\Big)^{-1}\Bigg]^{-\gamma_j^K}\Bigg[\sum_{f\in\mathcal{F}_j}s_{fj}\Big(\tilde{\mu}_{fj}\Big)^{-1}\Bigg]^{-\gamma_j^M}\times(W_j/\gamma_j^L)^{\gamma_j^L}(\varrho/\gamma_j^K)^{\gamma_j^K}(P^M_j/\gamma_j^M)^{\gamma_j^M}.$$

$\square$

Proof of Proposition 3(i) First, we show that $s_{fj} = \frac{(\tilde{a}_{fj}\phi_{fj})^{\frac{1}{\frac{\sigma_j}{\sigma_j-1}-\gamma_j}}}{\sum_{g\in\mathcal{F}_j}(\tilde{a}_{gj}\phi_{gj})^{\frac{1}{\frac{\sigma_j}{\sigma_j-1}-\gamma_j}}}$ holds. We omit the subscript t for notational convenience and introduce it when necessary. Note that

$$r_{fj} = p^d_{fj}y^d_{fj} + p^x_{fj}y^x_{fj} = (p^d_{fj})^{1-\sigma_j}(P^H_j)^{\sigma_j-\rho_j}P_j^{\rho_j-1}E_j + (p^x_{fj})^{1-\sigma_j}D^x_{fj} \propto (p^d_{fj})^{1-\sigma_j} + (p^x_{fj})^{1-\sigma_j}\tilde{D}^x_{fj},$$

where $\tilde{D}^x_{fj} = D^x_{fj}/(P^H_j)^{\sigma_j-\rho_j}P_j^{\rho_j-1}E_j$ is firm-specific foreign demand relative to domestic demand. Note that domestic demand $(P^H_j)^{\sigma_j-\rho_j}P_j^{\rho_j-1}E_j$ is common across firms.

Using equation (2.11) and the fact that P^d_{fj} and p^x_{fj} only differ in μ^d_{fj} and μ^x_{fj}, we obtain

$$r_{fj} \propto \left(a_{fj}^{-\frac{1}{\gamma_j}}\widetilde{mrpl}_{fj}^{\frac{\gamma_j^L}{\gamma_j}}\widetilde{mrpk}_{fj}^{\frac{\gamma_j^K}{\gamma_j}}\widetilde{mrpm}_{fj}^{\frac{\gamma_j^M}{\gamma_j}}y_{fj}^{\frac{1-\gamma_j}{\gamma_j}}\right)^{1-\sigma_j}\tilde{D}^{x,MA}_{fj}. \tag{A.12}$$

Note that y_{fj} can be expressed as $y_{fj} = (p^d_{fj})^{-\sigma_j}(P^H_j)^{\sigma_j-\rho_j}P_j^{\rho_j}E_j + (p^x_{fj})^{-\sigma_j}D^x_{fj}$ and we can obtain that

$$y_{fj} \propto \left(a_{fj}^{-\frac{1}{\gamma_j}}\widetilde{mrpl}_{fj}^{\frac{\gamma_j^L}{\gamma_j}}\widetilde{mrpk}_{fj}^{\frac{\gamma_j^K}{\gamma_j}}\widetilde{mrpm}_{fj}^{\frac{\gamma_j^M}{\gamma_j}}y_{fj}^{\frac{1-\gamma_j}{\gamma_j}}\right)^{-\sigma_j}\tilde{D}^{x,RTS}_{fj}$$

$$\Leftrightarrow y_{fj}^{\frac{\gamma_j(1-\sigma_j)+\sigma_j}{\gamma_j}} \propto \left(a_{fj}^{-\frac{1}{\gamma_j}}\widetilde{mrpl}_{fj}^{\frac{\gamma_j^L}{\gamma_j}}\widetilde{mrpk}_{fj}^{\frac{\gamma_j^K}{\gamma_j}}\widetilde{mrpm}_{fj}^{\frac{\gamma_j^M}{\gamma_j}}\right)^{-\sigma_j}\tilde{D}^{x,RTS}_{fj}. \tag{A.13}$$

Substituting equation (A.13) into equation (A.12), we obtain that

$$r_{fj} \propto \left(a_{fj}\widetilde{mrpl}_{fj}^{-\gamma_j^L}\widetilde{mrpk}_{fj}^{-\gamma_j^K}\widetilde{mrpm}_{fj}^{-\gamma_j^M}\right)^{\frac{1}{\frac{\sigma_j}{\sigma_j-1}-\gamma_j}}\phi_{fj}^{\frac{1}{\frac{\sigma_j}{\sigma_j-1}-\gamma_j}} \propto (\tilde{a}_{fj}\phi_{fj})^{\frac{1}{\frac{\sigma_j}{\sigma_j-1}-\gamma_j}}.$$

Note that the second relationship holds due to the fact that $\widetilde{MRPL}_j$, $\widetilde{MRPK}_j$, and $\widetilde{MRPM}_j$ are common across firms within sectors. From the above expression, we can express firm sales shares as

$$s_{fj} = \frac{(\tilde{a}_{fj}\phi_{fj})^{\frac{1}{\frac{\sigma_j}{\sigma_j-1}-\gamma_j}}}{\sum_{g\in\mathcal{F}_j}(\tilde{a}_{gj}\phi_{gj})^{\frac{1}{\frac{\sigma_j}{\sigma_j-1}-\gamma_j}}} = \frac{(\tilde{a}_{fj}\phi_{fj})^{\frac{1}{\frac{\sigma_j}{\sigma_j-1}-\gamma_j}}}{\Omega_j}, \tag{A.14}$$

where Ω_j denote the sector-wide denominator.

In the next step, we show that $\Omega_j = (A_j\Phi_j)^{\frac{1}{\frac{\sigma_j}{\sigma_j-1}-\gamma_j}}$.

$$s_{fj} = (\tilde{a}_{fj}\phi_{fj})^{\frac{1}{\frac{\sigma_j}{\sigma_j-1}-\gamma_j}}\Omega_j^{-1} \Rightarrow s_{fj} = (\frac{\tilde{a}_{fj}}{s_{fj}^{1-\gamma_j}}\phi_{fj})^{\frac{1}{\frac{\sigma_j}{\sigma_j-1}-\gamma_j}} s_{fj}^{\frac{1-\gamma_j}{\frac{\sigma_j}{\sigma_j-1}-\gamma_j}}\Omega_j^{-1}$$

$$\Rightarrow s_{fj}^{\frac{1}{\sigma_j-1}} = \left(a_{fj}\frac{\widetilde{TFPR}_j}{\widetilde{tfpr}_{fj}}\right)\phi_{fj}\Omega_j^{-(\frac{\sigma_j}{\sigma_j-1}-\gamma_j)}$$

$$\Rightarrow \left(a_{fj}\frac{\widetilde{TFPR}_j}{\widetilde{tfpr}_{fj}}\right)^{\sigma_j-1} = s_{fj}\phi_{fj}^{1-\sigma_j}\Omega_j^{(\frac{\sigma_j}{\sigma_j-1}-\gamma_j)(\sigma_j-1)}.$$

Summing over both sides across firms,

$$\sum_{f\in\mathcal{F}_{jt}}\left(a_{fj}\frac{\widetilde{TFPR}_j}{\widetilde{tfpr}_{fj}}\right)^{\sigma_j-1} = \sum_{f\in\mathcal{F}_{jt}} s_{fj}\phi_{fj}^{1-\sigma_j}\Omega_j^{(\frac{\sigma_j}{\sigma_j-1}-\gamma_j)(\sigma_j-1)}$$

$$\Rightarrow \underbrace{\left[\sum_{f\in\mathcal{F}_{jt}}\left(a_{fj}\frac{\widetilde{TFPR}_j}{\widetilde{tfpr}_{fj}}\right)^{\sigma_j-1}\right]^{\frac{1}{\sigma_j-1}}}_{=\tilde{A}_j} = \underbrace{\left(\sum_{f\in\mathcal{F}_{jt}} s_{fj}\phi_{fj}^{1-\sigma_j}\right)^{\frac{1}{\sigma_j-1}}}_{=\Phi_j^{-1}}\Omega_j^{(\frac{\sigma_j}{\sigma_j-1}-\gamma_j)},$$

which gives $\Omega_j^{(\frac{\sigma_j}{\sigma_j-1}-\gamma_j)} = \tilde{A}_j\Phi_j$.

Now, we introduce the subscript t to denote for year t. Substituting $\Omega_{jt}^{(\frac{\sigma_j}{\sigma_j-1}-\gamma_j)} = \tilde{A}_{jt}\Phi_{jt}$ into equation (A.14), taking logs, and differencing between $t-p$ and t, we obtain that

$$\ln\frac{s_{fjt}}{s_{fj,t-p}} = \frac{1}{\frac{\sigma_j}{\sigma_j-1}-\gamma_j}\Big(\ln\frac{\tilde{a}_{fjt}/\tilde{A}_{jt}}{\tilde{a}_{fj,t-p}/\tilde{A}_{j,t-p}} + \ln\frac{\phi_{fjt}/\Phi_{jt}}{\phi_{fj,t-p}/\Phi_{j,t-p}}\Big). \tag{A.15}$$

Note that s_{fjt} and $s_{fj,t-p}$ can be re-expressed as

$$s_{fjt} = \frac{r_{fjt}}{\sum_{g\in\mathcal{F}^{3,cont}_{jt,t-p}} r_{gjt}}\frac{\sum_{f\in\mathcal{F}^{3,cont}_{jt,t-p}} r_{fjt}}{\sum_{g\in\mathcal{F}^3_{jt}} r_{gjt}}\frac{\sum_{f\in\mathcal{F}^3_{jt}} r_{fjt}}{\sum_{g\in\mathcal{F}_{jt}} r_{gjt}} = s^{3,cont}_{fjt}S^{3,cont}_{jt}S^3_{jt}. \tag{A.16}$$

$$s_{fj,t-p} = \frac{r_{fj,t-p}}{\sum_{g\in\mathcal{F}^{3,cont}_{jt,t-p}} r_{gj,t-p}}\frac{\sum_{f\in\mathcal{F}^{3,cont}_{jt,t-p}} r_{fj,t-p}}{\sum_{g\in\mathcal{F}^3_{j,t-p}} r_{gj,t-p}}\frac{\sum_{f\in\mathcal{F}^3_{j,t-p}} r_{fj,t-p}}{\sum_{g\in\mathcal{F}_{j,t-p}} r_{gj,t-p}} = s^{3,cont}_{fj,t-p}S^{3,cont}_{j,t-p}S^3_{j,t-p}. \tag{A.17}$$

Define

$$\omega_{fjt,t-p} = \frac{\frac{s^{3,cont}_{fjt}-s^{3,cont}_{fj,t-p}}{\ln s^{3,cont}_{fjt}-\ln s^{3,cont}_{fj,t-p}}}{\sum_{g\in\mathcal{F}^{3,cont}_{jt,t-p}}\frac{s^{3,cont}_{gjt}-s^{3,cont}_{gj,t-p}}{\ln s^{3,cont}_{gjt}-\ln s^{3,cont}_{gj,t-p}}}.$$

We sum across continuing top 3 firms of both sides of equation (A.15) using the weights:

$$\sum_{f\in\mathcal{F}^{3,cont}_{jt,t-p}} \omega_{fjt,t-p} \ln \frac{s_{fjt}}{s_{fj,t-p}} = \frac{1}{\frac{\sigma_j}{\sigma_j-1}-\gamma_j} \sum_{f\in\mathcal{F}^{3,cont}_{jt,t-p}} \Big(\ln \frac{\tilde{a}_{fjt}/\tilde{A}_{jt}}{\tilde{a}_{fj,t-p}/\tilde{A}_{j,t-p}} + \ln \frac{\phi_{fjt}/\Phi_{jt}}{\phi_{fj,t-p}/\Phi_{j,t-p}} \Big). \tag{A.18}$$

Note that the left hand side can be expressed as

$$\sum_{f\in\mathcal{F}^{3,cont}_{jt,t-p}} \omega_{fjt,t-p} \ln \frac{s_{fjt}}{s_{fj,t-p}} = \underbrace{\sum_{f\in\mathcal{F}^{3,cont}_{jt,t-p}} \omega_{fjt,t-p} \ln \frac{s^{t3.cont}_{fjt}}{s^{3,cont}_{fj,t-p}}}_{=0} + \ln \frac{S^{cont,t3}_{jt} S^3_{jt}}{S^{cont,t3}_{j,t-p} S^3_{j,t-p}} \tag{A.19}$$

Combining equations (A.18) and (A.19), we can obtain the desired result. □

Proof of Proposition 3(ii) $S^3_t = \frac{\sum_{j\in\mathcal{J}_M}\sum_{f\in\mathcal{F}^3_{fjt}} r_{fjt}}{\sum_{j\in\mathcal{J}_M}\sum_{f\in\mathcal{F}_{fjt}} r_{fjt}}$ can be written as $S^3_t = \sum_{j\in\mathcal{J}_M} S_{jt}S^3_{jt}$. From this,

$$\frac{S^3_t}{S^3_{t-p}} = \sum_{j\in\mathcal{J}_M} \omega^3_{j,t-p} \frac{S_{jt}}{S_{j,t-p}} \frac{S^3_{jt}}{S^3_{j,t-p}}.$$

Log approximating the above equation, we obtain that

$$\ln \frac{S^3_t}{S^3_{t-p}} \approx \sum_{j\in\mathcal{J}_M} \omega^3_{j,t-p} \Big(\ln \frac{S_{jt}}{S_{j,t-p}} + \ln \frac{S^3_{jt}}{S^3_{j,t-p}} \Big).$$

Substituting equation (2.23) into the above expression gives equation (2.24). □

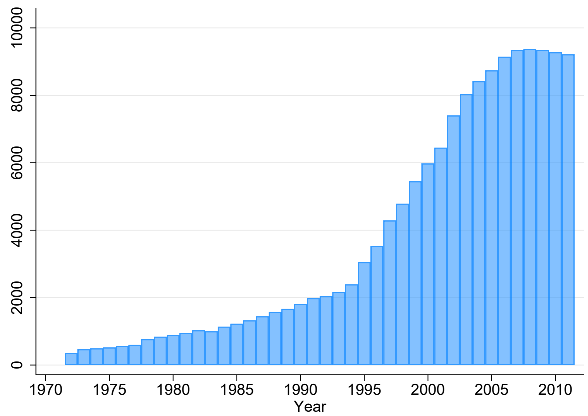
Appendix B Data and Quantification

B.1 Data

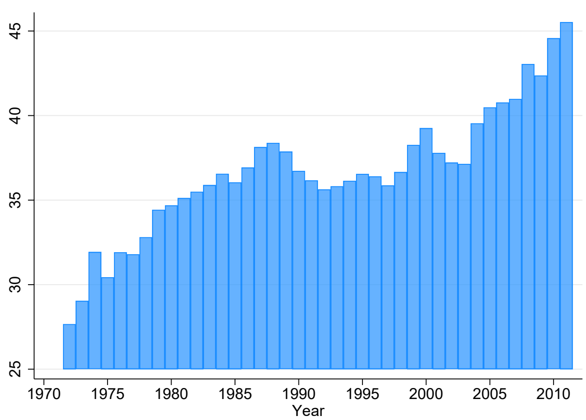
We describe how we constructed our main dataset. The main data set combines three main sources of data. First, firm-level data for 1972 to 1981 comes from constructed by the historical Annual Report of Korean Companies published by the Korea Productivity Center; and the data for 1982 to 2011 comes from KIS-VALUE. The coverage of the data from the Annual Report of Korean Companies is larger than that of KIS-VALUE. Therefore, we use the criterion for inclusion in KIS-VALUE, where asset threshold is roughly 2.3 million USD in 2023. Firms with asset below this threshold in the survey data are excluded. We merge these two firm-level datasets based on their names, years of starting operation, and firms' historical records available on their websites. Finally, firm-level data is merged to the sectoral data obtained from KLEMS and IO tables from Bank of Korea based on firms' industry affiliations. Figure B1 reports the yearly number of observations. Sector classification is listed in Table atable:classification.

One issue is business groups, known as Chaebols, that own multiple firms. We treat each firm within groups as an independent entity. There were three special cases in which existing corporations were closed, and new corporations were formed as big business groups changed their ownership structure by establishing new holding companies. In such cases, we match these existing and new corporations. These cases include LG Electronics in 2002, LG Chemicals in 2002, and SK Innovation in 2007, which were identified by tracking historical records of big business groups.

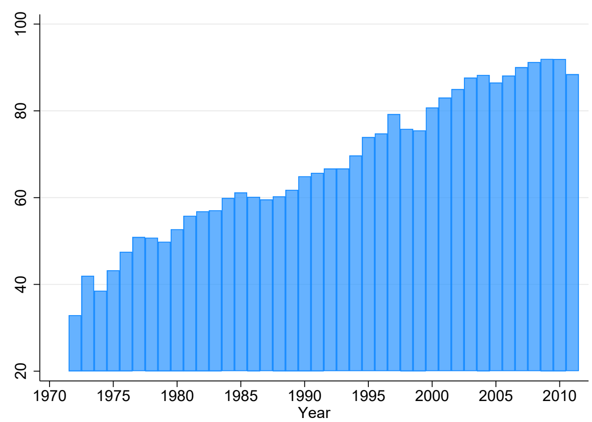
Figure B1. Additional Information of the Data



A. The Number of Mfg. Firm-year Observations



B. Mfg. Sectors' Shares (%) of Gross Output



C. Shares of the Sum of All Mfg. Firms' Sales to Mfg. Gross Output

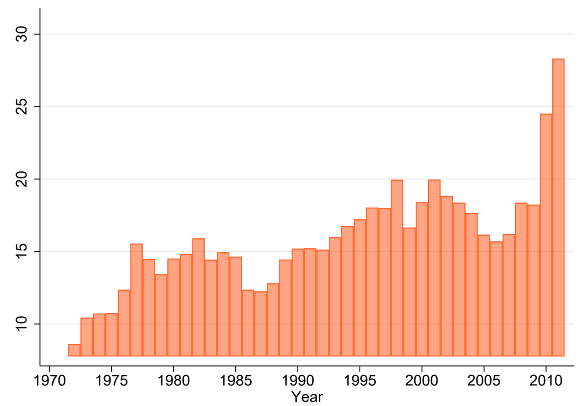
Notes. Panel A reports the number of observations for each year. The total number of firm-year observations is 323,514. The number of unique firms is 23,464. Panel B reports manufacturing sectors' shares of gross output to total gross output.

Table B1: Sector Classification

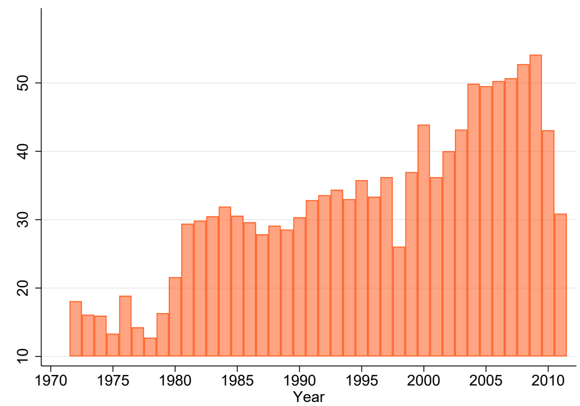
Aggregated Industry	Industry
Petrochemicals*	Coke oven products (231), Refined petroleum products (232)
Chemicals, and rubber and plastic products*	Basic chemicals (241), Other chemical products (242) Man-made fibres (243) except for pharmaceuticals and medicine chemicals (2423) Rubber products (251), Plastic products (252)
Pharmaceuticals*	pharmaceuticals and medicine chemicals (2423)
Electronics*	Office, accounting, & computing machinery (30) Electrical machinery and apparatus n.e.c. (31) Ratio, television and communication equipment and apparatus (32) Medical, precision, and optical instruments, watches and clocks (33)
Metals*	Basic metals (27), Fabricated metals (28)
Machinery, and transportation equipment*	Machinery and equipment n.e.c. (29) Motor vehicles, trailers and semi trailers (34) Manufacture of other transport equipment (35)
Food*	Food products and beverages (15), Tobacco products (16)
Textiles, Apparel, and Leather*	Textiles (17), Apparel (18) Leather, luggage, handbags, saddlery, harness, and footwear (19)
Manufacturing n.e.c.*	Manufacturing n.e.c. (369)
Wood*	Wood and of products, cork (20), Paper and paper products (21) Publishing and printing (22), Furniture (361)
Other nonmetallic mineral products*	Glass and glass products (261), On-metallic mineral products n.e.c. (269)
Commodity	Agriculture, hunting, and forestry (A), Fishing (B)
Mining	Mining and quarrying (C)
Construction	Construction (F)
Utility	Electricity, gas and water supply (E)
Retail	Wholesale and retail trade; repair of motor vehicles, motorcycles and personal and household goods (G)
Transportation	Land transport; transport via pipelines (60) Water transport (61), Air transport (62), Supporting and auxiliary transport activities; activities of travel agencies (63)
Business service	Post and telecommunications (64), Financial intermediation (J) Real estates, renting, and business activities (K)
Other service	Public administration and defence; compulsory social security (L) Education (M), Health and social work (N) Other community, social and personal service activities (O) Activities of private households as employers and undifferentiated production activities of private households (P) Extra-territorial organizations and bodies (Q)

Notes. * denotes for =manufacturing sectors. The numbers inside parenthesis denote ISIC Rev 3.1 codes.

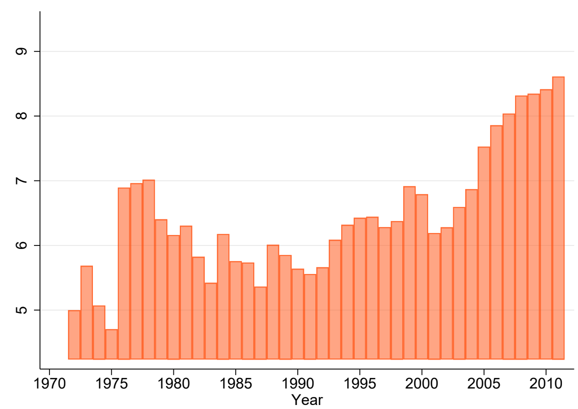
Figure B2. Robustness. The Top 3 Concentration Ratio. Alternative Variables.



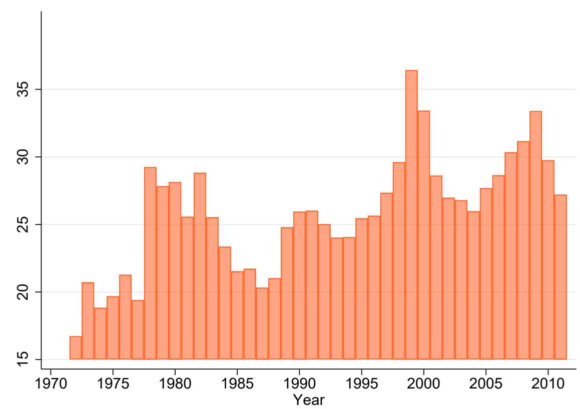
A. Domestic sales



B. Exports



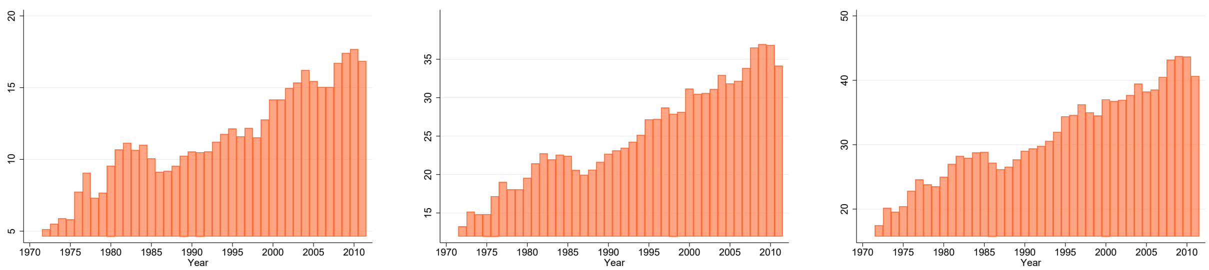
C. Employment



D. Fixed asset

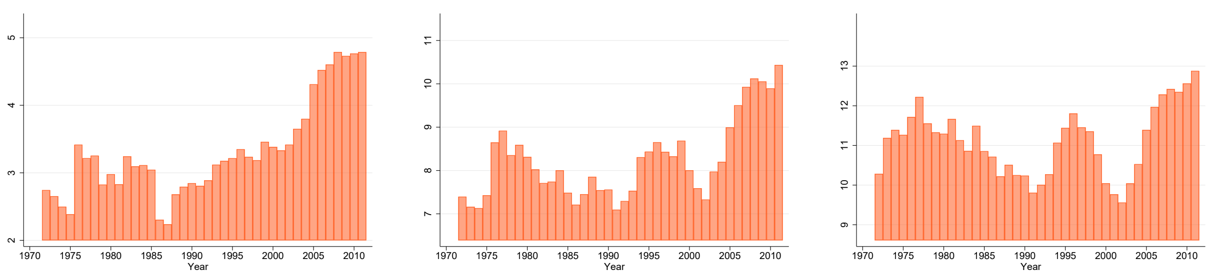
Notes. This figure plots shares of the sum of the top 3 manufacturing firms' domestic sales, exports, employment, and fixed asset across sectors to the total manufacturing gross output net of exports, exports, employment, and fixed asset, respectively. The sectoral data come from KLEMS and IO tables.

Figure B3. Robustness. Concentration Ratio. Alternative Ranking.



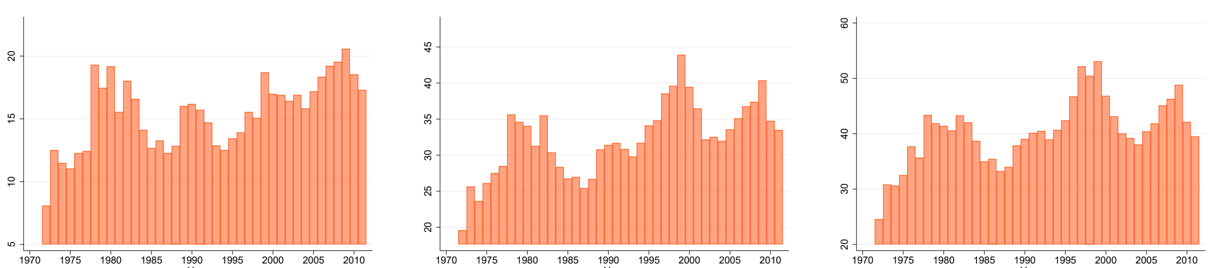
Sale

A. Top 1 B. Top 5 C. Top 10



Employment

D. Top 1 E. Top 5 F. Top 10

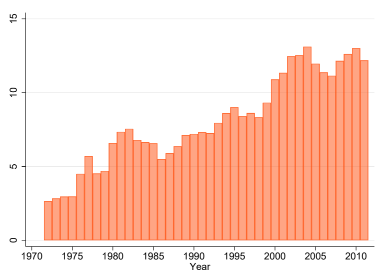


Fixed Asset

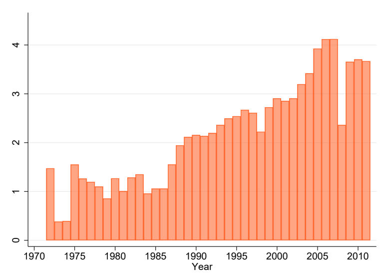
G. Top 1 H. Top 5 I. Top 10

Notes. This figure plots shares of the sum of the top 1, 5, and 10 firms' sales, employment, and fixed asset relative to sectoral gross output, employment, and fixed asset. The sectoral data come from KLEMS and IO tables.

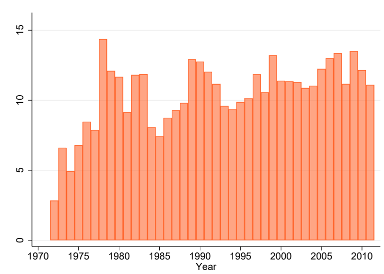
Figure B4. Robustness. Top 3 Concentration Ratio. Whole Manufacturing.



A. Sales



B. Employment



C. Fixed asset

Notes. This figure plots shares of the sum of the top 3 firms' sales, employment, and fixed asset relative to sectoral gross output, employment, and capital. The selection of top firms is based on corresponding variables within the entire manufacturing sector. The sectoral data come from KLEMS and IO tables.

Table B2: List of Top 3 Firms

Sector	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Food	Samyang Food Daehan Flour Sajo Dongah	Sajo Dongah Samyang Food Daehan Flour	Seoul Miwon Samyang Food Hite Jinro	Hite Jinro Samyang Food Sajo Dongah	Samyang Food Hatae Food Hite Jinro	Hatae Food Samyang Food Hite Jinro	Hatae Food Samyang Food Seoul Miwon	Hatae Food Hite Jinro Samyang Food	Hatae Food Sammi Food Samyang Food	Sammi Food Samyang Food Hatae Food
Textile	Hanil Hapsung Dongyang Nylon Banglim	Hanil Hapsung Daenong Dongyang Nylon	Hanil Hapsung Daenong Banglim	Hanil Hapsung Daenong Dongyang Nylon	Hanil Hapsung Kookje Chemical Daenong	Hanil Hapsung Kookje Chemical Daenong	Kookje Chemical Hanil Hapsung Daenong	Hanil Hapsung Kookje Chemical Choongnam Textile	Kookje Chemical Hanil Hapsung Dongyang Nylon	Kookje Chemical Hanil Hapsung Donggook Trading
Wood	Daesung Lumber Hankuk Plywood Kwangmyoung Lumber	Daesung Lumber Hankuk Plywood Kwangmyoung Lumber	Daesung Lumber Hankook Paper Hankuk Plywood	Daesung Lumber Kwangmyoung Lumber Hankuk Plywood	Daesung Lumber Hankuk Plywood Seonchang Industry	Daesung Lumber Seonchang Industry Hankuk Plywood	Daesung Lumber Seonchang Industry Hankuk Plywood	Moolim PNP Daesung Lumber Seonchang Industry	Daesung Lumber Seonchang Industry Hankuk Plywood	Daesung Lumber Seonchang Industry Hyundai Lumber
Print	Honam Petroleum Kyoungin Energy Hyundai Oil Bank	Honam Petroleum Kyoungin Energy Hyundai Oil Bank	Kyoungin Energy Hyundai Oil Bank Mobil Korea	Kyoungin Energy Hyundai Oil Bank Mobil Korea	Honam Petroleum Kyoungin Energy Hyundai Oil Bank	Honam Petroleum Kyoungin Energy Hyundai Oil Bank	Honam Petroleum Kyoungin Energy Hankuk Iran Petroleum	Honam Petroleum Hankuk Iran Petroleum Kyoungin Energy	Honam Petroleum Kyoungin Energy Hankuk Iran Petroleum	Honam Petroleum Kyoungin Energy Hankuk Iran Petroleum
Pharma.	Jong Geun Dang Yuhan Handok Parmaceutical	Daewon Paper Jong Geun Dang Yuhan	Yuhan Jong Geun Dang Handok Parmaceutical	Jong Geun Dang Daewon Paper Yuhan	Yuhan Jong Geun Dang Daewon Paper	Jong Geun Dang Yuhan Daewon Paper	Orient Watch Jong Geun Dang Donghwa Parmaceutical	Yuhan Jong Geun Dang Daewon Paper	Yuhan Jong Geun Dang Orient Watch	Yuhan Jong Geun Dang Orient Watch
Chemical	Hanhwa Solution Lucky Dongseo Petroleum	Hankook Chemical Lucky Wonpoong Industry	Hankuk Fertilizer Lucky Hankook Chemical	Namhae Chemical Lucky Hankook Chemical	Lucky Jinyang Industry Wonpoong Industry	Lucky Jinyang Industry Pacific Chemical	Lucky Namhae Chemical Jinyang Industry	Lucky Namhae Chemical Honam Petrochemical	Namhae Chemical Lucky Honam Petrochemical	Lucky Namhae Chemical Korea Hapseom
Mineral	Ssangyong Cement Dongyang Cement Hanil holdings	Ssangyong Cement Dongyang Cement Seongshin Chemical	Ssangyong Cement Hanil holdings Dongyang Cement	Ssangyong Cement Seongshin Chemical Hanil holdings	Ssangyong Cement Dongyang Cement Hankuk Thread	Ssangyong Cement Dongyang Cement Hanil holdings	Ssangyong Cement Dongyang Cement Hanil holdings	Ssangyong Cement Dongyang Cement Hanil holdings	Ssangyong Cement Dongyang Cement Hanil holdings	Ssangyong Cement Dongyang Cement Hanil holdings
Metal	Union Steel Dongkuk Steel KZ Dongboo Steel	POSCO Union Steel Dongkuk Steel	POSCO Union Steel Dongkuk Steel	POSCO Dongkuk Steel Hyundai B&G Steel	POSCO Union Steel Dongkuk Steel	POSCO Union Steel Dongkuk Steel	POSCO Union Steel Dongkuk Steel	POSCO Union Steel KZ Dongboo Steel	POSCO Kangwon Industry Union Steel	POSCO Kangwon Industry Union Steel
Machinery	Hyundai Motor Kia Motor Hankuk Machinery Industry	Kia Motor Hyundai Motor Daedong Industry	Kia Motor Hyundai Motor Daedong Industry	Kia Motor Hyundai Motor Dongwoo Production	Hyundai Heavy Industry Kia Motor Hyundai Motor	Hyundai Heavy Industry Hyundai Motor Kia Motor	Hyundai Heavy Industry Hyundai Motor Kia Motor	Hyundai Motor Hyundai Heavy Industry Kia Motor	Hyundai Heavy Industry Hyundai Motor Hankuk Machinery Industry	Hyundai Heavy Industry Hyundai Motor Hyundai Yanghaeng
Electronics	LG Daehan Wire Hannong	LG Daehan Wire Samsung Electronics	LG Daehan Wire Samsung Electronics	LG Daehan Wire Samsung Electronics	LG Daehan Wire Samsung Electronics	LG Daehan Wire Samsung Electronics	LG Samsung Electronics Daehan Wire	LG Samsung Electronics Daehan Wire	LG Samsung Electronics Daehan Wire	LG Samsung Electronics Daehan Wire
Etc.	Samyoung Mobang Samhwa Hankuk Zipper	Ssangyong Paper Samhwa Samyoung Mobang	Samhwa Ssangyong Paper Samyoung Mobang	Samhwa Ssangyong Paper Samyoung Mobang	Samhwa Ssangyong Paper Samyoung Mobang	Samhwa Ssangyong Paper Samik Instrument	Samik Instrument Ssangyong Paper Samhwa	Ssangyong Paper Samik Instrument Youngchang Instrument	Samik Instrument Youngchang Instrument Soye Industry	Samik Instrument Youngchang Instrument Hankuk Pilot

Sector	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Food	Hatae Food Sammi Food Samyang Food	Samyang Food Hatae Food Daehan Jedang	Samyang Food Hatae Food Nongshim	Samyang Food Nongshim Dongbang Yooryang	Samyang Food Nongshim Dongbang Yooryang	Samyang Food Nongshim Dongbang Yooryang	Hatae Food Nongshim Samyang Food	Nongshim Hatae Food Chilsung Beverage	Nongshim Chilsung Beverage Hatae Food	Chilsung Beverage Nongshim Hatae Food
Textile	Kookje Chemical Hanil Hapsung Kolong	Kookje Chemical Hanil Hapsung Kolong	Kookje Chemical Hanil Hapsung Kolong	Kookje Chemical Hanil Hapsung Kolong	Kolong Kookje Chemical Hanil Hapsung	Kolong Hanil Hapsung Dongyang Nylon	Kolong Dongyang Nylon Hanil Hapsung	Kolong Dongyang Nylon Hanil Hapsung	Kolong Dongyang Nylon Cheil HapSum	Kolong Dongyang Nylon Cheil Mojik
Wood	Hyundai Lumber Moolim PNP Daesung Lumber	Hyundai Lumber Moolim PNP Daesung Lumber	Hyundai Lumber Boruneo Trading Moolim PNP	Hyundai Lumber Dongyang Broadcasting Moolim PNP	Hankuk Plywood Hyundai Lumber Dongyang Broadcasting	Hankuk Plywood Hyundai Lumber Yoohan Kimberly	Hyundai Lumber Hankuk Plywood Yoohan Kimberly	Hyundai Lumber Yoohan Kimberly Hankuk Plywood	Hyundai Lumber Yoohan Kimberly Dongyang Broadcasting	Hyundai Lumber Yoohan Kimberly Choseon Ilbo
Print	Honam Petroleum Hankuk Iran Petroleum Kyoungin Energy	Honam Petroleum Kyoungin Energy Hankuk Iran Petroleum	Honam Petroleum Kyoungin Energy Hankuk Iran Petroleum	Honam Petroleum Hankuk Iran Petroleum Kyoungin Energy	Honam Petroleum Hankuk Iran Petroleum Kyoungin Energy	Honam Petroleum Hankuk Iran Petroleum Kyoungin Energy	Honam Petroleum Hankuk Iran Petroleum Kyoungin Energy	Honam Petroleum Hankuk Iran Petroleum Kyoungin Energy	Honam Petroleum Hankuk Iran Petroleum Hyundai Oil Bank	Honam Petroleum Hankuk Iran Petroleum Kyoungin Energy
Pharma.	Yuhan Jong Geun Dang Youngjin Parmaceutical	Yuhan Jong Geun Dang Orient Watch	Yuhan Jong Geun Dang Donghwa Parmaceutical	Jong Geun Dang Yuhan Orient Watch	Yuhan Jong Geun Dang Orient Watch	Orient Watch Yuhan Jong Geun Dang	Yuhan Jong Geun Dang Orient Watch	Yuhan Jong Geun Dang Orient Watch	Jong Geun Dang Yuhan Ilyang Parmaceutical	Yuhan Jong Geun Dang Ilyang Parmaceutical
Chemical	Lucky Namhae Chemical Korea Hapseom	Lucky Namhae Chemical Honam Petrochemical	Lucky Namhae Chemical Hanhwa Solution	Lucky Namhae Chemical Hanhwa Solution	Lucky Hanhwa Solution Namhae Chemical	Lucky Hanhwa Solution Korea Hapseom	Lucky Hanhwa Solution Taekwang Industry	Lucky Hanhwa Solution Korea Hapseom	Lucky Hanhwa Solution Korea Hapseom	Lucky Hanhwa Solution Korea Hapseom
Mineral	Ssangyong Cement Dongyang Cement Hanil holdings	Ssangyong Cement Dongyang Cement Hanil holdings	Ssangyong Cement Dongyang Cement Hanil holdings	Ssangyong Cement Dongyang Cement Hanil holdings	Ssangyong Cement Dongyang Cement Hanil holdings	Ssangyong Cement Dongyang Cement Hanil holdings	Ssangyong Cement Dongyang Cement Hanil holdings	Ssangyong Cement Dongyang Cement Hanil holdings	Ssangyong Cement Dongyang Cement Hanil holdings	Ssangyong Cement Dongyang Cement Hanil holdings
Metal	POSCO Union Steel Kangwon Industry	POSCO Union Steel Hyundai Steel	POSCO Union Steel Kangwon Industry	POSCO Union Steel Kangwon Industry	POSCO Union Steel Kangwon Industry	POSCO Union Steel Hankook Mining	POSCO Hankook Mining KZ Dongboo Steel	POSCO KZ Dongboo Steel Hankook Mining	POSCO Hyundai Steel Hankook Mining	POSCO Hyundai Steel KZ Dongboo Steel
Machinery	Hyundai Heavy Industry Daewoo Shipbuilding Hyundai Motor	Hyundai Heavy Industry Hyundai Motor Daewoo Shipbuilding	Hyundai Heavy Industry Hyundai Motor Daewoo Shipbuilding	Hyundai Heavy Industry Hyundai Motor Daewoo Shipbuilding	Hyundai Motor Hyundai Heavy Industry Kia Motor	Hyundai Motor Kia Motor Hyundai Heavy Industry	Hyundai Motor Kia Motor Hyundai Heavy Industry	Hyundai Motor Kia Motor Hyundai Heavy Industry	Hyundai Motor Kia Motor Hyundai Heavy Industry	Hyundai Motor Kia Motor Hyundai Heavy Industry
Electronics	LG Samsung Electronics Daehan Wire	LG Samsung Electronics Daehan Wire	Samsung Electronics LG Daewoo Electronics	Samsung Electronics LG Daewoo Electronics	Samsung Electronics LG Daewoo Electronics	Samsung Electronics LG Daewoo Electronics	Samsung Electronics LG Daewoo Electronics	Samsung Electronics LG Daewoo Electronics	Samsung Electronics LG Daewoo Electronics	Samsung Electronics LG Daewoo Electronics
Etc.	Samik Instrument Youngchang Instrument Ssangyong Paper	Ssangyong Paper Samik Instrument Youngchang Instrument	Ssangyong Paper Samik Instrument Youngchang Instrument	Samik Instrument Ssangyong Paper Youngchang Instrument	Samik Instrument Youngchang Instrument Ssangyong Paper	Samik Instrument Youngchang Instrument Ssangyong Paper	Samik Instrument Youngchang Instrument Ssangyong Paper	Samik Instrument Ssangyong Paper Youngchang Instrument	Samik Instrument Youngchang Instrument Ssangyong Paper	Samik Instrument Youngchang Instrument Ssangyong Paper

Sector	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Food	Chilsung Beverage Nongshim Hatae Food	Nongshim Chilsung Beverage Hatae Food	Chilsung Beverage Nongshim Hatae Food	Nongshim Chilsung Beverage Hatae Food	Nongshim Hatae Food Chilsung Beverage	Nongshim Hatae Food Chilsung Beverage	Seoul Miwon Nongshim Hatae Food	Seoul Miwon Nongshim Hatae Food	Nongshim Seoul Miwon Chilsung Beverage	Chilsung Beverage Seoul Miwon Hankuk Yagurt
Textile	Kolong Dongyang Nylon Cheil Mojik	Kolong Dongyang Nylon Cheil Mojik	Kolong Dongyang Nylon Cheil Mojik	Kolong Dongyang Nylon Cheil Mojik	Kolong Dongyang Nylon Cheil Mojik	Kolong Dongyang Nylon Cheil Mojik	Kolong Dongyang Nylon Cheil HapSum	Dongyang Nylon Kolong Cheil Mojik	Dongyang Nylon Cheil Mojik Cheil HapSum	Dongyang Nylon Cheil Mojik Cheil HapSum
Wood	Hyundai Lumber Yoohan Kimberly Choseon Ilbo	Hyundai Lumber Choseon Ilbo Yoohan Kimberly	Hyundai Lumber Choseon Ilbo Dongyang Broadcasting	Hyundai Lumber Dongyang Broadcasting Choseon Ilbo	Hyundai Lumber Dongyang Broadcasting Choseon Ilbo	Hyundai Lumber Dongyang Broadcasting Yoohan Kimberly	Yoohan Kimberly Hyundai Lumber Hankook Paper	Yoohan Kimberly Choseon Ilbo Daehan Pulp Industry	Yoohan Kimberly Hansol Art Choseon Ilbo	Yoohan Kimberly Hansol Art Kyowon Property
Print	Honam Petroleum Hankuk Iran Petroleum Kyoungin Energy	Honam Petroleum Hankuk Iran Petroleum Kyoungin Energy	Honam Petroleum Hankuk Iran Petroleum Kyoungin Energy	Honam Petroleum Hankuk Iran Petroleum Kyoungin Energy	Honam Petroleum Hankuk Iran Petroleum Hyundai Oil Bank	Honam Petroleum Hankuk Iran Petroleum Hyundai Oil Bank	Honam Petroleum Hankuk Iran Petroleum Hyundai Oil Bank	Honam Petroleum Hankuk Iran Petroleum Hyundai Oil Bank	Honam Petroleum Hankuk Iran Petroleum Hyundai Oil Bank	Honam Petroleum Hankuk Iran Petroleum Hyundai Oil Bank
Pharma.	Yuhan Ilyang Parmaceutical Donghwa Parmaceutical	Yuhan Ilyang Parmaceutical Donghwa Parmaceutical	Yuhan Ilyang Parmaceutical Donghwa Parmaceutical	Yuhan Jong Geun Dang Donghwa Parmaceutical	Yuhan Nokshipja Cell Jong Geun Dang	Nokshipja Cell Yuhan Jong Geun Dang	Jong Geun Dang Yuhan Nokshipja Cell	Jong Geun Dang Yuhan Daehan Joongwe	Jong Geun Dang Yuhan Daehan Joongwe	Jong Geun Dang Yuhan Daehan Joongwe
Chemical	Lucky Hanhwa Solution Korea Hapseom	Lucky Hanhwa Solution Korea Hapseom	Lucky Hanhwa Solution Korea Hapseom	Lucky Hanhwa Solution Hankuk Chemical	Lucky Hankuk Chemical Hanhwa Solution	Lucky Hankuk Chemical Hanhwa Solution	Lucky Hankuk Chemical Hanhwa Solution	Lucky Hankuk Chemical Hanhwa Solution	Lucky Hankuk Chemical Yeocheon NCC	Lucky Hankuk Chemical Yeocheon NCC
Mineral	Ssangyong Cement Dongyang Cement Hanil holdings	Ssangyong Cement Dongyang Cement Hanil holdings	Ssangyong Cement Dongyang Cement Hanil holdings	Ssangyong Cement Dongyang Cement Hanil holdings	Ssangyong Cement Dongyang Cement Halla Cement	Ssangyong Cement Dongyang Cement Hanil holdings	Ssangyong Cement Dongyang Cement Hankuk Electric Glass	Ssangyong Cement Dongyang Cement Hankuk Electric Glass	Dongyang Cement Ssangyong Cement Hankuk Electric Glass	Dongyang Cement Ssangyong Cement Hankuk Electric Glass
Metal	POSCO Hyundai Steel Hankook Mining	POSCO Hyundai Steel Dongkuk Steel	POSCO Hyundai Steel Hankook Mining	POSCO Hyundai Steel Hankook Mining	POSCO Hankook Mining Hyundai Steel	POSCO Hankook Mining Hyundai Steel	POSCO Hankook Mining Hyundai Steel	POSCO Hyundai Steel Dongkuk Steel	POSCO Hyundai Steel Dongkuk Steel	POSCO Hyundai Steel Dongkuk Steel
Machinery	Hyundai Motor Kia Motor Hyundai Heavy Industry	Hyundai Motor Kia Motor Hyundai Heavy Industry	Hyundai Motor Kia Motor Hyundai Heavy Industry	Hyundai Motor Kia Motor Hankuk Machinery Industry	Hyundai Motor Kia Motor Hankuk Machinery Industry	Hyundai Motor Kia Motor Hyundai Heavy Industry	Hyundai Motor Hyundai Heavy Industry Hankuk Machinery Industry	Hyundai Motor Kia Motor Hyundai Heavy Industry	Hyundai Motor Kia Motor Hyundai Heavy Industry	Hyundai Motor Kia Motor Hyundai Heavy Industry
Electronics	Samsung Electronics LG Daewoo Electronics	Samsung Electronics LG Daewoo Electronics	Samsung Electronics LG Daewoo Electronics	Samsung Electronics LG SK Hynics	Samsung Electronics LG Daewoo Electronics	Samsung Electronics LG Daewoo Electronics	Samsung Electronics LG Daewoo Electronics	Samsung Electronics LG SK Hynics	Samsung Electronics LG SK Hynics	Samsung Electronics LG Samsung Display
Etc.	Samik Instrument Ssangyong Paper Youngchang Instrument	Samik Instrument Ssangyong Paper Youngchang Instrument	Ssangyong Paper Youngchang Instrument Samik Instrument	Ssangyong Paper Samik Instrument Youngchang Instrument	Ssangyong Paper Youngchang Instrument Samik Instrument	Ssangyong Paper Youngchang Instrument Samik Instrument	Youngchang Instrument Samik Instrument Ssangyong Paper	Ssangyong Paper Samik Instrument Youngchang Instrument	Samik Instrument Ssangyong Paper Youngchang Instrument	Ssangyong Paper Samik Instrument Youngchang Instrument

Sector	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Food	Nongshim Chilsung Beverage Seoul Miwon	Nongshim Seoul Miwon Chilsung Beverage	Nongshim Seoul Miwon Chilsung Beverage	Nongshim Chilsung Beverage Seoul Miwon	Nongshim Chilsung Beverage Seoul Miwon	Nongshim Chilsung Beverage Ottogi Food	CJ Nongshim Ottogi Food	CJ Nongshim Ottogi Food	CJ Nongshim Dongseo Food	CJ Nongshim Paris Crasuant
Textile	Dongyang Nylon Cheil Mojik Donggook Trading	Dongyang Nylon Cheil Mojik Donggook Trading	Dongyang Nylon Cheil Mojik Donggook Trading	Dongyang Nylon Cheil Mojik Donggook Trading	Dongyang Nylon Cheil Mojik Eland World	Dongyang Nylon Cheil Mojik Eland World	Dongyang Nylon Cheil Mojik Eland World	Dongyang Nylon Cheil Mojik Eland World	Dongyang Nylon Cheil Mojik LF	Dongyang Nylon Cheil Mojik LF
Wood	Yoohan Kimberly Hansol Art Choseon Ilbo	Yoohan Kimberly Hansol Art Choseon Ilbo	Yoohan Kimberly Hansol Art Kyowon Property	Yoohan Kimberly Hansol Art Kyowon Property	Yoohan Kimberly Kyowon Property Molim Paper	Yoohan Kimberly Kyowon Property Molim Paper	Yoohan Kimberly Woongjin Thinkbig Kyowon Property	Yoohan Kimberly Woongjin Thinkbig Kyowon Property	Yoohan Kimberly Woongjin Thinkbig Kyowon Property	Yoohan Kimberly Woongjin Thinkbig Kyowon Property
Print	Honam Petroleum Hankuk Iran Petroleum Hyundai Oil Bank	Honam Petroleum Hankuk Iran Petroleum Hyundai Oil Bank	Honam Petroleum Hankuk Iran Petroleum Hyundai Oil Bank	Honam Petroleum Hankuk Iran Petroleum Hyundai Oil Bank	Honam Petroleum Hankuk Iran Petroleum Hyundai Oil Bank	Honam Petroleum SK Innovation Hankuk Iran Petroleum	SK Innovation Honam Petroleum Hankuk Iran Petroleum	SK Innovation Honam Petroleum Hankuk Iran Petroleum	SK Innovation Honam Petroleum Hankuk Iran Petroleum	Honam Petroleum Hankuk Iran Petroleum Hyundai Oil Bank
Pharma.	Yuhan Daehan Joongwe Handok Parmaceutical	Yuhan Daehan Joongwe Handok Parmaceutical	Yuhan Daehan Joongwe Daewoong Parmaceutical	Yuhan Sang Ah Pharmaceutical Daehan Joongwe	Yuhan Sang Ah Pharmaceutical Daehan Joongwe	Yuhan Sang Ah Pharmaceutical Daewoong Parmaceutical	Yuhan Sang Ah Pharmaceutical Daewoong Parmaceutical	Sang Ah Pharmaceutical Yuhan Daewoong Parmaceutical	Sang Ah Pharmaceutical Yuhan Daewoong Parmaceutical	Daewoong Parmaceutical Sang Ah Pharmaceutical Yuhan
Chemical	Lucky Hankuk Chemical Yeocheon NCC	Lucky Hankuk Chemical Yeocheon NCC	Lucky Yeocheon NCC Hanhwa Total	Lucky Yeocheon NCC Hanhwa Total	Lucky Yeocheon NCC Hanhwa Total	Lucky Yeocheon NCC Hanhwa Total	Lucky Yeocheon NCC Hanhwa Total	Lucky Honam Petrochemical Yeocheon NCC	Lucky Honam Petrochemical Yeocheon NCC	Lucky Honam Petrochemical Yeocheon NCC
Mineral	Ssangyong Cement Hankuk Electric Glass Seongshin Chemical	Ssangyong Cement Corning Precision Material Seongshin Chemical	Corning Precision Material Ssangyong Cement Hanil holdings	Corning Precision Material Ssangyong Cement Hanil holdings	Corning Precision Material Ssangyong Cement Hanil holdings	Corning Precision Material Ssangyong Cement Hanil holdings	Corning Precision Material Ssangyong Cement AGC Fine Technology	Corning Precision Material AGC Fine Technology Ssangyong Cement	Corning Precision Material AGC Fine Technology Ssangyong Cement	Corning Precision Material AGC Fine Technology Pohang Furnace
Metal	POSCO Hyundai Steel Dongkuk Steel	POSCO Hyundai Steel Dongkuk Steel	POSCO Hyundai Steel Dongkuk Steel	POSCO Hyundai Steel Dongkuk Steel	POSCO Hyundai Steel Onsandong	POSCO Hyundai Steel Onsandong	POSCO Hyundai Steel Dongkuk Steel	POSCO Hyundai Steel Onsandong	POSCO Hyundai Steel Onsandong	POSCO Hyundai Steel Onsandong
Machinery	Hyundai Motor Kia Motor Hyundai Heavy Industry	Hyundai Motor Kia Motor Hyundai Heavy Industry	Hyundai Motor Kia Motor Hyundai Heavy Industry	Hyundai Motor Kia Motor Hyundai Heavy Industry	Hyundai Motor Kia Motor Hyundai Heavy Industry	Hyundai Motor Kia Motor Hyundai Heavy Industry	Hyundai Motor Hyundai Heavy Industry Kia Motor	Hyundai Motor Hyundai Heavy Industry Kia Motor	Hyundai Motor Kia Motor Hyundai Heavy Industry	Hyundai Motor Kia Motor Hyundai Heavy Industry
Electronics	Samsung Electronics LG Samsung Display	Samsung Electronics LG LG Display	Samsung Electronics LG LG Display	Samsung Electronics LG LG Display	Samsung Electronics LG LG Display	Samsung Electronics LG LG Display	Samsung Electronics LG LG Display	Samsung Electronics LG LG Display	Samsung Electronics LG LG Display	Samsung Electronics LG LG Display
Etc.	Samik Instrument Youngchang Instrument Ssangyong Paper	Samik Instrument Ssangyong Paper Advent Enterprise	Samik Instrument Ssangyong Paper Samjin LND	Ssangyong Paper Samik Instrument Hankuk Zipper	Samjin LND Hankuk Zipper Samik Instrument	Samjin LND Hankuk Zipper Samik Instrument	Hankuk Zipper Samjin LND Samik Instrument	Hankuk Zipper Samik Instrument Samjin LND	Samik Instrument Samjin LND Ssangyong Paper	Hankuk Zipper Samjin LND Samik Instrument

B.2 Production Function Estimation

B.2.1 Derivation

Derivation of equation (3.1) Using that $p^d_{fj} = (y^d_{fj}/Y^H_j)^{-\frac{1}{\sigma_j}} P^H_j$, we obtain that for non-exporters,

$$r^d_{fj} = (y^d_{fj})^{\frac{\sigma_j - 1}{\sigma_j}} (Y^H_j)^{\frac{1}{\sigma_j}} = (\Lambda^d_{fj})^{\frac{\sigma_j - 1}{\sigma_j}} y_{fj}^{\frac{\sigma_j - 1}{\sigma_j}} (Y^H_j)^{\frac{1}{\sigma_j}},$$

where the second equality comes from that $\Lambda^d_{fj} = y^d_{fj}/y_{fj}$. Combining the above expression with the production function and taking logs, we obtain that

$$\ln \frac{r^d_{fj}}{P^H_j} = \gamma^L_j \frac{\sigma_j - 1}{\sigma_j} \ln l_{fj} + \gamma^K_j \frac{\sigma_j - 1}{\sigma_j} \ln k_{fj} + \gamma^M_j \frac{\sigma_j - 1}{\sigma_j} \ln m_{fj} + \frac{\sigma_j - 1}{\sigma_j} \ln \Lambda^d_{fj} + \frac{1}{\sigma_j} \ln Y^H_j + \ln a_{fj}.$$

For non-exporters, $\Lambda^d_{fj} = 1$.

Derivation of equation (3.2) From the FOC with respect to material inputs, we obtain that $\gamma^M_j r^d_{fj} = \mu^d_{fj} P^M_j m_{fj}$. Using equation (2.7) and the FOC, we can re-express as

$$\gamma^M_j = \mu^d_{fj} \frac{P^M_j m_{fj}}{r^d_{fj}}.$$

After summing over both sides across non-exporters and taking the average, we obtain the desired result.

B.3 Backing Out the Shocks

Data input

- Sales, export, employment, and fixed asset of manufacturing firms, $\forall f \in \mathcal{F}_j/\{\tilde{f}\}$, $\forall j \in [0, J_m]$
- Sectoral gross output, exports, and import shares, PPI, $j \in [0, 1]$
- Aggregate real GDP growth, working hours per worker

Structural parameters

- Production function $\{\gamma^L_j, \gamma^K_j, \gamma^M_j\}_{j \in [0,1]}$
- Cobb-Douglas shares of intermediate inputs $\{\gamma^j_i\}_{i,j \in [0,1]}$
- Elasticities of substitution σ_j and ρ_j
- Labor supply elasticities, η, θ, and ψ

Backing out relative productivity and distortions Using sales and exports data, we calculate fringe firms' domestic sales and exports as residuals: $r^d_{\tilde{f}jt} = R^{d,\text{Agg}}_{jt} - \sum_{f \in \mathcal{F}^{\text{Firm}}_{jt}} r^{\text{d,Firm}}_{fjt}$, and $r^x_{\tilde{f}jt} = R^{x,\text{Agg}}_{jt} - \sum_{f \in \mathcal{F}^{\text{Firm}}_{jt}} r^{\text{x,Firm}}_{fjt}$, where $\mathcal{F}^{\text{Firm}}_{jt}$ is the set of sector j firms observed in the firm-level data in year t. $R^{d,\text{Agg}}_{jt}$ and $R^{x,\text{Agg}}_{jt}$ are sectoral domestic sales and exports from KLEMS and IO tables. $r^{d,\text{Firm}}_{fjt}$

Table B3: Calibrated Values of Elasticity of Substitution and Estimates of Production Function Parameters

	Baseline. $\sigma_j = 5$, $\rho_j = 2$					Robustness. σ_j, BW (2006), $\rho_j = 2$				
	σ_j	γ_j^L	γ_j^K	γ_j^M	γ_j	σ_j	γ_j^L	γ_j^K	γ_j^M	γ_j
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Food, Beverage, & Tobacco	5	0.09	0.10	0.65	0.84	4.73	0.07	0.08	0.66	0.81
Textile, Apparel, & Leather	5	0.30	0.23	0.53	1.06	5.12	0.33	0.21	0.52	1.07
Wood	5	0.22	0.15	0.57	0.94	6.29	0.27	0.23	0.54	1.04
Pharmaceuticals	5	0.35	0.25	0.41	1.01	1.77	0.64	0.47	0.76	1.88
Chemicals, Plastics, & Rubber (Petrochemical)	5	0.21	0.09	0.64	0.94	4.01	0.27	0.07	0.68	1.02
Non-metallic minerals	5	0.35	0.27	0.56	1.18	2.00	0.52	0.32	0.90	1.74
Metal	5	0.08	0.08	0.65	0.81	5.14	0.08	0.08	0.65	0.81
Machinery, & Trans. equip.	5	0.24	0.09	0.59	0.92	5.28	0.23	0.13	0.58	0.94
Electronics	5	0.19	0.18	0.60	0.97	4.44	0.20	0.19	0.62	1.02
Mfg. nec	5	0.16	0.30	0.45	0.91	2.74	0.08	0.16	0.57	0.81
Mfg. average	5	0.22	0.17	0.57	0.96	4.14	0.27	0.18	0.65	1.10

Notes. This table reports the calibrated values of the elasticity of substitution and the Cobb-Douglas production function parameters for each manufacturing sector. In columns 6-10, we take the estimates of σ_j from Broda and Weinstein (2006). $\gamma_j = \gamma_j^L + \gamma_j^K + \gamma_j^M$.

and $r^{x,\text{Firm}}_{fjt}$ are firm-level domestic sales and exports from the firm-level data. From these constructed fringe firms' $r^d_{\tilde{f}jt}$ and $r^x_{\tilde{f}jt}$, we can compute the markup-adjusted revenue share $\Lambda^d_{\tilde{f}jt}$.

Then, using these fringe firms' domestic sales and exports, we construct sales shares as $s^d_{fjt} = \frac{r^d_{fjt}}{\sum_{g\in\mathcal{F}_{jt}} r^d_{gjt}}$ and $s^x_{fjt} = \frac{r^x_{fjt}}{\sum_{g\in\mathcal{F}^x_{jt}} r^x_{\tilde{f}jt}}$. Given $\{s^d_{fjt}, s^x_{fjt}\}$ and the structural parameters, we calculate fringe firms' distortions and labor and capital inputs in a model-consistent way. We assume that fringe firms' distortions are the average of those of granular firms. We proceed with the following algorithm for each sector and year.

Step 1. Guess $\{\tau^L_{fj}, \tau^K_{fj}\}_{f\in\mathcal{F}_j}$, where $\tau^L_{\tilde{f}j} = \tau^K_{\tilde{f}j} = 0$.

Step 2.

- Make a guess on $l_{\tilde{f}j}$ and compute $\{s^L_{fj}\}_{f\in\mathcal{F}_j}$ and $\{\mu^L_{fj}\}_{f\in\mathcal{F}_j}$.
- Using the first order conditions (equation (2.10)) and the inverse labor supply function $w_{fj} = F_j^{\frac{1}{\eta}} l_{fj}^{\frac{1}{\eta}} L_j^{\frac{1}{\theta}-\frac{1}{\eta}} W$, we obtain that

$$\sum_{f\in\mathcal{F}_{(-\tilde{f})j}} \gamma^L_j r^d_{fj}/\Lambda^d_{fj} = \Big(\sum_{f\in\mathcal{F}_{(-\tilde{f})j}} \mu^d_{fj}\mu^L_{fj}(1+\tau^L_{fj}) l_{fj}^{\frac{\eta+1}{\eta}} \Big) L_j^{\frac{1}{\theta}-\frac{1}{\eta}} W,$$

  which gives

$$L_j^{\frac{1}{\theta}-\frac{1}{\eta}} W = \underbrace{\frac{\sum_{f\in\mathcal{F}_{(-\tilde{f})j}} \gamma^L_j r^d_{fj}/\Lambda^d_{fj}}{\sum_{f\in\mathcal{F}_{(-\tilde{f})j}} \mu^d_{fj}\mu^L_{fj}(1+\tau^L_{fj}) l_{fj}^{\frac{\eta+1}{\eta}}}}_{\text{Data and guess}},$$

  where the right hand side can be measured using the guessed $\{\tau^L_{fj}\}_{f\in\mathcal{F}_{(-\tilde{f})j}}$ and employment from the data.
- Using the measured $L_j^{\frac{1}{\theta}-\frac{1}{\eta}} W$ and fringe firms' first order conditions, we can obtain that

$$l_{\tilde{f}j} = \left(\frac{\gamma^L_j r^d_{\tilde{f}j}/\Lambda^d_{\tilde{f}j}}{\frac{\sigma_j}{\sigma_j-1}\frac{\epsilon+1}{\epsilon}(1+\tau^L_{\tilde{f}j}) L_j^{\frac{1}{\theta}-\frac{1}{\eta}} W} \right)^{\frac{\eta}{\eta+1}}.$$

- Using the obtained $l_{\tilde{f}j}$, compute the new $\{s^L_{fj}\}_{f\in\mathcal{F}_j}$ and compare with the previous $\{s^L_{fj}\}_{f\in\mathcal{F}_j}$.
- Iterate until $\{s^L_{fj}\}_{f\in\mathcal{F}_j}$ is consistent with fringe firms' first order conditions and the initial guess of $\{\tau^L_{fj}\}_{f\in\mathcal{F}_{(-\tilde{f})j}}$.

Step 3.

- Make a guess on $k_{\tilde{f}j}$ and compute $\{s^K_{fj}\}_{f\in\mathcal{F}_j}$.

- Using the first order conditions (equation (2.10)), we obtain that

$$\sum_{f \in \mathcal{F}_{(-\tilde{f})j}} \gamma_j^K r_{fj}^d / \Lambda_{fj}^d = \sum_{f \in \mathcal{F}_{(-\tilde{f})j}} \mu_{fj}^d (1 + \tau_{fj}^K) R k_{fj},$$

which gives

$$R = \frac{\sum_{f \in \mathcal{F}_{(-\tilde{f})j}} \gamma_j^K r_{fj}^d / \Lambda_{fj}^d}{\sum_{f \in \mathcal{F}_{(-\tilde{f})j}} \mu_{fj}^d (1 + \tau_{fj}^K) k_{fj}},$$

where the right hand side can be measured using the guessed $\{\tau_{fj}^K\}_{f \in \mathcal{F}_{(-\tilde{f})j}}$ and fixed asset from the data.

- Using the measured R and fringe firms' first order conditions, we can obtain that

$$k_{\tilde{f}j} = \left(\frac{\gamma_j^K r_{\tilde{f}j}^d // \Lambda_{\tilde{f}j}^d}{\frac{\sigma_j}{\sigma_j - 1}(1 + \tau_{\tilde{f}j}^K) R} \right).$$

- Using the obtained $l_{\tilde{f}j}$, compute the new $\{s_{fj}^K\}_{f \in \mathcal{F}_j}$ and compare with the previous $\{s_{fj}^K\}_{f \in \mathcal{F}_j}$.
- Iterate until $\{s_{fj}^K\}_{f \in \mathcal{F}_j}$ is consistent with fringe firms' first order conditions and the guess of $\{\tau_{fj}^K\}_{f \in \mathcal{F}_{(-\tilde{f})j}}$.

Step 4. Using fringe firms' labor and capital inputs calculated in the previous steps, we construct $\{s_{fj}^L, s_{fj}^K\}_{f \in \mathcal{F}_j}$.

Step 5. Using $\{s_{fj}^d, s_{fj}^x, s_{fj}^L, s_{fj}^K\}_{f \in \mathcal{F}_j}$ and $\{\Lambda_{fj}^d\}_{f \in \mathcal{F}_j}$, solve the system of equation (equations (2.12), (2.13), (2.14), and (2.15)) and obtain $\{a_{fj}, \tau_{fj}^L, \tau_{fj}^K, D_{fj}^x\}_{f \in \mathcal{F}_j}$ that is normalized relative to fringe firms. For non-exporters, set $D_{fj}^x = 0$.

Step 6. Compare obtained $\{\tau_{fj}^L, \tau_{fj}^K\}_{f \in \mathcal{F}_j}$ in the previous step to the initial guess.

Step 7. Iterate until $\{\tau_{fj}^L, \tau_{fj}^K\}_{f \in \mathcal{F}_j}$ converge.

Step 8. We set $1+\tau_{\tilde{f}j}^L$ and $1+\tau_{\tilde{f}j}^K$ to satisfy $\sum_{f \in \mathcal{F}_j} s_{fj} \frac{1}{(1+\tau_{fj}^L)\tilde{\mu}_{fj}\mu_{fj}^L} = 1$ and $\sum_{f \in \mathcal{F}_j} s_{fj} \frac{1}{(1+\tau_{fj}^K)\tilde{\mu}_{fj}} = 1$, respectively.

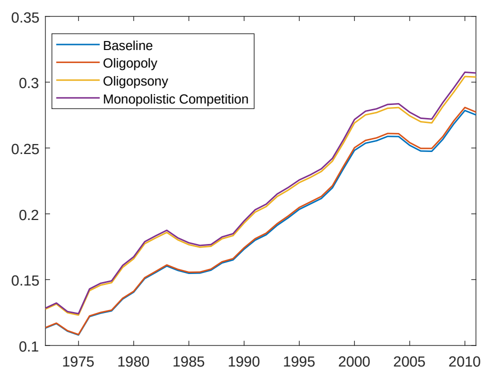
Backing out the remaining shocks We describe the procedure to back out the remaining shocks: $\bar{\phi}_t$ and $\{P_{jt}^F, a_{\tilde{f}jt}, D_{\tilde{f}jt}^x\}_{j \in [0,1]}$. To back out these remaining shocks, we solve the full model and proceed with the following algorithm.

1. Make a guess for the shocks: $\bar{\phi}_t^{(0)}$ and $\{P_{jt}^{F,(0)}, D_{\tilde{f}jt}^{x,(0)}, a_{\tilde{f}jt}^{(0)}\}_{j \in [0,1]}$
2. Based on the guess, compute firms' productivity and foreign demand shocks as $a_{fjt}^{(0)} = a_{\tilde{f}jt}^{(0)} \times \dot{A}_{fjt}$ and $D_{fjt}^{x,(0)} = D_{\tilde{f}jt}^{x,(0)} \times \dot{D}_{fjt}^x$ for all firms and sectors, where $\dot{A}_{fjt}$ and $\dot{D}_{fjt}^x$ are the backed out productivity and foreign demands relative to the fringe firm within sectors.
3. Feed the firm-level shocks $\{a_{fjt}^{(0)}, D_{fjt}^{x,(0)}, \tau_{fjt}^L, \tau_{fjt}^K\}_{f \in \mathcal{F}_{jt}, j \in [0,1]}$, $\{P_{jt}^{F,(0)}\}_{j \in [0,1]}$, and $\bar{\phi}_t^{(0)}$ and solve the model. Note that distortions are backed out from the previous procedure.

4. Update $\{P_{jt}^{F,(0)}\}_{j\in[0,1]}$ until the import shares of the model fit the data
5. Update $\{D_{\tilde{f}jt}^{x,(0)}\}_{j\in[0,1]}$ until the sectoral exports of the model fit the data
6. Update $\{\alpha_{jt}\}_{j\in[0,1]}$ until the sectoral gross outputs of the model fit the data
7. Update fringe firm's productivity relative to that of the reference sector j_0, $\{a_{\tilde{f}jt}/a_{\tilde{f}j_0t}\}_{j\in[0,1]}$, by fitting PPI_{jt}/PPI_{j_0t}. We assume $PPI_{j0} = 1$ for all j.
8. Update fringe firm's productivity of the reference sector $a_{\tilde{f}j_0t}/a_{\tilde{f}j_0t_0}$ by fitting the aggregate real GDP growth, where t_0 denotes the initial year of our data. We normalize $a_{\tilde{f}j_0t_0}$ to one.
9. Update $\bar{\phi}_t$ by fitting working hours per worker in the model (equation (2.1)) to the data counterpart.

B.4 Additional Tables and Figures

Figure B5. Top 3 Concentratio Ratio. Alternative Market Structures



Notes. This figure plots concentration ratios of the top 3 firms under alternative market structures.

Table B4: Robustness. The Top 3 Micro Shocks

Counterfactual vs. Factual Shocks					
All shocks			Productivity shocks		
△ CR in 2011 (pp)	△ Real GDP per capita in 2011 (%)	△ Welfare (%)	△ CR in 2011 (pp)	△ Real GDP per capita in 2011 (%)	△ Welfare (%)
(1)	(2)	(3)	(4)	(5)	(6)
Panel A. Baseline					
−13.27	−11.96	−3.60	−9.15	−10.71	−2.30
Panel B. Robustness. σ_j *(Broda and Weinstein, 2006)*					
−12.80	−13.65	−3.98	−8.01	−11.72	−2.35
Panel C. Robustness. $\rho_j = 5, \forall j$					
−13.37	−11.48	−3.22	−9.16	−10.43	−2.04
Panel D. Robustness. $\zeta = 0.5$					
−13.27	−11.96	−3.64	−9.15	−10.71	−2.13
Panel E. Robustness. $\zeta = 0$					
−13.27	−11.96	−3.66	−9.15	−10.71	−1.99
Panel F. Robustness. $\eta = 3$					
−13.49	−11.07	−3.41	−9.96	−10.95	−2.27
Panel G. Robustness. $\eta = 6$					
−13.25	−13.18	−3.65	−9.00	−10.66	−2.01

Notes. This table reports the sensitivity analysis of the top 3 shock counterfactuals under alternative sets of parameters.