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 the 10 largest firms' differential productivity growth would have decreased firm concentration and lowered markups, but nonetheless would have reduced welfare by 13.6%. Differential distortions and foreign market access of the 10 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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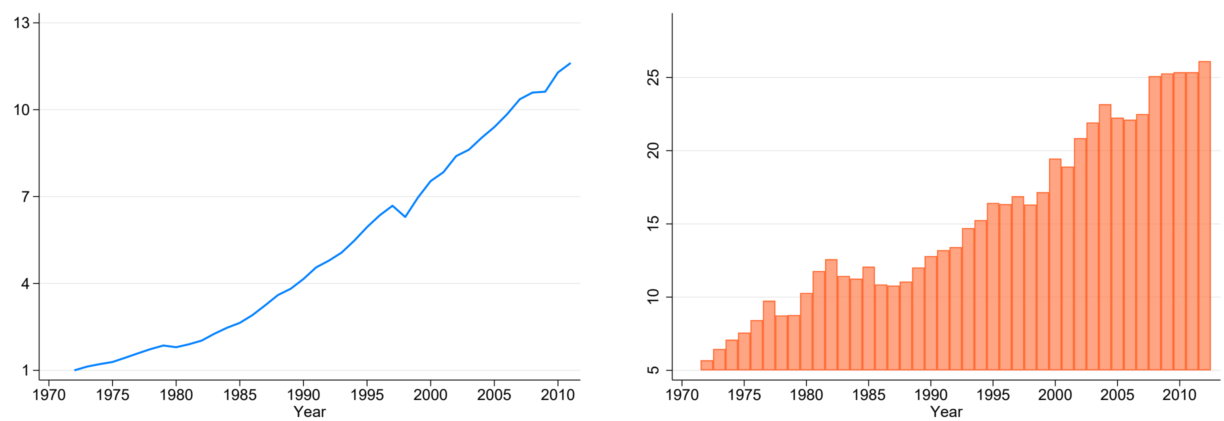
1 Introduction

The rise of "superstar" firms and firm concentration has gained a great deal of attention (e.g. Covarrubias et al., 2020; De Loecker et al., 2020; Autor et al., 2020). It has 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 B. Mfg. Concentration Ratio 10 (%)

Notes. Panel A illustrates real GDP per capita in 2010 US dollars. We normalize the real GDP per capital in 1972 to 1. Panel B plots shares of the top 10 manufacturing firms' sales to 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 growth was a staggering 7.7% per annum). On the other hand, South Korea is famous for the presence of very large firms.[1] While this fact is familiar in levels, the right panel of Figure 1 documents the changes in firm concentration over this period.

[1]For example, di Giovanni and Levchenko (2012) document that Samsung Electronics alone accounted for 7 percent of GDP and 15.5 percent of total exports in 2006.

The shares of the top 10 manufacturing firms to the total manufacturing gross output increased from 5.7% to 25.4% between the 1970s and the 2010s. 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 has 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. This paper develops a general equilibrium multi-sector heterogeneous firm small open economy model. Firm size is pinned down 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). Productivity, market power, distortions, and differential exporting interact with each other and shape firm concentration. We disentangle contributions of each factor through the lens of the model.

Our key theoretical and computational contributions are twofold. First, we solve the structural model that simultaneously allows for firm market power in both goods and labor markets, distortions, and heterogeneous trade at the firm level. Second, despite these complicating features, we derive a system of equations that tightly maps unobservable firm primitives to observable firm market shares in the data. Importantly, our model is implemented directly on firm-level data, so that actual firms in South Korea correspond to firms in the model. This allows us to use this mapping to invert the model and 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. Our data contribution is to assemble a panel firm-level dataset spanning 40 years, 1972-2011. We combine the model and the data to provide a joint account of the micro (changing concentration) and the macro (long-run economic performance) in South Korea.

Our results can be summarized as follows. The top 10 Korean firms experienced substantially higher TFP growth than the rest of the economy over this period. While these firms were about 3 times more productive than other firms in the 1970s, they are about 5.5 times more productive in the 2000s. They also experienced a faster increase in foreign demand and a fall in the relative labor distortions, whereas the relative capital distortion remained unchanged over the long run. Correspondingly, most of the increases in firm concentration are attributable to higher productivity growth of the largest firms. This implies that the takeoff of the large firms was welfare-improving. We perform counterfactuals in which we attribute the average change in productivity, distortions, and market access to the top 10 Korean firms. Had the top 10 Korean firms' productivity grown at the same rate as the rest of the firms', welfare in 2011 would have been 13.6% lower. This is in spite of the fact that higher concentration leads to higher markups and markdowns. Differential foreign market access and distortions had a modest welfare impact.

Related literature This paper contributes to several strands of the literature. The first is the literature on market power in the macroeconomy (see among many others, Atkeson and Burstein, 2008; Eaton et al., 2012; Amiti et al., 2014, 2019; Edmond et al., 2015; Carvalho and Grassi, 2019; Autor et al., 2020; Covarrubias et al., 2020; De Loecker et al., 2020; Gaubert and Itskhoki, 2021; Burstein et al., 2021; Berger et al., 2022; Deb et al., 2022a,b; Edmond et al., 2023; Yeh et al., 2022; Alviarez et al., 2023). 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.

Second, we contribute to the literature on the aggregate implications of microeconomic shocks (see among many others, Gabaix, 2011; Acemoglu et al., 2012; Carvalho and Gabaix, 2013; di Giovanni and Levchenko, 2012; di Giovanni et al., 2014; Grassi, 2017; di Giovanni et al., 2018; Cravino and Levchenko, 2017; Huneeus, 2018; Baqaee and Farhi, 2019, 2020; di Giovanni et al., 2020; Huo et al., 2023). 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 (Young, 1995; Hsieh, 2002; Fernald and Neiman, 2011). The growth accounting literature has not widely used firm-level data to quantitatively assess importance of individual firms on aggregate growth. 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

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 $f \in \mathcal{F}_j = \{1, \ldots, F_j, \tilde{f}\}$ where $\mathcal{F}_j$ is the set of sector j firms and $\tilde{f}$ denotes the fringe firm. Heterogeneous firms have oligopolistic and oligopsonistic market power in domestic goods and factor markets, but fringe firms do not have market power.[2] In the remaining commodity and service sectors $\mathcal{J}_{\mathrm{NM}} = [0,1]/\mathcal{J}_{\mathrm{M}}$, 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.

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

Households There is a representative household that maximizes GHH preferences (Greenwood et al., 1988):

$$\max_{\{C,\{l_{fj}\}\}} U\Big(C - \bar{\phi}\frac{L^{1+\frac{1}{\phi}}}{1+\frac{1}{\phi}}\Big),$$

subject to the budget constraint $PC = WL + \Pi + T$, where C is consumption whose price is P, L is composite labor earning the wage index W, Π is aggregate profits, and T is lump sum transfers from the government.

The composite labor is a CES aggregate with 2 nests:

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

where L_j is sectoral employment, l_{fj} is employment in firm f, and η and θ are the elasticities of substitution within and across sectors. We assume that jobs within sectors are more substitutable than jobs across sectors $\eta > \theta$. The associated wage indices are

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

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

$$L = \Big(\frac{1}{\bar{\phi}}\frac{W}{P}\Big)^{\phi}. \tag{2.1}$$

Sectors Home sector j output is a CES aggregate of outputs of Home firms:

$$Y_j^H = \Big(\sum_{f\in\mathcal{F}_j} (y_{fj}^d)^{\frac{\sigma_j-1}{\sigma_j}}\Big)^{\frac{\sigma_j}{\sigma_j-1}},$$

where y_{fj}^d is the quantity of firm f output demanded in domestic markets and σ_j is the elasticity of substitution across firms within a sector. The price of Home's sectoral output is

$$P_j^H = \Big(\sum_{f\in\mathcal{F}_j} (p_{fj}^d)^{1-\sigma_j}\Big)^{\frac{1}{1-\sigma_j}},$$

where p_{fj}^d is firm f's domestic price.

The sector j output is a CES aggregator of Home and Foreign sector j outputs:

$$Y_j = \Big((Y_j^H)^{\frac{\rho_j-1}{\rho_j}} + (Y_j^F)^{\frac{\rho_j-1}{\rho_j}}\Big)^{\frac{\rho_j}{\rho_j-1}},$$

where Y_j^F is the quantity of Foreign sector j output demanded by Home and ρ_j is the elasticity of substitution between Home and Foreign sectoral outputs. The sectoral price index is

$$P_j = \Big((P_j^H)^{1-\rho_j} + (P_j^F)^{1-\rho_j}\Big)^{\frac{1}{1-\rho_j}},$$

where P_j^F is the Foreign sector j price that Home takes as exogenous. 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 $\lambda_j^H = 1 - \lambda_j^F$.

Finally, there are perfectly competitive final consumption goods and intermediate goods producers that produce final consumption and intermediate goods using sectoral outputs, which are sold to households and firms, respectively. The final consumption goods and intermediate goods producers have the following Cobb-Douglas production functions:

$$C = \exp\Big(\int_0^1 \alpha_j \ln Y_j^C \mathrm{d}j\Big), \qquad \int_0^1 \alpha_j \mathrm{d}j = 1$$

and

$$M_j^M = \exp\Big(\int_0^1 \gamma_j^i \ln Y_j^{i,M} \mathrm{d}i\Big), \qquad \int_0^1 \gamma_j^i \mathrm{d}i = 1, \quad \forall j \in [0,1],$$

where α_i and γ_j^i are the Cobb-Douglas shares, and Y_i^C and $Y_j^{i,M}$ are sectoral outputs demanded by final consumption and intermediate goods producers. The ideal price indices are

$$P = \exp\Big(\int_0^1 \alpha_j \ln P_j \mathrm{d}j\Big) \qquad \text{and} \qquad P_j^M = \exp\Big(\int_0^1 \gamma_j^i \ln P_i \mathrm{d}i\Big).$$

Firms Heterogeneous firms produce a unique variety using the Cobb-Douglas production function:

$$y_{fj} = A_{fj} l_{fj}^{\gamma_j^L} k_{fj}^{\gamma_j^K} m_{fj}^{\gamma_j^M}, \qquad \gamma_j^L + \gamma_j^K + \gamma_j^M = \gamma_j.$$

γ_j^L, γ_j^K, and γ_j^M are Cobb-Douglas shares of costs spent on labor, capital, and intermediate inputs to total costs, respectively, and A_{fj} is exogenous productivity.

Firms face the following demand schedules in domestic and foreign goods markets:

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

where E_j is total domestic expenditure on sector j goods. 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 takes E_j as given. In the foreign market, we assume firms are infinitesimally small and are monopolistically competitive. The firm charges price p_{fj}^x and faces is a firm-specific exogenous foreign demand shifter D_{fj}^x, inclusive of any iceberg trade costs. For non-exporters, $D_{fj}^x = 0$. Firms allocate their output to domestic and foreign markets subject to the following resource constraint: $y_{fj} = y_{fj}^d + y_{fj}^x$.

Labor supply functions in factor markets are

$$l_{fj} = w_{fj}^{\eta} W_j^{\theta-\eta} W^{-\theta} L. \tag{2.2}$$

The inverse demand functions in domestic and foreign markets are expressed as

$$p_{fj}^d = (y_{fj}^d)^{-\frac{1}{\sigma_j}} (Y_j^H)^{\frac{1}{\sigma_j}-\frac{1}{\rho_j}} (Y_j)^{\frac{1}{\rho_j}-1} E_j \qquad p_{fj}^x = (y_{fj}^x)^{-\frac{1}{\sigma_j}} (D_{fj}^x)^{\frac{1}{\sigma_j}}.$$

The inverse labor supply function is given by

$$w_{fj} = l_{fj}^{\frac{1}{\eta}} L_j^{\frac{1}{\theta}-\frac{1}{\eta}} W. \tag{2.3}$$

For notational convenience, we denote firm sales in domestic and foreign markets as $r_{fj}^e \equiv p_{fj}^e y_{fj}^e$ for $e \in \{d, x\}$, and total sales as $r_{fj} \equiv r_{fj}^e + r_{fj}^x$. We define firm domestic sales, labor, capital, and export shares

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

respectively. Note that s_{fj}^L can be expressed in terms of only labor: $s_{fj}^L = l_{fj}^{(\eta+1)/\eta} / L_j^{(\eta+1)/\eta}$.

Firms maximize their profits

$$\pi_{fj} = \max_{\{y_{fj}^d, y_{fj}^x, l_{fj}, k_{fj}, m_{fj}\}} \Big\{ p_{fj}^d y_{fj}^d + p_{fj}^x y_{fj}^x - (1+\tau_{fj}^L) w_{fj} l_{fj} - (1+\tau_{fj}^K) R k_{fj} - P_j^M m_{fj} \Big\}, \tag{2.4}$$

subject to resource constraints, demands, and labor supply:

$$y_{fj} = y_{fj}^d + y_{fj}^x, \quad y_{fj}^d = p_{fj}^{-\sigma_j} (P_j^H)^{\sigma_j-\rho_j} P_j^{\rho_j-1} E_j, \quad y_{fj}^x = p_{fj}^{-\sigma_j} D_{fj}^x, \quad l_{fj} = w_{fj}^{\eta} W_j^{\theta-\eta} W^{-\theta} L.$$

Firms are subject to labor and capital distortions, τ_{fj}^L and τ_{fj}^K, which are interpreted as taxes or subsidies to labor and capital inputs. R is rental rate of capital common across all firms. Given Cournot competition in the domestic goods and labor market, heterogeneous firms internalize quantity choices of the other. Since the equilibrium concept is Cournot, firms take Y_j^F and other competitors' domestic quantities and employment as given, denoted as $\mathbf{y}_{-fj}^d$ and $\mathbf{l}_{-fj}$.

Taking the first order conditions with respect to l_{fj}, y_{fj}^d, and y_{fj}^x, we obtain that

$$p_{fj}^d \Big(1 - \frac{1}{\epsilon_{fj}}\Big) \frac{\partial y_{fj}}{\partial l_{fj}} = p_{fj}^x \Big(1 - \frac{1}{\sigma_j}\Big) \frac{\partial y_{fj}}{\partial l_{fj}} = (1+\tau_{fj}^L) \Big(1 + \frac{1}{\epsilon_{fj}^L}\Big) w_{fj}. \tag{2.5}$$

The firms two terms are marginal revenue product of labor in domestic and foreign markets. The third term is marginal costs of labor. Firms' profit maximization implies that marginal revenue product of labor in both domestic and foreign markets should be equal to marginal costs of labor. ϵ_{fj} and ϵ^L_{fj} are the elasticity of residual demand in the domestic market and labor supply elasticity defined as

$$\epsilon_{fj} = -\left(\frac{\partial \ln p^d_{fj}}{\partial \ln y^d_{fj}}\bigg|_{\mathbf{y}^d_{-fj}, Y^F_j}\right)^{-1} \quad \text{and} \quad \epsilon^L_{fj} = \left(\frac{\partial \ln w_{fj}}{\partial \ln l_{fj}}\bigg|_{\mathbf{l}_{-fj}}\right)^{-1},$$

respectively. With the CES structure, these two elasticities admit the closed-form expressions that can be written as functions of sales and wage bill shares:

$$\epsilon_{fj} = \epsilon(s^d_{fj}, \lambda^H_j) = \left[\frac{1}{\sigma_j} + \left(\frac{1}{\rho_j} - \frac{1}{\sigma_j}\right)s^d_{fj} + \left(1 - \frac{1}{\rho_j}\right)\lambda^H_j s^d_{fj}\right]^{-1} \tag{2.6}$$

and

$$\epsilon^L_{fj} = \epsilon^L(s^L_{fj}) = \left[\frac{1}{\eta} + \left(\frac{1}{\theta} - \frac{1}{\eta}\right)s^L_{fj}\right]^{-1}. \tag{2.7}$$

We define markups and markdowns as the ratio of price over marginal cost and marginal revenue product of labor over effective wage inclusive of labor distortions.[3] Markups and markdowns are expressed as a function of the elasticities:

$$\mu^d_{fj} = \mu^d(s^d_{fj}, \lambda^H_j) = \frac{\epsilon(s^d_{fj}, \lambda^H_j)}{\epsilon(s^d_{fj}, \lambda^H_j) - 1}, \qquad \mu^x_{fj} = \frac{\sigma_j}{\sigma_j - 1}, \qquad \mu^L_{fj} = \mu^L(s^L_{fj}) = \frac{\epsilon^L(s^L_{fj}) + 1}{\epsilon^L(s^L_{fj})}.$$

These expressions imply that firms with higher domestic sales shares s^d_{fj} charge higher markups. Also, foreign competition limits the extent of oligopolistic power (e.g. Edmond et al., 2015). Firms in sectors with higher foreign competition captured by lower domestic shares λ^H_j charge lower markups. Similar to markups, firms with higher wage bill shares set higher markdowns.

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 $\mu^L_{\tilde{f}j} = (\epsilon + 1)/\epsilon$.

We can write the first order conditions with respect to inputs as

$$\gamma^L_j p^e_{fj} y_{fj} = \mu^e_{fj}\mu^L_{fj}(1+\tau^L_{fj})w_{fj}l_{fj}, \quad \gamma^K_j p^e_{fj} y_{fj} = \mu^e_{fj}(1+\tau^K_{fj})Rk_{fj}, \quad \gamma^M_j p^e_{fj} y_{fj} = \mu^e_{fj}P^M_j m_{fj}, \tag{2.8}$$

for $e \in \{d, x\}$. Combining these first order conditions, firm prices are expressed as

$$p^e_{fj} = \mu^e_{fj}(\mu^L_{fj}(1+\tau^L_{fj}))^{\frac{\gamma^L_j}{\gamma_j}}(1+\tau^K_{fj})^{\frac{\gamma^K_j}{\gamma_j}}\frac{c_{fj}}{A^{1/\gamma_j}_{fj}}, \qquad e \in \{d, x\}, \tag{2.9}$$

[3]Specifically, $\mu^L_{fj} = \text{MRPL}_{fj}/(1+\tau^L_{fj})w_{fj}$ where MRPL_{fj} is marginal revenue product of labor.

where c_{fjt} is unit price of input bundles

$$c_{fj} = \left[y_{fj}^{1-\gamma_j} \left(\frac{w_{fj}}{\gamma_j^L}\right)^{\gamma_j^L} \left(\frac{R}{\gamma_j^K}\right)^{\gamma_j^K} \left(\frac{P_j^M}{\gamma_j^M}\right)^{\gamma_j^M} \right]^{\frac{1}{\gamma_j}}. \tag{2.10}$$

The introduction of potentially non-constant return to scale allows c_{fj} to change with scale. For decreasing returns to scale, c_{fj} is increasing in output, and vice versa. Variation in price reflects productivity, distortions, scale, variable markups and markdowns, and firm-specific wages.

2.2 Equilibrium

Market clearing Goods market clearing is

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

where $\Pi = \int_0^1 \big(\sum_{f\in\mathcal{F}_j} \pi_{fj}\big)\mathrm{d}j$. Labor and capital market clearing conditions are

$$L = \int_0^1 \sum_{f\in\mathcal{F}_j} l_{fj}\mathrm{d}j \qquad \text{and} \qquad K = \int_0^1 \sum_{f\in\mathcal{F}_j} k_{fj}\mathrm{d}j$$

Market clearing conditions imply balanced trade. The government budget is balanced

$$T = (1-\zeta)\int_0^1 \Bigg(\sum_{f\in\mathcal{F}_j} \tau_{fj}^L w_{fj} l_{fj} + \tau_{fj}^K R k_{fj} \Bigg) \mathrm{d}j,$$

where ζ is a parameter that governs how much resources are wasted due to distortions.

We formally define an equilibrium as follows.

Definition 1. *An equilibrium is a set of prices* $\{p_{fj}^d, p_{fj}^x, w_{fj}\}_{f\in\mathcal{F}_j, j\in[0,1]}$, $\{P, P_j^H, P_j, P_j^{i,M}\}_{i,j\in[0,1]}$ *and factor allocations* $\{y_{fj}^d, y_{fj}^x, l_{fj}, k_{fj}, m_{fj}\}_{f\in\mathcal{F}_j, j\in[0,1]}$, $\{Y_j^H, Y_j^F, Y_j, Y_j^{i,M}\}_{i,j\in[0,1]}$ *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.*

Market shares For each sector, firm domestic sales, wage bill, capital, and export shares can be characterized as follows.

Proposition 1. ***(Market Shares)*** *For each sector, given sectoral import shares* $\{\lambda_j^H\}_{j\in\mathcal{J}^M}$ *and firm sales in domestic and foreign markets* $\{r_{fj}^d, r_{fj}^x\}$*, firm domestic sale, wage bill, capital, and* *export shares* $\{s^d_{fj}, s^L_{fj}, s^K_{fj}, s^x_{fj}\}_{f\in\mathcal{F}_j}$ *satisfy the following* $3\times|\mathcal{F}_j|+|\mathcal{F}^x_j|$ *equations:*

$$s^d_{fj} = \frac{\left(A_{fj}^{-\frac{1}{\gamma_j}}\mu^d_{fj}\big(\mu^L_{fj}(1+\tau^L_{fj})\big)^{\frac{\gamma^L_j}{\gamma_j}}(1+\tau^K_{fj})^{\frac{\gamma^K_j}{\gamma_j}}(s^L_{fj})^{\frac{\gamma^L_j}{\gamma_j(\eta+1)}}(1+ex_{fj})^{\frac{1-\gamma_j}{\gamma_j}}\right)^{-\frac{\gamma_j}{\frac{\sigma_j}{\sigma_j-1}-\gamma_j}}}{\sum_{g\in\mathcal{F}_j}\left(A_{gj}^{-\frac{1}{\gamma_j}}\mu^d_{gj}\big(\mu^L_{gj}(1+\tau^L_{gj})\big)^{\frac{\gamma^L_j}{\gamma_j}}(1+\tau^K_{gj})^{\frac{\gamma^K_j}{\gamma_j}}(s^L_{gj})^{\frac{\gamma^L_j}{\gamma_j(\eta+1)}}(1+ex_{gj})^{\frac{1-\gamma_j}{\gamma_j}}\right)^{-\frac{\gamma_j}{\frac{\sigma_j}{\sigma_j-1}-\gamma_j}}}, \quad (2.11)$$

$$s^L_{fj} = \frac{s^d_{fj}(1+ex_{fj})\Big(\mu^d_{fj}(1+\tau^L_{fj})\mu^L_{fj}\Big)^{-1}}{\sum_{g\in\mathcal{F}_j}s^d_{gj}(1+ex_{gj})\Big(\mu^d_{gj}(1+\tau^L_{gj})\mu^L_{gj}\Big)^{-1}}, \quad (2.12)$$

$$s^K_{fj} = \frac{s^d_{fj}(1+ex_{fj})\Big(\mu^d_{fj}(1+\tau^K_{fj})\Big)^{-1}}{\sum_{g\in\mathcal{F}_j}s^d_{gj}(1+ex_{gj})\Big(\mu^d_{gj}(1+\tau^K_{gj})\Big)^{-1}}, \quad (2.13)$$

$$s^x_{fj} = \frac{s^d_{fj}\Big((\mu^d_{fj})^{-1}(ex_{fj})^{\frac{\gamma_j-1}{\gamma_j}}(D^x_{fj})^{\frac{\gamma_j}{1-\sigma_j}}\Big)^{-\frac{\gamma_j}{\frac{\sigma_j}{\sigma_j-1}-\gamma_j}}}{\sum_{g\in\mathcal{F}^x_j}s^d_{gj}\Big((\mu^d_{gj})^{-1}(ex_{gj})^{\frac{\gamma_j-1}{\gamma_j}}(D^x_{gj})^{\frac{\gamma_j}{1-\sigma_j}}\Big)^{-\frac{\gamma_j}{\frac{\sigma_j}{\sigma_j-1}-\gamma_j}}}, \quad (2.14)$$

where

$$\mu^d_{fj} = \frac{\epsilon(s^d_{fj},\lambda^H_j)}{\epsilon(s^d_{fj},\lambda^H_j)-1}, \quad \epsilon(s^d_{fj},\lambda^H_j) = \left[\frac{1}{\sigma_j}+\Big(\frac{1}{\rho_j}-\frac{1}{\sigma_j}\Big)s^d_{fj}+\Big(1-\frac{1}{\rho_j}\Big)\lambda^H_j s^d_{fj}\right]^{-1}, \quad \mu^x_{fj} = \frac{\sigma_j}{\sigma_j-1},$$

$$ex_{fj} = \frac{\mu^d_{fj}}{\mu^x_{fj}}\frac{r^x_{fj}}{r^d_{fj}}, \quad \mu^L_{fj} = \frac{\epsilon^L(s^L_{fj})+1}{\epsilon^L(s^L_{fj})}, \quad \epsilon^L(s^L_{fj}) = \left[\frac{1}{\eta}+\Big(\frac{1}{\theta}-\frac{1}{\eta}\Big)s^L_{fj}\right]^{-1}.$$

Proof. See Appendix Section A.1. □

Equation (2.11) is the key expression related to firm concentration (Figure 1). Domestic sales shares reflect productivity as well as markups and markdowns, and distortions. Because of differential foreign demand, markup adjusted ratio between exports and domestic sales ex_{fj} that measures each firm's relative size of foreign demand to domestic one appear in the expression for domestic sales shares. If all firms have the same level of foreign demand, ex_{fj} drops out of the expression. Foreign demand affects domestic sales shares through returns-to-scale and markdowns. Even if firms have the same level of productivity and distortions, but if they have different levels of foreign demand, due to returns-to-scale, foreign demand make firms have different levels of costs of production. Also, firms with larger foreign demand hire more employment, which in turn affect their markdowns. Without market power, distortions, and differential foreign demand, higher domestic sales shares reflect only productivity as in Melitz (2003).

The labor and capital shares are related to labor and capital distortions (Equations (2.12) and (2.13)). From these expressions, we can identify labor and capital distortions. The intuition for identifying distortions is analogous to Hsieh and Klenow (2009).[4] Without distortions, there is a one-to-one mapping between domestic sales shares and labor or capital shares, conditioning on productivity and foreign demand. We interpret any deviations from this mapping in the data as distortions.

From the export shares, we can identify firm-specific foreign demand (Equation (2.14)). Conditioning on other primitives, if one firm exports more than the other, we interpret that firm has higher foreign demand than the other.

There are two main implications of Proposition 1. First, the expressions allow us to back out firm-level shocks from the tight mappings between the model objectives and the micro data.[5] The second is computational simplicity. When backing out the shocks, we only have to solve out the system of nonlinear equations sector by sector, and do not have to solve the full model. Solving the full model can be computational costly because we have to solve the Nash equilibrium with many firms and sectors jointly.

3 Taking the Model to the Data

In this section, we provide an overview of our firm-level and sectoral data for South Korea, and we describe the procedure by which we calibrate the model. Appendix Sections **??** and B elaborate in detail on both the underlying data and the calibration procedure.

3.1 Data

Our analysis relies heavily on firm-level data collected from two different sources, and it allows us to quantify the importance of large firms for the South Korean economy from 1972 through 2011. Firm balance sheet data for 1972 to 1982 comes from digitizing the historical Annual Report of Korean Companies published by the Korea Productivity Center. Data for 1982 to 2011 comes 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 Joint-Stock Corporations.[6] We merge these two data sets based on firm names.

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 to say—while the 1970-1982 data has 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 23,464 unique firms, with the number of firm-year observations increasing from 731 in 1972 to 18,761 in 2011 (Appendix Table 4).

While our firm-level data covers most of South Korea's economic activity, to describe the economy

[4]Under the closed economy with monopolistic competition, the two expressions can be re-formulated to the formulas derived by Hsieh and Klenow (2009) that identify labor and capital distortions.

[5]Similarly, Hsieh and Klenow (2009), Berger et al. (2022), and Deb et al. (2022a) establish mappings between the model and the observables, and use this mapping to back out firm-specific distortions or productivity.

[6]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.

fully 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 covers imports, exports, gross output, producer price indexes (PPI), capital, and employment. Our final data set consists of 24 sectors. Among these 24 sectors, 15 sectors are manufacturing sectors with firm-level information.

3.2 Structural Parameters

Demand and production parameters We estimate the demand and the production parameters jointly because—as in most firm-level data sets—we observe firms' sales but not their prices and quantities separately. To that effect, we combine the firm-level production function with the demand curve that the firms face, in the style of De Loecker (2011), and rearrange the resulting expression to solve for firms sales $p_{fjt}y_{fjt}$ deflated by the the sectoral price index P^H_{it}:

$$\ln \frac{p_{fjt}y_{fjt}}{P^H_{jt}} = \beta^M_j \ln m_{fjt} + \beta^L_j \ln l_{fjt} + \beta^K_j \ln k_{fjt} + \beta^Y_j \ln Y^H_{jt} + \beta^A_j \ln A_{fjt} + \ln u_{fjt}.$$

The resulting 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. We also allow for measurement error u_{fjt}.

For our baseline estimation, we impose symmetry in substitution between domestic and foreign inputs ($\sigma_j = \rho_j$) because it leads to a transparent mapping between the reduced-form revenue elasticities β and the structural demand (σ_j) and production (γ^L_j, γ^K_j, γ^M_j) parameters. Specifically, the industry size revenue elasticity $\beta^Y_j = 1/\sigma_j$ identifies the demand parameter σ_j. The revenue elasticities on the production inputs are a combination of demand and production parameters, $\beta^V_j \equiv \frac{\sigma_j - 1}{\sigma_j}\gamma^V_j$ for $V \in \{M, K, L\}$. Using the recovered σ_j and the revenue elasticities β^V_j, we can then back out the production parameters γ^L_j, γ^K_j, and γ^M_j, whose sum γ_j constitutes the returns to scale.

In terms of data, the dependent variable is log nominal sales deflated by sectoral PPIs. k_{fjt} is fixed asset deflated by investment deflators. 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_j as real gross output obtained from KLEMS. Because material expenditures are available only after 1985, we restrict the sample to observations after 1985.

Our estimation proceeds in two steps. In the first step, we pin down the revenue elasticity of material inputs using the following relationship for each sector[7]:

$$\hat{\beta}^M_j = \frac{1}{N}\sum_t \sum_{f \in \mathcal{F}_{jt}} \frac{1}{1 - \lambda^H_j s_{fjt}} \frac{P^M_{jt} m_{fjt}}{p_{fjt}y_{fjt}},$$

where λ^H_j is the expenditure share on domestic inputs by sector j. In addition to reducing the set

[7] We closely follow Ruzic and Ho (2023) who proceeds in these two steps to recover the revenue elastiticities.

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, which have been highlighted by Ackerberg et al. (2015) and Gandhi et al. (2020). 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 from the initial expression to take to the data the following modified estimating equation:

$$\ln \frac{p_{fjt} y_{fjt}}{P^H_{jt}} - \hat{\beta}^M_j \ln m_{fjt} = \beta^L_j \ln l_{fjt} + \beta^K_j \ln k_{fjt} + \beta^Y_j \ln Y^H_{jt} + \beta^A_j \ln A_{fjt} + \ln u_{fjt}. \tag{3.1}$$

Estimates of Equation (3.1) by OLS suffer from as 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 Equation (3.1) using the control function approach (Olley and Pakes, 1996; Levinsohn and Petrin, 2003). We assume that productivity follows a first-order Markov process, $\ln A_{fjt} = g(\ln A_{fj,t-1}) + \xi_{fjt}$, 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 (Doraszelski and Jaumandreu, 2021; De Ridder et al., 2021). Because markups and markdowns are functions of s_{fjt} and s^L_{fjt}, it is sufficient to invert productivity conditional on these observable shares:

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

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

$$\ln \frac{p_{fjt} y_{fjt}}{P^H_{jt}} - \hat{\beta}^M_j \ln m_{fjt} = h(\ln l_{fjt}, lnk_{fjt}, \ln m_{fjt}, s_{fjt}, s^L_{fjt}, \ln Y^H_{jt}) + u_{fjt}$$

and obtaining the estimated fit $\hat{h}$. Then, using the timing structure, we construct the following moment conditions

$$\mathbb{E}_t\left(\xi_{fjt}(\gamma^L_j, \gamma^K_j, \sigma_j) \times \begin{bmatrix} \ln k_{fjt} \\ \ln l_{fj,t-1} \\ \ln Y_{j,t-1} \end{bmatrix} \right) = 0.$$

We obtain $\xi_{fjt}(\beta^L_j, \beta^K_j, \beta^Y_j)$ from projecting $\ln A_{fjt}$ on polynomials of $\ln A_{fj,t-1}$, where

$$\ln A_{fjt} = \frac{1}{\beta^A_j}\Big(\ln \frac{p_{fjt} y_{fjt}}{P^H_{jt}} - \hat{\beta}^M_j \ln m_{fjt} - \beta^L_j \ln l_{fjt} - \beta^K_j \ln k_{fjt} - \beta^Y_j \ln Y^H_{jt} \Big)$$

Table 1: Estimates for Elasticity of Substitution and Production Function Parameters

Sector	σ	γ_j^L	γ_j^K	γ_j^M	γ_j
Food	9.0	0.48	0.05	0.44	0.97
Textiles	3.61	0.31	0.1	0.36	0.78
Apparel	2.0	0.05	0.2	0.19	0.43
Leather	11.0	0.05	0.18	0.44	0.67
Wood	4.98	0.39	0.07	0.39	0.84
Petrochemicals	2.14	0.44	0.26	0.32	1.02
Chemicals	11.0	0.5	0.26	0.28	1.04
Pharmaceuticals	10.02	0.45	0.09	0.44	0.99
Rubber & plastic products	3.47	0.55	0.05	0.37	0.97
Non-metallic minerals	10.83	0.19	0.09	0.40	0.68
Metal	2.0	0.85	0.07	0.25	1.17
Machinery	6.81	0.49	0.06	0.38	0.93
Electronics	2.0	0.79	0.16	0.24	1.18
Motor vehicles	10.90	0.35	0.16	0.47	0.98
Shipbuilding	10.60	0.37	0.18	0.32	0.87

Notes. This table reports the calibrated values of the elasticity of substitution and the Cobb-Douglas production function parameters for each manufacturing sector. $\gamma_j = \gamma_j^L + \gamma_j^K + \gamma_j^M$.

for a given guess of β_j^L, β_j^K, and β_j^Y.

Table 1 reports the estimation results. The mean of estimated σ_j is 6.9, which is in line with the previous estimates in the literature. Burstein et al. (2021) reports the value of 7; and De Loecker et al. (2021), 5.8. The mean of labor share of value added $\gamma_j^L/(\gamma_j^L + \gamma_j^K)$ and returns to scale γ_j is 0.74 and 0.9, respectively, which are comparable to commonly calibrated values 0.66 and 0.8.

Labor supply elasticity We externally calibrate 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.[8] 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.

The remaining parameters We use the Bank of Korea input-output tables to obtain the final consumption shares α_j and to characterize the input-output structure γ_j^k of material inputs used by sector j.

[8]The value of 4 is also broadly consistent with estimates from other recent works. 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; Dhyne et al. (2022) in Belgium; and Huneeus et al. (2022) the range of 3–6 in Chile

3.3 Shocks

To back out the firm-level shocks, our calibration proceeds in two steps. As part of the calibration, each firm we observe is an object in the model, and we take the model to the data year by year.

The first step of the calibration identifies heterogeneous firms' productivity, distortions and foreign demands relative to fringe firms. Specifically, using data on domestic sales, employment, capital, and export shares, we solve for $\{A_{fjt}, \tau^L_{fjt}, \tau^K_{fjt}, D^x_{fjt}\}_{j \in \mathcal{F}_{jt}}$ for each sector and time. Productivity A_{ftj} can be identified from Equation (2.11); labor distortions τ^L_{fjt} from Equation (2.12); capital distortions tau^K_{fjt} from Equation (2.13), and foreign demand D^x_{fjt} from Equation (2.14). We normalize fringe firms' distortions by the sales-weighted average of finite firms' distortions.

In the second step—given these identified productivity, distortions, and foreign demands relative to fringe firms—we pin down the fringe firms' productivity and foreign demands $\{A_{\tilde{f}jt}, D^x_{\tilde{f}jt}\}_{j\in[0,1]}$, the foreign import price shocks $\{P^F_{jt}\}_{j\in[0,1]}$, and the aggregate preference shock to the disutility of labor $\bar{\phi}_t$. We treat trade deficits as exogenous as standard in the trade literature. We calibrate fringe firms' productivity by fitting sectoral PPI changes and aggregate real GDP growth, and their foreign demand by fitting aggregate exports.[9] Import price shocks are identified by imports shares and $\bar{\phi}_t$ from changes in aggregate working hours per employment.

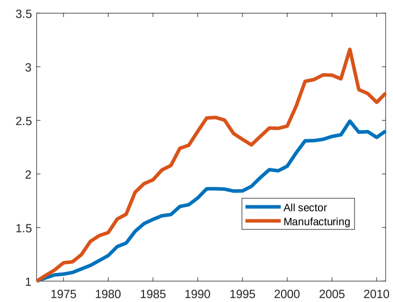
The shocks we back out for productivity and demand—and plot in Figure 2 below—capture salient trends in the South Korean economy since the 1970s. Panel A illustrates the rapid increase in productivity, both for all firms and for manufacturing firms separately. During the sample period, the average manufacturing productivity increased 325%.[10] Panel B plots the export-weighted average of foreign demand relative to domestic demand, $\tilde{D}^F_{jt} \equiv D^F_{jt}/((P^H_{jt})^{\sigma_j-\rho_j} P^{\rho_j-1}_{jt})$. We label $\tilde{D}^F_{jt}$ the relative foreign demand shocks that measure the foreign demand shocks relative to domestic price levels. The relative foreign demand shocks were volatile and that their movement was closely associated with global demand conditions and 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 depreciating exchange rate and low oil prices drove an increase in foreign demand. And, around 1998, foreign demand increased sharply as the real exchange rate depreciated in the midst of the 1997 Asian financial crisis.

Moreover, the various forms of distortions we model and back out all show a tendency to increase over time. We normalize each firm's labor and capital distortion by its respective sectoral sales-weighted average, and we report in Panels C and D the standard deviations of normalized labor and capital distortions. The dispersion of labor distortions increased in the 1970s and remained relatively

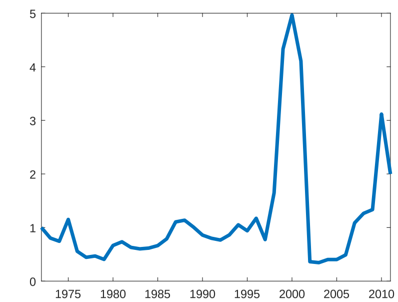
[9] We use changes in PPI (relative to a reference sector) to pin down the relative productivity changes of sectors (relative to the reference sector). We then pin down the productivity changes of the reference sector using aggregate real GDP growth.

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

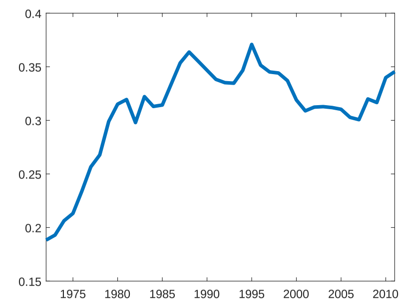
Figure 2. Backed-out Shocks and Market Power



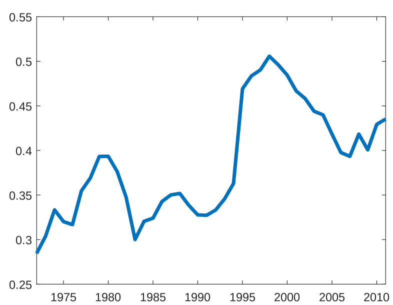
A. Aggregate productivity A_{fjt}



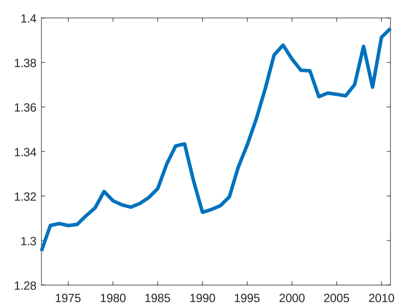
B. Relative foreign demand $\tilde{D}^F_{jt}$



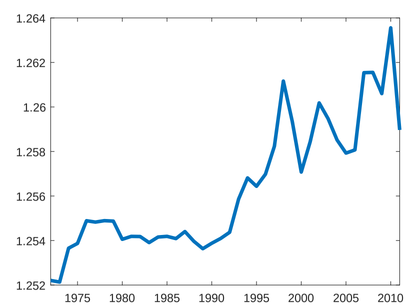
C. Std. labor distortion τ^L_{fjt}



D. Std. capital distortion τ^K_{fjt}



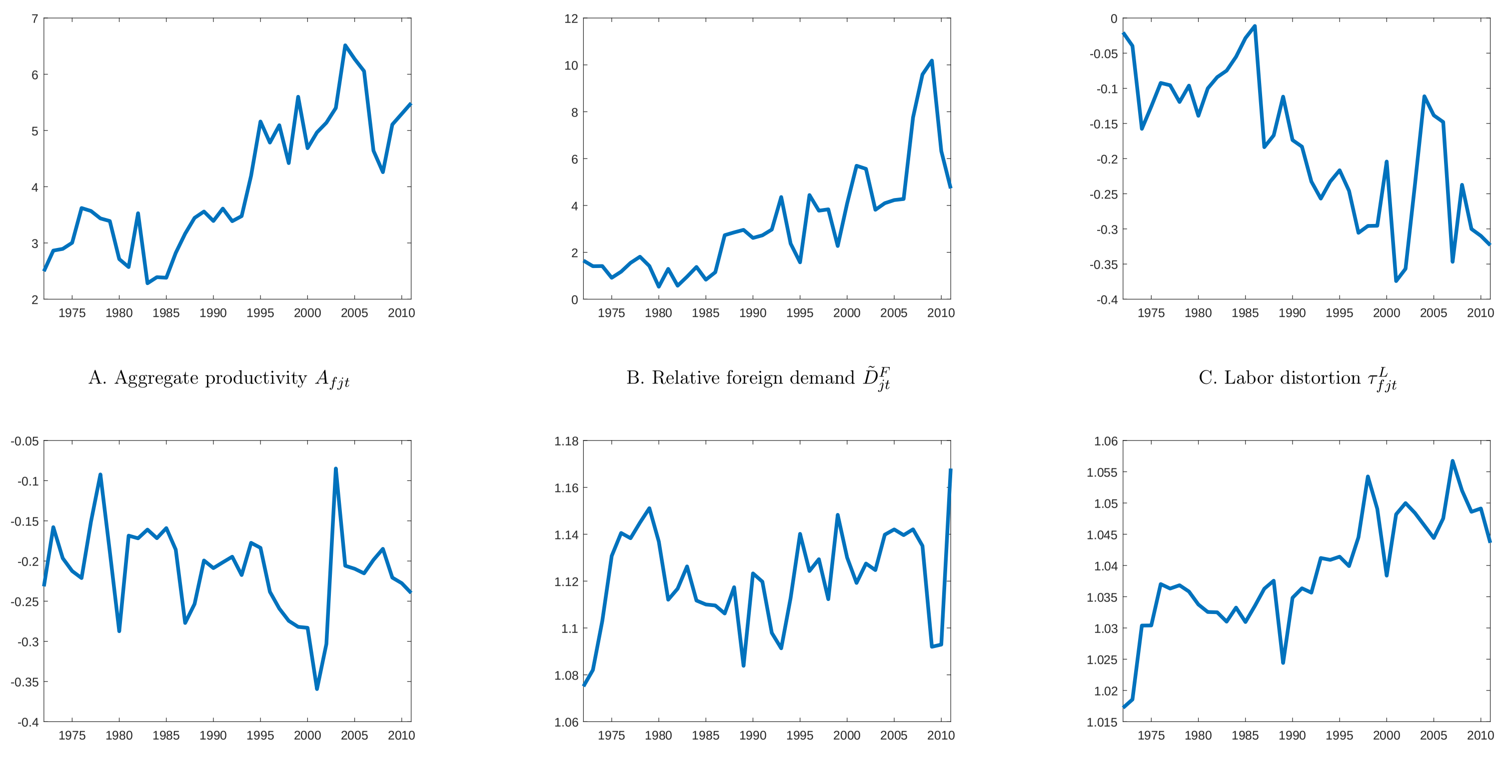
E. Markup μ_{fjt}



F. Markdown μ^L_{fjt}

Notes. This figure illustrates the backed-out shocks and market power. Panel A plots the sales-weighted average of productivity of all and manufacturing firms. Panel B plots the export-weighted average of foreign demand relative to domestic demand. Panels C and D plot the standard deviations of labor and capital distortions normalized by the corresponding sectoral sales-weighted average. Panels E and F plot the sales-weighted average of markups and markdowns, where the weights are given by sales.

Figure 3. Backed-out Shocks and Market Power of Top 10 Firms Relative to the Others



A. Aggregate productivity A_{fjt}

B. Relative foreign demand $\tilde{D}^F_{jt}$

C. Labor distortion τ^L_{fjt}

D. Capital distortion τ^K_{fjt}

E.Markup μ_{fjt}

F. Markdown μ^L_{fjt}

Notes. This figure illustrates the top 10 manufacturing firms' backed-out shocks and market power relative to the other firms in the same sector. We divide the top 10 firms' shocks by the weighted average of shocks of the other firms in the same sector. The weights are given by sales for productivity, labor and capital distortions, markups and markdowns. For foreign demand relative to domestic demand, the weights are given by exports. Then, we take the unweighted average of these relative shocks across the top 10 firms.

flat. The dispersion of capital distortions also increased during the 1970s, potentially due to large-scale industrial policy that subsidized purchases of capital equipment by heavy manufacturing firms (Choi and Levchenko, 2023). The dispersion in capital distortions reached its peak around the 1997 Asian financial crisis, consistent with financial frictions being exacerbated by the crisis (Midrigan and Xu, 2014). Furthermore—in a manner consistent with concern regarding increased firm concentration—the sales-weighted average of markups and markdowns increased by 7.8% and 0.6%, respectively.

We then look at how all of these shocks affected the top 10 largest manufacturing firms relative to other firms. We focus on the top 10 firms by sales in each year, so that the set of the top 10 firms varies across years. For each of the 10 firms, we then divide its shocks by the weighted average of shocks of the other firms in the same sector. The weights are given by sales for productivity, labor and capital distortions, markups and markdowns. For foreign demand, the weights are given by exports. We then take the unweighted average of these relative shocks across the top 10 firms.

The plots in Figure 3 show that the top 10 firms experienced faster growth in productivity and foreign demand while also experiencing relative declines in the labor-market distortions they faced. Panels A shows that in 1972 the productivity of the top 10 firms was 2.5 times higher than that of the other firms; by contrast, near its peak in 2004, it was 6.5 times higher. In 1972, foreign demand of the top 10 firms—plotted in panel B—was 1.4 times higher than that of the other firms, whereas it was 9 times higher near its 2007 peak. Panels C and D show that labor distortions of the top 10 firms decreased over time relative to the others, while their capital distortions remained relatively comparable. Consistently with increasing productivity, increasing foreign demand and decreasing labor distortions, the top 10 firms' markups and markdowns increased relative to the others.

4 Quantitative Results

In this section we examine the impacts of market structure, microeconomic shocks, and idiosyncratically large firms both for concentration and for welfare in South Korea since the 1970s. First, our findings confirm the notion that exercises of market power (particularly those in product markets) lower welfare as well as concentration: the exercise of market power leads firms to be smaller than their socially optimal size. Second, our findings suggest that the welfare losses from exercises of market power are dwarfed by the welfare gains from unequal productivity growth at the top of the firm size distribution. Counterfactual exercises in which all firms experience the same growth (thereby depressing the runaway productivity growth of the largest firms) would have led to welfare losses that are an order of magnitude higher than the losses due to the exercise of market power. We highlight this second point at the end of this section by examining the impact of a particularly large and important firm to the South Korean economy: Samsung Electronics.

Market Structure namely market power exercised through product and labor markets—has tended to depress concentration and decrease welfare. We examine these impacts by constructing counterfactuals where we displace oligopolistics and oligopsonistic market power with their monopolistic and

Table 2: Counterfactual. Welfare Effects of Market Structure

Goods Market Labor Market	Oligopoly Monop. Competition	Monop. Competition Oligopsony	Monop. Competition Monop. Competition
	(1)	(2)	(3)
$\triangle$ Welfare (%)	−0.06	0.60	0.47

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

monopsonistic equivalents, showing that these counterfactuals would have led to increases in both concentration by 16% and welfare by 0.6%.

Table 2 reports these welfare changes in consumption equivalent variation for counterfactuals under three alternative market structures, all the while maintaining the same firm-level shocks.[11] Without oligopolistic market power, the welfare increases around 0.6%, whereas oligopsonistic market power had negligible welfare impacts.[12] In Figure 4, we examine how firm concentration would have evolved differently in the counterfactual economies. The top 10 firms' concentration ratio increased around 16% when goods markets are monopolistically competitive, because under oligopoly, firms charge higher prices and produce less quantities, which in turn leads to lower revenues.

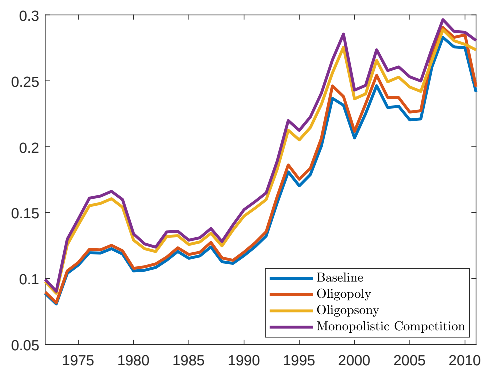
Micro vs. macro shocks Out of the various microeconomic shocks, the exceptional productivity growth of the largest firms (relative to their smaller counterparts) has played the most striking role in rising concentration and welfare over time, with welfare gains roughly an order of magnitude higher than the welfare costs from market power. In addition, firm-level distortions and foreign demand shocks have also shaped the South Korean economy, often with roughly equal importance for welfare as market power.

To examine the importance of differential microeconomic shocks faced by the largest firms, we consider counterfactuals in which we substitute the heterogeneous shocks experienced by firms with homogeneous macroeconomic (e.g., weighted average) shocks common to all firms. This exercise is motivated by the earlier Figure 3, which showed that the large firms experienced shocks that had different trends relative to those of the other firms.

[11] Specifically, we compute λ such that $\sum_{t=1972}^{2011} U((1+\lambda)C_t, L_t) = \sum_{t=1972}^{2011} U(C_t^c, L_t^c)$, where C_t^c and L_t^c are the counterfactual consumption and labor supply.

[12] The reason why welfare gains of the economy with oligopsonistic market power (column (2)) are larger than those of the economy without such power (column (3)) is due to the interaction between other firm primitives and oligopsony. When we only feed productivity shocks, an economy under monopolistic competition in both goods and labor markets have the largest welfare gains.

Figure 4. Counterfactual. Market Structure



A. Top 10 Mfg. Firms' Concentration Ratio

Notes. This figure illustrates counterfactual the top 10 firms' concentration ratio with alternative market structure.

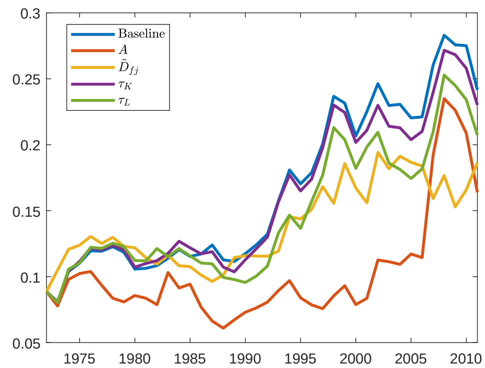
For instance, we define macro productivity shocks as the unweighted average of firm-level productivity shocks within sectors: $A^c_{jt} \equiv \frac{1}{|\mathcal{F}_{jt}|}\sum_{f\in\mathcal{F}_{jt}} A_{fjt}$. Then, we compare the baseline economy to the counterfactual economy in which firms are growing at the same rate of $A^c_{jt}/A^c_{j,t-1}$, while keeping all other shocks the same in both economies. Starting from the initial productivity, we construct the hypothetical shock of the next period as $A^c_{fj,t_0+1} = \frac{A^c_{j,t_0+1}}{A^c_{jt_0}} \times A_{fjt_0}$, and we repeat this process for the subsequent periods.

Similarly to the productivity shocks, we define macro relative foreign demand shocks as the unweighted average of firm-level relative foreign demand shocks: $\tilde{D}^{F,c}_{jt} \equiv \frac{1}{|\mathcal{F}_{jt}|}\sum_{f\in\mathcal{F}_{jt}} \tilde{D}^F_{fjt}$. Then, we construct the counterfactual firm-level shocks under the assumption that firms' relative foreign demand shocks are growing at the same rate of $\tilde{D}^{F,c}_{jt}/\tilde{D}^{F,c}_{j,t-1}$. This counterfactual shock is fed to only exporting firms with positive export values each year.

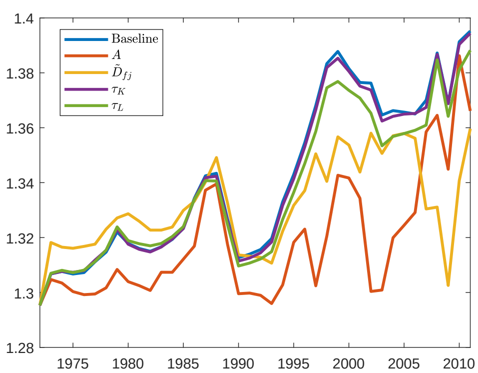
Finally, to treat distortions in a similar manner, we consider the counterfactual economy in which firms' distortions do not change from their initial level. For firms operating since the start of the sample period, their distortion levels are held fixed at the levels in 1972. For new entrants after 1972, we fix their distortion levels to their entry levels. To neutralize the level effects of distortions, for each sector and year, we normalize distortions by the sales-weighted average of distortions.

Panel A of Figure 5 emphasizes that all of the above counterfactuals would have reduced the concentration growth among South Korean firms. The productivity shocks had the largest effects on firm concentration. Without the micro productivity shocks, the top 10 concentration ratio could have been decreased by 60%. The relative foreign demand shock had the second largest impact (24%). The

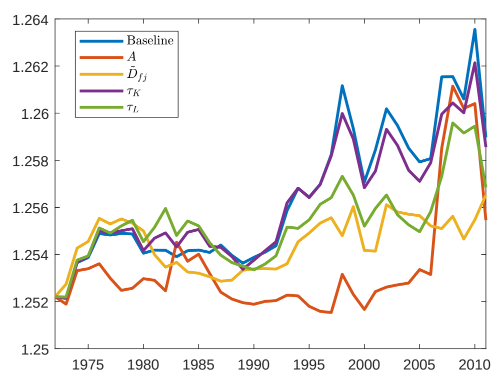
Figure 5. Counterfactual. Micro vs. Macro Shocks



A. Top 10 Mfg. Firms' Concentration Ratio



B. Markup



C. Markdown

Notes. This figure illustrates counterfactual the top 10 firms' concentration ratio, the sales-weighted markups, and the sales-weighted markdowns with alternative market structure and hypothetical macro shocks.

counterfactual labor and capital distortions had more limited impacts (14% and 8%). The reductions in firm concentration lead to decreases in the sales-weighted markups and markdowns (Panels B and C). The counterfactual productivity shocks could have decreased the weighted markups and markdowns by 4% and 0.6%, respectively.

Table 3 reports the welfare comparisons in consumption equivalent variation, emphasizing that—while these counterfactuals would have reduced concentration—many counterfactuals would have also strongly reduced welfare. The counterfactual (homogeneous) productivity shock would have decreased welfare by as much as 13.6%, as the largest firms would have grown at the same rate as their smaller

Table 3: Counterfactual. Welfare Effects of Micro Shocks

Shocks	Productivity A_{fjt}	Foreign demand (Relative) $\tilde{D}^{f}_{fjt}$	Labor distortion τ^{L}_{fjt}	Capital distortion τ^{K}_{fjt}
	(1)	(2)	(3)	(4)
△ Welfare (%)	−13.59	−0.47	−0.46	−1.97

Notes. This table reports the welfare effects of micro shocks.

counterparts. The counterfactual (homogeneous) relative foreign demand shock would have decreased welfare by 0.5%. The counterfactuals that hold fixed the initial distortion levels would have also decreased welfare, by 0.6% and 2.0% for labor and for capital distortions, respectively. This fall in welfare comes from the fact that the largest firms have been experiencing sharper declines in the distortions they've faced since the 1970s (as per Panels C and D, Figure 3); holding these distortions artificially high in the counterfactual leads to welfare losses.

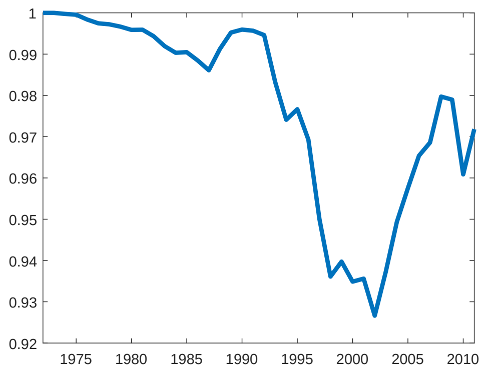
Granular firm In the previous counterfactual exercise, we showed that micro shocks have different macroeconomic implications from homogeneous macro shocks; we now push this finding further and examine how one large firm contributes to the aggregate economy. We focus on the productivity growth of South Korea's largest firm, Samsung Electronics, and shut down its productivity growth. Instead, we construct a hypothetical sequence of Samsung's productivity shocks under the assumption that Samsung grew similarly to other firms.[13]

Restricting Samsung's productivity in this way would have indeed reduced concentration, price markups and wage markdown, as per panels B-D of Figure 6. Without Samsung's productivity growth, the top 10 firms' concentration ratio would have decreased by 6 percentage points around the 2000s, the periods that exhibit the largest differences between the baseline and the counterfactual outcomes. Moreover, around the 2000s, the sales-weighted average markups and markdowns would have decreased by 4 percentage points and a 0.005 percentage point, respectively (Panels C and D).

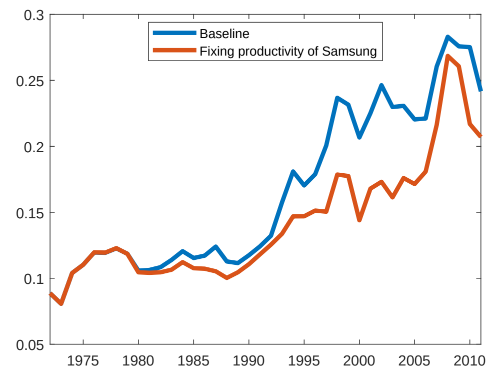
However, while concentration would have declined, so too would have real output: without Samsung's idiosyncratic productivity growth, the real GDP in 2011 would have been 3% below that of the baseline, as per Panel A of Figure 6. Moreover, around the Asian financial crisis, real GDP would have have decreased by 7%. This big drop is due to the fact that, unlike other firms, Samsung did not experience large decreases in productivity during this crisis.

[13]Staring from the initial 1972 productivity level, we sequentially multiply the growth of the macro productivity shock to Samsung's productivity level in the previous period.

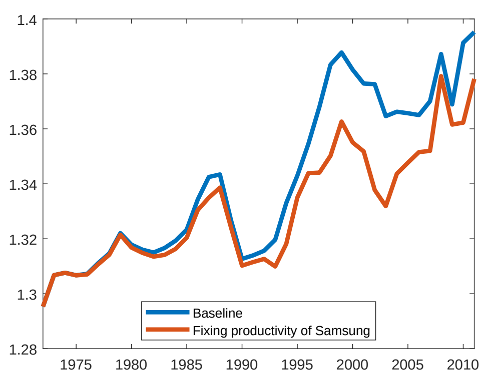
Figure 6. Counterfactual. Samsung Electronics



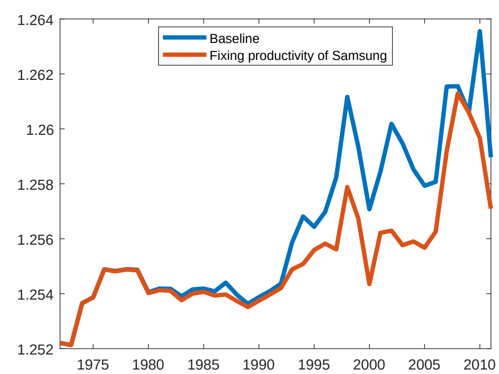
A. Real GDP relative to the Baseline



B. Concentration Ratio 10



C. Markup



D. Markdown

Notes. This figure illustrates counterfactual results on Samsung Electronics. In the counterfactual, we consider the hypothetical productivity shocks of Samsung that its productivity grows by the same rate with the unweighted average of productivity shocks within electronic sector.

5 Conclusion

Using the novel historical data, we document a novel fact on increasing firm concentration during South Korea's growth miracle periods. To understand driving forces behind 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 disrotions and foreign demand. The model allows us to disentangle which factors drove such higher concentration. We find that productivity growth of large firms explain most of firm concentration increase. Also, our quantitative exercises show that counterfactual productivity growth of a few large firms had sizable impacts to real GDP, firm concentration, and the average markup and markdown levels of the economy. Our findings highlight the importance of granular firms' contributions to economic growth.

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ONLINE APPENDIX

(NOT FOR PUBLICATION)

Table 4: The Number of Firm-year Observations

Year	Number of observations
1972	731
1973	852
1974	918
1975	979
1976	1,087
1977	1,227
1978	1,341
1979	1,436
1980	1,528
1981	1,571
1982	1,864
1983	1,814
1984	2,022
1985	2,189
1986	2,386
1987	2,655
1988	2,927
1989	3,119
1990	3,461
1991	3,845
1992	4,007
1993	4,291
1994	4,840
1995	6,399
1996	7,446
1997	9,130
1998	10,661
1999	13,499
2000	15,384
2001	16,860
2002	18,263
2003	19,369
2004	20,427
2005	21,374
2006	18,901
2007	19,114
2008	19,063
2009	18,950
2010	18,823
2011	18,761

Notes. The total number of firm-year observations is 323,514. The number of unique firms is 23,464.

Table 5: Sector Classification

Aggregated Industry	Industry
Petrochemicals*	Coke oven products (231), Refined petroleum products (232)
Chemicals*	Basic chemicals (241), Other chemical products (242) Man-made fibres (243) except for pharmaceuticals and medicine chemicals (2423)
Pharmaceuticals*	pharmaceuticals and medicine chemicals (2423)
Rubber and plastic products*	Rubber products (251), Plastic products (252)
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*	Machinery and equipment n.e.c. (29)
Motor vehicles*	Motor vehicles, trailers and semi trailers (34)
Shipbuilding*	Manufacture of other transport equipment (35)
Food*	Food products and beverages (15), Tobacco products (16)
Textiles*	Textiles (17)
Apparel*	Apparel (18)
Leather*	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 heavy manufacturing sectors. The numbers inside parenthesis denote ISIC Rev 3.1 codes.

Appendix A Model

A.1 Derivation

Derivation of Equation (2.5) Lagrangian for the profit maximization problem is

$$\max_{y^d_{fj}, y^x_{fj}, l_{fj}, k_{fj}, m_{fj}} p^d_{fj} y^d_{fj} + p^x_{fj} y^x_{fj} - (1+\tau^L_{fj}) w_{fj} l_{fj} - (1+\tau^K_{fj}) R k_{fj} - P^M_j m_{fj} + \lambda(y_{fj} - y^d_{fj} - y^x_{fj}),$$

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

$$p^d_{fj} + y^d_{fj} \frac{\partial p^d_{fj}}{\partial y^d_{fj}} = p^d_{fj}\Big(1 + \frac{\partial \ln p^d_{fj}}{\partial \ln y^d_{fj}}\Big) = \lambda, \qquad p^x_{fj} + y^x_{fj} \frac{\partial p^x_{fj}}{\partial y^x_{fj}} = p^x_{fj}\Big(1 + \frac{\partial \ln p^x_{fj}}{\partial \ln y^x_{fj}}\Big) = \lambda,$$

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

where $-\frac{\partial \ln p^d_{fj}}{\partial \ln y^d_{fj}} = -\epsilon(s^d_{fj}, \lambda^H_j)^{-1}$ and $-\frac{\partial \ln p^x_{fj}}{\partial \ln y^x_{fj}} = -\frac{1}{\sigma_j}$, and $\frac{\partial \ln w_{fj}}{\partial \ln l_{fj}} = \epsilon^L(s^L_{fj})$. Combining the above three first order conditions gives the expression in Equation (2.5).

Derivation of Equation (2.6) We show that ϵ_{fj} can be written as sale and import shares. The inverse demand function is expressed as

$$p^d_{fj} = (y^d_{fj})^{-\frac{1}{\sigma_j}} (Y^H_j)^{\frac{1}{\sigma_j} - \frac{1}{\rho_j}} (Y_j)^{\frac{1}{\rho_j} - 1} E_j.$$

$$\epsilon^{-1}_{fj} = -\frac{\partial \ln p^d_{fj}}{\partial \ln y^d_{fj}} = \frac{1}{\sigma_j} + \Big(\frac{1}{\rho_j} - \frac{1}{\sigma_j}\Big)\frac{\partial \ln Y^H_j}{\partial \ln y^d_{fj}} + \Big(1 - \frac{1}{\rho_j}\Big)\frac{\partial \ln Y_j}{\partial \ln y^d_{fj}}. \tag{A.1}$$

Note that

$$\frac{\partial \ln Y^H_j}{\partial \ln y^d_{fj}} = s^d_{fj}$$

and that

$$\frac{\partial \ln Y_j}{\partial \ln y^d_{fj}} = \underbrace{\frac{\partial \ln Y_j}{\partial \ln Y^H_j}}_{=\lambda^H_j} \underbrace{\frac{\partial \ln Y^H_j}{\partial \ln y^d_{fj}}}_{=s^d_{fj}}.$$

Substituting the above two expression into Equation (A.1) gives

$$\epsilon^{-1}_{fj} = \frac{1}{\sigma_j} + \Big(\frac{1}{\rho_j} - \frac{1}{\sigma_j}\Big) s^d_{fj} + \Big(1 - \frac{1}{\rho_j}\Big)\lambda^H_j s^d_{fj}.$$

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 $\sigma_j = \rho_j$,

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

Derivation of Equation (2.7) The inverse labor supply function can be written as

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

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

$$(\epsilon_{fj}^L)^{-1} = \frac{\partial \ln w_{fj}}{\partial \ln l_{fj}} = \frac{1}{\eta} + \Big(\frac{1}{\theta} - \frac{1}{\eta}\Big) \underbrace{\frac{\partial \ln L_j}{\partial \ln l_{fj}}}_{=s_{fj}^L}$$

Derivation of Equation (2.9) Using Equation (2.8), we obtain

$$l_{fj} = \frac{\gamma_j^L p_{fj}^e y_{fj}}{\mu_{fj}^e \mu_{fj}^L (1+\tau_{fj}^L) w_{fj}}, \quad k_{fj} = \frac{\gamma_j^K p_{fj}^e y_{fj}}{\mu_{fj}^e R(1+\tau_{fj}^K)}, \quad m_{fj} = \frac{\gamma_j^M p_{fj}^e y_{fj}}{P_j^M \mu_{fj}^e},$$

for $e \in \{d, x\}$. Substituting the above expressions into production function $y_{fj} = A_{fj} l_{fj}^{\gamma_j^L} k_{fj}^{\gamma_j^K} m_{fj}^{\gamma_j^M}$, we obtain

$$y_{fj} = A_{fj} (\mu_{fj}^e)^{-\gamma_j} (p_{fj}^e y_{fj})^{\gamma_j} \big(\mu_{fj}^L (1+\tau_{fj}^L)\big)^{-\gamma_j^L} (1+\tau_{fj}^K)^{-\gamma_j^K} \Big(\frac{w_{fj}}{\gamma_j^L}\Big)^{-\gamma_j^L} \Big(\frac{R}{\gamma_j^K}\Big)^{-\gamma_j^K} \Big(\frac{P_j^M}{\gamma_j^M}\Big)^{-\gamma_j^M}.$$

Rearranging the above expression, we obtain

$$p_{fj}^e = \mu_{fj}^e \big(\mu_{fj}^L (1+\tau_{fj}^L)\big)^{\frac{\gamma_j^L}{\gamma_j}} (1+\tau_{fj}^K)^{\frac{\gamma_j^K}{\gamma_j}} c_{fj} A_{fj}^{-1/\gamma_j}.$$

Proof of Proposition 1

Proof. Because price differences in domestic and export markets come from variation in market power, a ratio between quantities produced for domestic and foreign markets can be written as

$$\frac{y^d_{fj}}{y^x_{fj}} = \frac{p^x_{fj}}{p^d_{fj}}\frac{r^d_{fj}}{r^x_{fj}} = \frac{\mu^x_{fj}}{\mu^d_{fj}}\frac{r^d_{fj}}{r^x_{fj}}.$$

Note that A_{fj} and c_{fj} are canceled out in the second expression. Using the above expression, total quantity produced can be expressed as

$$y_{fj} = \Big(1 + \frac{r^x_{fj}}{r^d_{fj}}\frac{\mu^d_{fj}}{\mu^x_{fj}}\Big)y^d_{fj} = \Big(1 + \frac{r^d_{fj}}{r^x_{fj}}\frac{\mu^x_{fj}}{\mu^d_{fj}}\Big)y^x_{fj}. \tag{A.2}$$

We first derive a formula in Equation (2.11). Using that $y^d_{fj} = (p^d_{fj})^{-\sigma_j}(P^H_j)^{\sigma_j-\rho_j}P_j^{\rho_j-1}E_j$ and Equation (A.2), we can rewrite Equation (2.9) as

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

where B_j is a collection of R, 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

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

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

$$(p^d_{fj})^{1-\sigma_j} \propto \Big(\mu^d_{fj}\big(\mu^L_{fj}(1+\tau^L_{fj})\big)^{\frac{\gamma^L_j}{\gamma_j}}(1+\tau^K_{fj})^{\frac{\gamma^K_j}{\gamma_j}}(s^L_{fj})^{\frac{\gamma^L_j}{\gamma_j(\eta+1)}}A_{fj}^{-\frac{1}{\gamma_j}}(1+ex_{fj})^{\frac{1-\gamma_j}{\gamma_j}}\Big)^{-\frac{\gamma_j}{\frac{\sigma_j}{\sigma_j-1}-\gamma_j}}.$$

Substituting the above expression into domestic sales shares $s^d_{fj} = \frac{(p^d_{fj})^{1-\sigma_j}}{\sum_{g\in\mathcal{F}_j}(p^d_{gj})^{1-\sigma_j}}$ gives the desired results.

Second, we derive the expression for wage bill shares in Equation (2.12). Substituting $w_{fj}l_{fj} = (\mu^d_{fj}\mu^L_{fj}(1+\tau^L_{fj}))^{-1}\gamma^L_j p^d_{fj}y_{fj}$ from the first order conditions and $y_{fj} = (1+ex_{fj})y^d_{fj}$ into wage bill shares and dividing both numerator and the denominator by $\sum_{f\in\mathcal{F}_j}p^d_{fj}y^d_{fj}$ give the desired result.

Third, we derive the expression for capital shares in Equation (2.13). Substituting $k_{fj} = (\mu^d_{fj}(1+\tau^K_{fj}))^{-1}R^{-1}\gamma^K_j p^d_{fj}y_{fj}$ from the first order conditions and $y_{fj} = (1+ex_{fj})y^d_{fj}$ into capital shares and dividing both numerator and the denominator by $\sum_{f\in\mathcal{F}_j}p^d_{fj}y^d_{fj}$ give the desired result.

Finally, using Equation (2.9), $y_{fj} = (1+1/ex_{fj})y^x_{fj}$, and $y^x_{fj} = (p^x_{fj})^{-\sigma_j}D^x_{fj}$, we obtain

$$(p^x_{fj})^{1-\sigma_j} \propto \Big(\big(\mu^L_{fj}(1+\tau^L_{fj})\big)^{\frac{\gamma^L_j}{\gamma_j}}(1+\tau^K_{fj})^{\frac{\gamma^K_j}{\gamma_j}}(s^L_{fj})^{\frac{\gamma^L_j}{\gamma_j(\eta+1)}}A_{fj}^{-\frac{1}{\gamma_j}}(1+1/ex_{fj})^{\frac{1-\gamma_j}{\gamma_j}}(D^x_{fj})^{\frac{1-\gamma_j}{\gamma_j}}\Big)^{-\frac{\gamma_j}{\frac{\sigma_j}{\sigma_j-1}-\gamma_j}},$$

which gives

$$(p^x_{fj})^{1-\sigma_j} D^x_{fj} \propto \left(\left(\mu^L_{fj}(1+\tau^L_{fj})\right)^{\frac{\gamma^L_j}{\gamma_j}} (1+\tau^K_{fj})^{\frac{\gamma^K_j}{\gamma_j}} (s^L_{fj})^{\frac{\gamma^L_j}{\gamma_j(\eta+1)}} A_{fj}^{-\frac{1}{\gamma_j}} (1+\frac{1}{ex_{fj}})^{\frac{1-\gamma_j}{\gamma_j}} (D^x_{fj})^{\frac{\gamma_j}{1-\sigma_j}} \right)^{-\frac{\gamma_j}{\frac{\sigma_j}{\sigma_j-1}-\gamma_j}},$$

Substituting the above expression into export shares $s^x_{fj} = \frac{(p^x_{fj})^{1-\sigma}_j D^x_{fj}}{\sum_{g\in\mathcal{F}^x_j}(p^x_{gj})^{1-\sigma}_j D^x_{gj}}$ gives the desired results.

□

Appendix B Quantification

B.1 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

Structural parameters

- Production function $\{\gamma^L_j, \gamma^K_j, \gamma^M_j\}_{j\in[0,1]}$
- Cobb-Douglas shares of preference and intermediate inputs $\{\alpha_j\}_{j\in[0,1]}$ and $\{\gamma^j_i\}_{i,j\in[0,1]}$
- 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:

$$r^d_{\tilde{f}jt} = R^{d,\text{Agg}}_{jt} - \sum_{f\in\mathcal{F}^{\text{Firm}}_{jt}} r^{\text{d,Firm}}_{fjt}, \qquad r^x_{\tilde{f}jt} = R^{x,\text{Agg}}_{jt} - \sum_{f\in\mathcal{F}^{\text{Firm}}_{jt}} r^{\text{x,Firm}}_{fjt}.$$

$\mathcal{F}^{\text{Firm}}_{jt}$ 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. $r^{d,\text{Firm}}_{fjt}$ and $r^{x,\text{Firm}}_{fjt}$ are granular firms' domestic sales and exports from the firm-level data.

Then, using these fringe firms' domestic sales and exports, we construct sales shares

$$s^d_{fjt} = \frac{r^d_{fjt}}{\sum_{g\in\mathcal{F}_{jt}} r^d_{gjt}}, \qquad s^x_{fjt} = \frac{r^x_{fjt}}{\sum_{g\in\mathcal{F}^x_{jt}} r^x_{fjt}}.$$

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 $\{\tau^L_{fj}, \tau^K_{fj}\}_{f\in\mathcal{F}_{(-\tilde{f})j}}$ where $\mathcal{F}_{(-\tilde{f})j}$ is a set of firms excluding $\tilde{f}$. Based on this guess, we set fringe firms' distortions as weighted averages of granular firms' distortions, where the weights are given by sales.

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 (2.8)) and the inverse labor supply function (Equation (2.3)), we obtain that

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

which gives

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

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

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

- 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 $\{\tau^L_{fj}\}_{f\in\mathcal{F}_{(-\tilde{f})j}}$. Once it converges, normalize granular firms' distortions by a fringe firm's distortion, so that a fringe firm's distortion to be zero.

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 (2.8)), we obtain that

$$\sum_{f\in\mathcal{F}_{(-\tilde{f})j}} \gamma^K_j(1+ex_{fj})r^d_{fj} = \sum_{f\in\mathcal{F}_{(-\tilde{f})j}} \mu^d_{fj}(1+\tau^K_{fj})Rk_{fj},$$

which gives

$$R = \frac{\sum_{f\in\mathcal{F}_{(-\tilde{f})j}} \gamma^K_j(1+ex_{fj})r^d_{fj}}{\sum_{f\in\mathcal{F}_{(-\tilde{f})j}} \mu^d_{fj}(1+\tau^K_{fj})k_{fj}},$$

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

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

$$k_{\tilde{f}j} = \left(\frac{\gamma_j^K (1 + ex_{\tilde{f}j}) r^d_{\tilde{f}j}}{\frac{\sigma_j}{\sigma_j - 1}(1 + \tau^K_{\tilde{f}j})R} \right).$$

- Using the obtained $l_{\tilde{f}j}$, compute the new $\{s^K_{fj}\}_{f\in\mathcal{F}_j}$ and compare with the previous $\{s^K_{fj}\}_{f\in\mathcal{F}_j}$.
- Iterate until $\{s^K_{fj}\}_{f\in\mathcal{F}_j}$ is consistent with fringe firms' first order conditions and the guess of $\{\tau^K_{fj}\}_{f\in\mathcal{F}_{(-\tilde{f})j}}$. Once it converges, normalize granular firms' distortions by a fringe firm's distortion, so that a fringe firm's distortion to be zero.

Step 4. Using fringe firms' labor and capital inputs calculated in the previous steps, we construct $\{s^L_{fj}, s^K_{fj}\} - f \in \mathcal{F}_j$.

Step 5. Using $\{s^d_{fj}, s^x_{fj}, s^L_{fj}, s^K_{fj}\}_{f\in\mathcal{F}_j}$ and $\{ex_{fj}\}_{f\in\mathcal{F}_j}$, solve the system of equation (Equations (2.11), (2.12), (2.13), and (2.14)) and obtain $\{A_{fj}, \tau^L_{fj}, \tau^K_{fj}, D^x_{fj}\}_{f\in\mathcal{F}_j}$ that is normalized relative to fringe firms. For non-exporters, set $D^x_{fj} = 0$.

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

Step 7. Iterate until $\{\tau^L_{fj}, \tau^K_{fj}\}_{f\in\mathcal{F}_j}$ converge.

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

1. Make a guess for the shocks: $\bar{\phi}^{(0)}_t$ and $\{P^{F,(0)}_{jt}, D^{x,(0)}_{\tilde{f}jt}, A^{(0)}_{\tilde{f}jt}\}_{j\in[0,1]}$
2. Based on the guess, compute firms' productivity and foreign demands as $A^{(0)}_{fjt} = A^{(0)}_{\tilde{f}jt} \times \bar{A}_{fjt}$ and $D^{(0)}_{fjt} = D^{(0)}_{\tilde{f}jt} \times \bar{D}_{fjt}$ for all firms and sectors, where $\bar{A}_{fjt}$ and $\bar{D}^x_{fjt}$ are the backed out productivity and foreign demands relative to the fringe firm within sectors.
3. Feed the firm-level shocks $\{A^{(0)}_{fjt}, D^{(0)}_{fjt}, \tau^L_{fjt}, \tau^K_{fjt}\}_{f\in\mathcal{F}_{jt}, j\in[0,1]}$, $\{P^{F,(0)}_{jt}\}_{j\in[0,1]}$, and $\bar{\phi}^{(0)}_t$ and solve the model. Note that distortions are backed out from the previous procedure.
4. Update $\{P^{F,(0)}_{jt}\}_{j\in[0,1]}$ until the import shares of the model fit the data
5. Update $\{D^{F,(0)}_{\tilde{f}jt}\}_{j\in[0,1]}$ until the sectoral exports of the model fit the data
6. 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 $\text{PPI}_{jt}/\text{PPI}_{j_0t}$.
7. 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.
8. Update $\bar{\phi}_t$ by fitting working hours per worker in the model (Equation 2.1) to the data counterpart.