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ABSTRACT

The Plant-Level View of Korea's Growth Miracle and Slowdown*

We analyze the evolution of the plant size distribution, static allocative efficiency, and business dynamism of the Korean manufacturing sector during its growth miracle (1967–2000) and the subsequent slowdown since 2000. The average plant size has an inverse-U pattern over time, uncorrelated with the level or the growth rate of value-added per worker. The measure of static misallocation decreases modestly until 1983, consistent with the fast economic growth, but increases substantially afterwards, without a corresponding negative trend in manufacturing productivity. These results are seemingly at odds with existing cross-country evidence on the relationship between plant size and economic development, as well as the one between static allocative efficiency and development. In addition, business dynamism, measured by either churning or responsiveness to shocks, diminished significantly since 2000, coinciding with the slowdown in manufacturing productivity. Our findings call for more systematic research on how economic growth correlates with establishment/firm size distribution and with static and dynamic allocative efficiency.

JEL Classification: O14, O47, O53
Keywords: size distribution, misallocaton, business dynamism

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1 Introduction

Over the last decade or so, the literature on economic growth and development has delved deeper to understand how macroeconomic performance is determined by what happens at the microeconomic level, both theoretically and empirically. This line of work has shown that the allocation of resources across firms and establishments, both statically and dynamically, is an important determinant of aggregate productivity.[1] The empirical support comes from a relatively small number of countries with available data, especially when it comes to dynamic allocation.

We contribute to this literature by analyzing the plant-level data from the Korean manufacturing sector that span a half-century (1967–2019). Korea makes a compelling case for at least two reasons. First, it transformed itself from a poor to a rich country during this period.[2] The real GDP per capita grew more than 13-fold between 1967 and 2000, which translates into an annual growth of 8 percent per year, before the growth markedly slowed down since 2000. Second, it has high-quality micro data, some of which were newly digitized. We use administrative data of all manufacturing plants with at least five employees (ten employees since 2007), which have panel dimension since 1982. Although this is admittedly data from but one country, they provide a unique window into how the microeconomy evolved as the macroeconomy traversed the development spectrum. This paper complements the body of knowledge in the literature built on cross-country evidence.

Are there systematic patterns at the plant-level behind the Korean economic miracle and the eventual slowdown? We obtain three main results. First, there is no clear relationship between the productivity of the manufacturing sector and the size distribution of plants. The manufacturing value-added per worker grew faster than GDP per capita between 1968

[1]For example, refer to the papers in the January 2013 special issue on misallocation and productivity in the *Review of Economic Dynamics* (Restuccia and Rogerson, 2013). For example, Brandt, Tombe and Zhu (2013) and Oberfield (2013) quantify sizable TFP losses due to resource misallocation in China and Chile, respectively.

[2]Its GDP per capita adjusted for purchasing power was 6.9 percent of the US level in 1967, but 64.4 percent of the US level in 2019, according to the Penn World Tables 10.01 (Feenstra, Inklaar and Timmer, 2015).

and 2010, with a brief slowdown in the 1980s. The average plant size (measured by the number of employees, for all plants with 5 or more employees) grew rapidly between 1968 and 1978, but then fell equally rapidly since 1979, stabilizing in the mid 2000s. This lack of a correlation is quite different from results in the cross-section of countries that show a positive relationship between economic development and establishment size.[3]

Second, the typical measures of static misallocation (i.e., the dispersion of marginal product within industries) do not necessarily co-move with the productivity of the manufacturing sector. Measured misallocation decreased between 1968 and 1983, consistent with the fast growth period. However, its substantial increases during the mid 1980s, and again since the early 2000s, did not necessarily imply a corresponding decline in the productivity of the manufacturing sector.

Finally, using the panel dimension of the data since 1982, we show that dynamism, defined either as labor reallocation across plants or as the correlation between a plant's productivity and its subsequent growth, diminished significantly after 2000, coinciding with the slowdown in the growth of manufacturing value-added per worker.

Our findings call for more systematic research of the evidence on how economic growth correlates with establishment/firm size distribution and with static and dynamic allocative efficiency, both across countries and over time within countries.

Related Literature: This paper contributes to three strands of the literature. First, the establishment/firm size distribution and allocative efficiency have been discussed as important sources of cross-country income differences (e.g., Bento and Restuccia (2017), Bento and Restuccia (2021), Poschke (2018), and Fattal-Jaef (2022) for the establishment/firm size distribution, Hsieh and Klenow (2009) and Hsieh and Klenow (2010) for the allocative efficiency). Overall, establishments are larger, and allocative efficiency is higher in rich countries than in poor countries in the cross-section. With the exception of the United States and a few other Western European countries, time series evidence on the relationship between

[3]For example, Bento and Restuccia (2017), Bento and Restuccia (2021), Poschke (2018), and Fattal-Jaef (2022)

establishment size and development and the one between misallocation and development is limited. We revisit the case of Korea which experienced a growth miracle and a slowdown in the last 60 years.

Second, since the early 1980s, the United States has seen a decline in business dynamism, measured by firm entry (Decker, Haltiwanger, Jarmin and Miranda, 2014), the rate of job and worker reallocation (Davis and Haltiwanger, 2014), and responsiveness to shocks (Decker, Haltiwanger, Jarmin and Miranda, 2020). We find that Korea also experienced a similar degree of decline in business dynamism in recent years, suggesting that it may be a global phenomenon. Our documentation of business dynamism in the development context is a unique contribution. There exists little evidence from developing countries in the literature, because few of them offer the panel data required for such calculations.

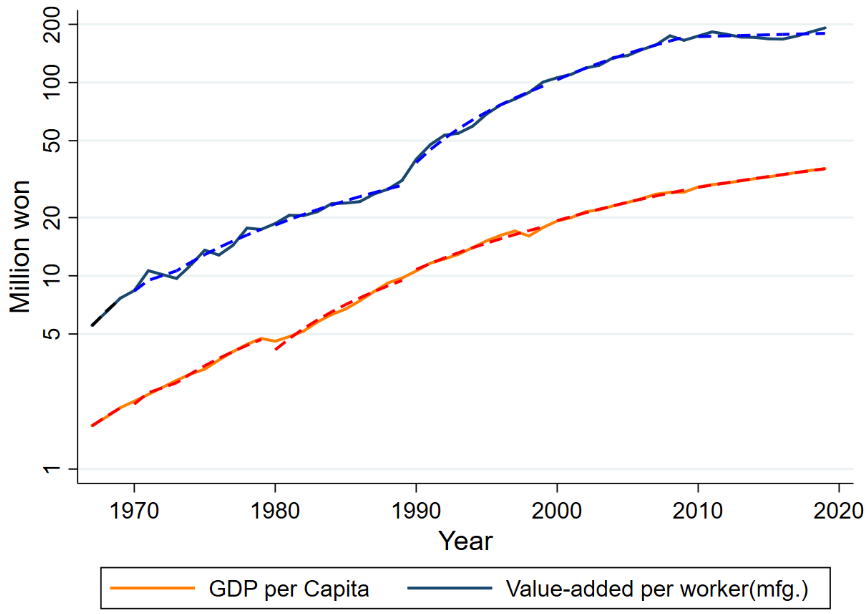
Lastly, this paper contributes to the literature that studies Korea's growth miracle. Young (1995) emphasized the role of factor accumulation during the East Asian growth experience. Connolly and Yi (2015) study trade reforms and Kim, Lee and Shin (2021) study industrial policy in the 1970s. This paper studies the development at the plant level during the growth miracle and extends the discussion to the recent slowdown that has received limited attention.

2 Background and Data

2.1 Background

Following the Korean War (1950-1953), South Korea underwent significant transformation from a low-income country to a developed nation. Figure 1 shows real GDP per capita and real value-added per worker in manufacturing from 1967 to 2019. During this timeframe, the GDP per capita and value-added per worker in manufacturing closely followed each other. Specifically, both aggregate economy and manufacturing sector in Korea grew rapidly until 1997 and began a significant slowdown started in early 2000s. The average growth rate of GDP per capita was 8.7% in 1970s, 7.8% in 1980s, 5.3% in 1990s, 3.5% in 2000s, and 2.2% in

Figure 1: Korea's Growth Miracle and Slowdown from 1967 to 2019



Notes: The figure shows GDP per capita (orange line) and value-added per worker in manufacturing (blue line). The data comes from the Bank of Korea's national accounts and Statistics Korea's annual Mining and Manufacturing Survey. The dotted lines represent the linear trend for each decade. GDP per capita is deflated by GDP deflator (2015=100), and value-added per worker is deflated by manufacturing industry deflator (2015=100).

2010s (represented by a dotted line for in Figure 1). The average growth rate of value-added per worker in manufacturing was 8.4% in 1970s, 5.3% in 1980s, 9.6% in 1990s, 4.6% in 2000s, and 1.0% in 2010s.

2.2 Data

We use Statistics Korea's annual Mining and Manufacturing Survey (MMS) from 1967 to 2019, except for the two missing years of 1970 and 1972.[4] The MMS covers all establishments in the mining and manufacturing sector with at least five employees until 2006 and with at least ten employees from 2007. Plant-level data includes gross output, fixed assets, number of employees, wage bills, costs of intermediate inputs, and location at the province level.

[4]The MMS started in 1967. Even though there were other surveys covering selected mining and manufacturing firms before 1967, plant-level microdata is only available from the MMS.

Prior to 1978, the fixed asset data is available for only one year, 1968. Anonymized plant IDs are available from 1982, which gives the data a panel dimension.

We convert nominal gross output and intermediate input values to real measures using GDP deflator for manufacturing. Real value added is defined as real gross output minus real intermediate input. Capital stock is the sum of the total fixed asset values of building structures, machinery, and transport equipment.

MMS's industrial classification is at the four-digit (before 1970) or five-digit level (since 1970) of the KSIC. During our sample period, the KSIC was revised eight times (Revision 3 in 1970, 4 in 1975, 5 in 1984, 6 in 1991, 7 in 1998, 8 in 2000, 9 in 2007, and 10 in 2017). We constructed a harmonized four-digit industry classification using a crosswalk based on the concordance tables for each revision. We excluded establishments belonging to mining industries.

3 Size Distribution and Static Allocative Efficiency

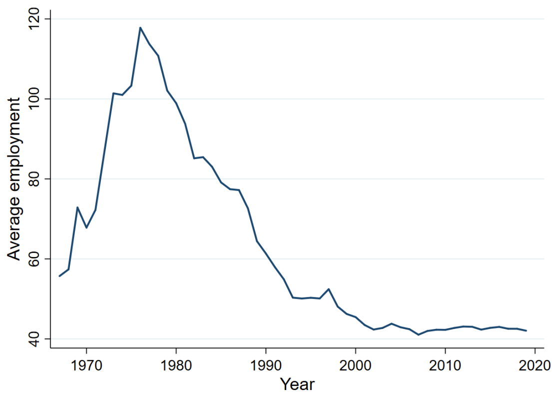
We study the evolution of plant size distribution and static allocative efficiency across plants from 1967 to 2019.

3.1 Plant Size Distribution

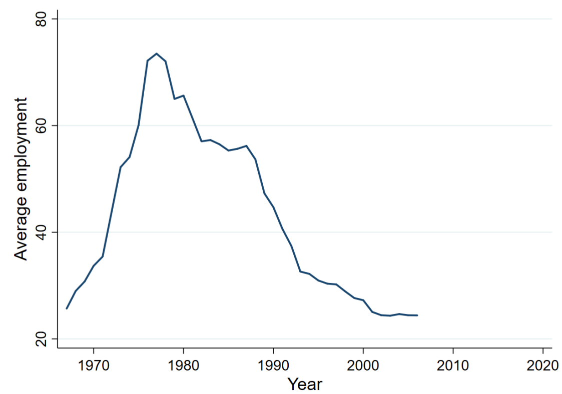
Figure 2 shows the average plant size and the employment share of large plants from 1967 to 2019. Panel (a) shows the average size of plants with at least 10 employees for the entire sample period. It started at 56, peaked at 118 in the late 1970s, and decreased to around 42 in the early 2000s. Similar increases and decreases are observed in panels (b), (c), and (d), which show the average size of plants with at least 5 employees (ending in 2006) and the employment shares of large-sized plants employing more than 250 and 500, respectively.

The period of rapid increase in plant size coincides with the period of active industrial policy. In 1961, General Park Chung-hee seized political power through a military coup

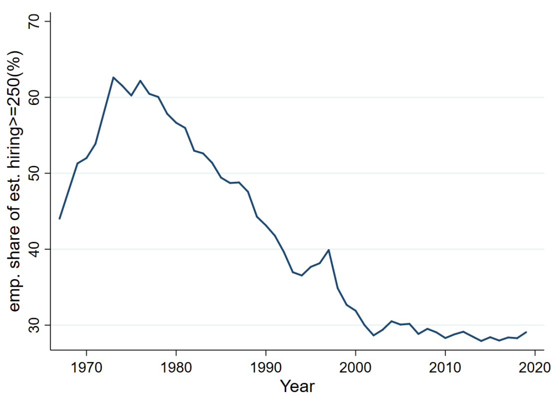
Figure 2: Average Plant Size and Employment Share of Large-sized Plants



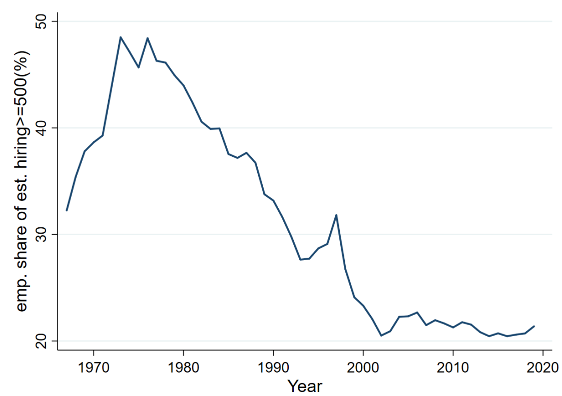
(a) Average Size of Plants w/ 10+



(b) Average Size of Plants w/ 5+



(c) Employment Share of Plants w/ 250+



(d) Employment Share of Plants w/ 500+

Notes: Panel (a) plots the average size of plants hiring at least 10 employees from 1967 to 2019. Panel (b) plots the average size of plants hiring at least 5 employees. The Mining and Manufacturing Survey (MMS) changed the minimum number of employees from 10 to 5 in 2007, so panel (b) is only available until 2006. Panel (c) and (d) plot the employment share of large-sized plants hiring more than 250 and 500 persons, respectively.

and implemented a series of five-year development plans. The first plan (1962-1966) sought to expand the electrical and coal energy industry and establish the basic infrastructure for manufacturing development. The second plan (1967-1971) named heavy and chemical industries as one of the priority areas. However, due to the lack of technological expertise and financial resources, this prioritization was unsuccessful. Major highways were built during the second plan period. The third plan (1972-1976) was a monumental shift toward a "Big Push." President Park stated in January 1973 that "the government is announcing the Heavy and Chemical Industry project. To achieve a 10-billion-dollar target of annual exports by the early 1980s, [...] the government will accelerate the promotion of HCIs such as steel, shipbuilding and petrochemical industries, and thereby increase their exports" (Park, 2005). The industrial policy ended suddenly when Park was assassinated in October 1979. Afterwards, the new President Chun Doo-hwan drastically changed the direction of industrial policy. The new head of state adopted "stability" and "private sector-led growth" as its slogan (Woo, 1991), embodied in the fifth five-year plan (1982–1986). As an outcome of the stabilization and liberalization, new establishments entered at a faster rate, driving down the average plant size, while the aggregate economy grew steadily.

The degree of concentration measured by employment shares of large plants closely followed the evolution of the average plant size. The only notable exception is a small spike in 1997 in panels (c) and (d), which is attributed to the 1997 Asian Financial Crisis, during which employment concentration temporarily increased because many small and medium-sized plants exited the market.

We can decompose the change in average plant size into two components: (i) within industries and (ii) between industries. Denote with m_t the average plant size in year t. It can be written as the weighted average of industry-level average plant size $m_{i,t}$:

$$m_t = \sum_i w_{i,t} m_{i,t} \ , \tag{1}$$

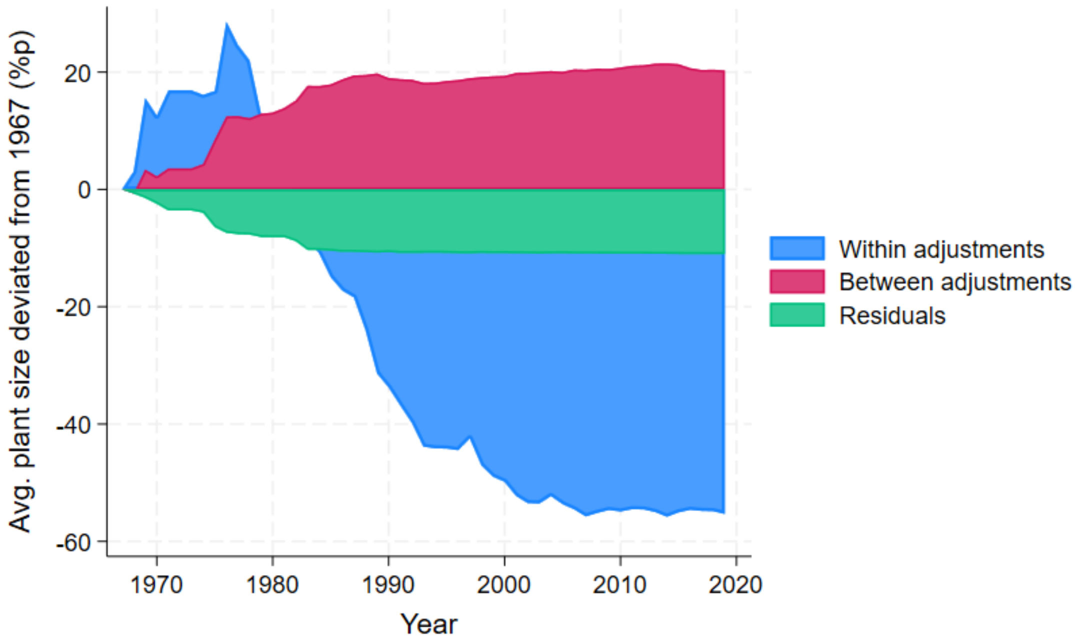
where $w_{i,t}$ is the employment share of industry i in year t. We can write the change in average plant size between year $t-1$ and t, Δm_t, as follows.

$$\Delta m_t = \sum_i w_{i,t-1} \Delta m_{i,t} + \sum_i \Delta w_{i,t} m_{i,t-1} + \sum_i \Delta w_{i,t} \Delta m_{i,t} \tag{2}$$

The first term is the within-industry change, the second term is the between-industry component, and the last term is the residual or the "cross" term.

Figure 3 shows the decomposition of the cumulative changes in average plant size since

Figure 3: Decomposition of Cumulative Changes in Average Plant Size



Notes: The figure decomposes cumulative changes in average plant size into within industries, between industries, and residuals, following equation 2.

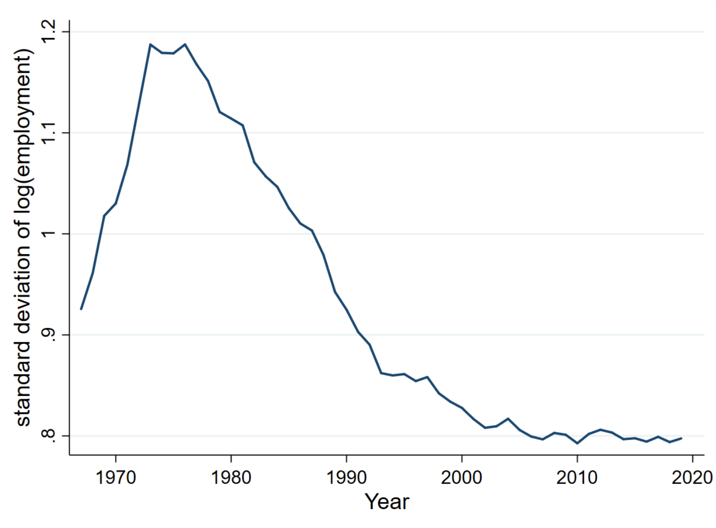
1967. From 1967 to 2019, the within-industry size change decreased the average plant size by 56 percent, the between-industry component *increased* the average plant size by 20 percent, and the residual decreased by 11 percent. The positive between-industry component means that the employment share of industries with a larger average plant size tended to increase, but most of the increase took place before the mid-1980s. The within-industry component contributed to the rise of the average plant size in the 1970s, but reversed its course afterwards, driving the average plant size in the 1980s and the 1990s. In summary, the upward arc of the inverse-U curve of the average plant size reflected both the plants getting bigger in all industries and employment reallocating to industries that started with larger plants on average. The downward arc after 1980, on the other hand, was nearly exclusively a within-industry phenomenon—that is, plants became smaller in all industries.

The degree of dispersion of employment across plants can be measured in two different ways. First, panel (a) of Figure 4 shows the evolution of the standard deviation of log employment. It resembles the patterns in Figure 2. Second, panel (b) of Figure 4 is the log-log plot in 1967, 1977, 1987, 1997, and 2006. In a log-log plot, the horizontal axis is the log of the number of employees and the curve traces the log of the fraction of establishments with at least as many employees as the corresponding number on the horizontal axis. The plot shifted to the right from 1967 to 1977. Reversing courses, the plot shifted to the left from 1977 to 1987, 1997, and 2006. The increase and the decrease of plant sizes were broad-based, with the entire size distribution shifting right and left, as shown in the log-log plots.

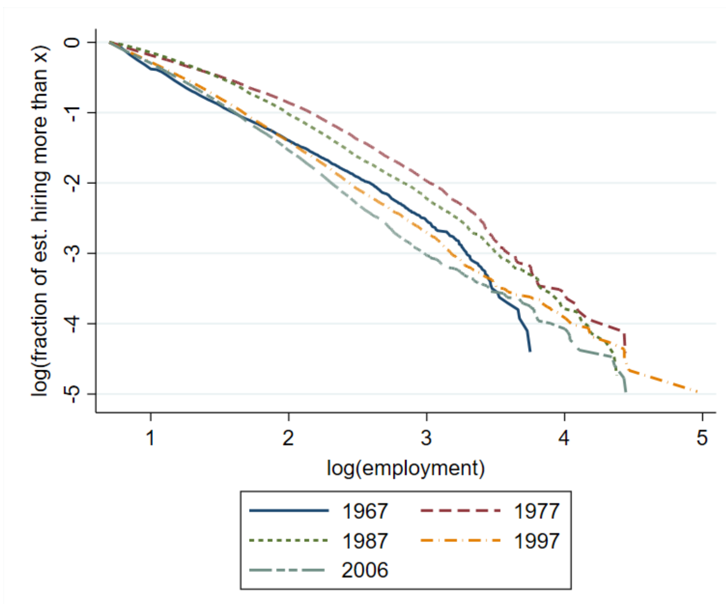
We find that there was no systematic relationship between the average plant size and the economic development of the Korean manufacturing sector. This is a different result from some existing works that document that development is associated with systematic changes in the plant/firm size distribution (Bento and Restuccia, 2017; Poschke, 2018; Bento and Restuccia, 2021). Given our findings, we present more evidence on the plant size-development link.

Time-series Evidence from Other Asian Economies The seminal paper by Lucas (1978) showed that the average firm size increased with per capita income over time in the United States. However, only limited evidence on trends in average firm size is available from other countries. A special issue of *Small Business Economics* in February 2002 (Small Firm Dynamism in East Asia) reports on the evolution of the average plant/firm size over time in several Asian economies. The manufacturing sector in Taiwan showed a similar inverse-U pattern of the average firm size over time. Employment per firm went from 20 in 1981 to 24 in 1986, and to 18 in 1991 (Aw, 2002). A paper on Korea (Nugent and Yhee, 2002) reports that the share of manufacturing employment by large enterprises (300+ employees) increased in the 1970s but decreased afterward, consistent with our findings. Similarly, in Japan, the share of manufacturing employment by large enterprises (300+ employees) went from 27 percent in 1957 to 31 percent in 1969, and to 26 percent in 1981. However, the share of service employment by large enterprises kept increasing over the same period

Figure 4: Dispersion of Employment



(a) Standard Deviation of Log Employment

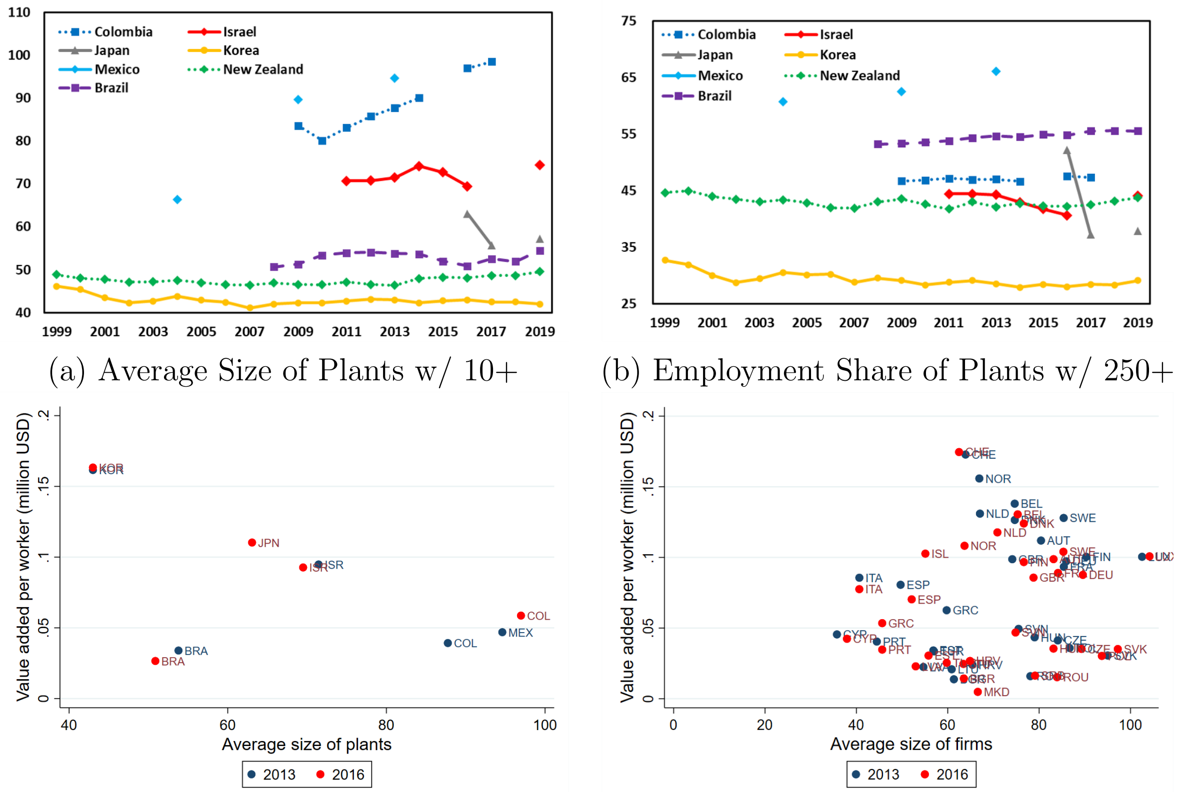


(b) Plant Size Distribution (log-log plot)

Notes: Panel (a) plots the standard deviation of log employment from 1967 to 2019. Panel (b) shows the log of the fraction of establishments larger than or equal to size s on the horizontal axis, where size is the number of employees. The data is truncated at 5 employees.

(Kawai and Urata, 2002). Papers in the same issue also show that the average plant size was stable in Indonesia between 1986 and 1996 (Berry, Rodriguez and Sandee, 2002), increased in Thailand between 1987 and 1996 (Wiboonchutikula, 2002), and increased in the machine

Figure 5: Comparison with Other OECD Countries



(a) Average Size of Plants w/ 10+

(b) Employment Share of Plants w/ 250+

(c) Plant Size and Labor Productivity

(d) Firm Size and Labor Productivity

Notes: Panels (a), (b), and (c) show plant size, while panel (d) show firm size. Panel (c) utilizes value-added at basic prices, but Panel (d) uses value-added at factor costs. For panels (c) and (d), two years that provide the most complete information, 2013 and 2016, are chosen. Panel (c) has 6 countries, and Panel (d) has 33 countries out of 47 countries in the SDBS database. Linear fitted lines for both panels are statistically insignificant. All data are for establishments or enterprises with at least 10 employees. Appendix A has more details on the data.

tools sector in Malaysia between 1984 and 1994 (Rasiah, 2002). In summary, the evidence on the relationship between plant/firm size and economic development is mixed, but the data from Japan, Korea, and Taiwan exhibit an inverse-U pattern over time.

Cross-sectional Evidence from OECD Countries We use the Structural and Demographic Business Statistics (SDBS) and explore the average plant/firm size over time and across countries.[5] Panels (a) and (b) of Figure 5 show the average plant size and the em-

[5]In the OECD SDBS database, some Non-OECD countries (Brazil, Bulgaria, Croatia, Cyprus, Malta, North Macedonia, Romania, Russia, and Serbia) are included along with OECD countries.

ployment share of large (250+) plants in the manufacturing sector over time, for the set of countries with comparable data. See appendix A for data availability. During the last 20 years, both measures of plant size remained stable in the seven countries. Panels (c) and (d) report the correlation between the average plant/firm size and labor productivity, again for the set of countries with comparable data. We find no systematic relationship between plant/firm size and level of productivity, neither over time nor in the cross-section, for this set of countries. An important caveat is that the literature found a positive relationship between firm/establishment size and economic development, using data with wider coverage in terms of sectors and/or countries (e.g., Bento and Restuccia, 2017, 2021; Poschke, 2018; Fattal-Jaef, 2022).

3.2 Static Allocative Efficiency across Plants

One standard measure of resource misallocation is the dispersion of revenue productivity. Foster, Haltiwanger and Syverson (2008) made a distinction between physical productivity (TFPQ) and revenue productivity (TFPR), and Hsieh and Klenow (2009) showed that—under simple parametric assumptions on market structure (monopolistic competition) and production technology (constant returns to scale)—TFPR dispersion within narrowly-defined industries represents plant-specific distortions and hence resource misallocation.[6] We apply the methodology of Hsieh and Klenow (2009) and express the TFP at the four-digit industry level (indexed by s) as follows.

$$TFP_s = \frac{Y_s}{K_s^{\alpha_s} L_s^{1-\alpha_s}} \left(\sum_{i=1}^{N_s} \left(A_{si} \frac{\overline{TFPR}_s}{TFPR_{si}} \right)^{\sigma-1} \right)^{\frac{1}{\sigma-1}} \tag{3}$$

[6]When parametric assumptions are violated or there are measurement errors, dispersion in measured average products need not imply dispersion in true marginal products. Kim, Lee and Shin (2021) calculate the degree of misallocation under constant returns to scale (CRS) and decreasing returns to scale (DRS) technologies and find that results are both qualitatively and quantitatively similar, using the Korean manufacturing data between 1967 and 1987. One way to estimate dispersion in true marginal products in the presence of measurement errors was suggested by Bils, Klenow and Ruane (2021). Their methodology exploits how revenue growth is less sensitive to input growth when plants' average products are overstated by measurement errors. It requires panel dimension in the data, which is only available after 1982 in our case. We plan to apply this methodology for the 1982-2019 sub-period.

where A_{si} is plant i's TFPQ defined as $Y_{si}/K_{si}^{\alpha_s}(wL_{si})^{1-\alpha_s}$, $TFPR_{si} = P_{si}A_{si}$ is the TFPR defined as the TFPQ multiplied by its output price, and $\overline{TFPR}_s$ is the geometric average of the marginal revenue products of capital and labor. α_s is the elasticity of output to capital.

The ratio between the amount of final goods that will be produced with and without idiosyncratic distortions (respectively, Y and Y_{eff}) can be written as:

$$\frac{Y}{Y_{eff}} = \Pi_{s=1}^{S}\left(\sum_{i=1}^{N_s}\left(\frac{A_{si}}{\overline{A}_s}\frac{\overline{TFPR}_s}{TFPR_{si}}\right)^{\sigma-1}\right)^{\frac{\theta_s}{\sigma-1}} \tag{4}$$

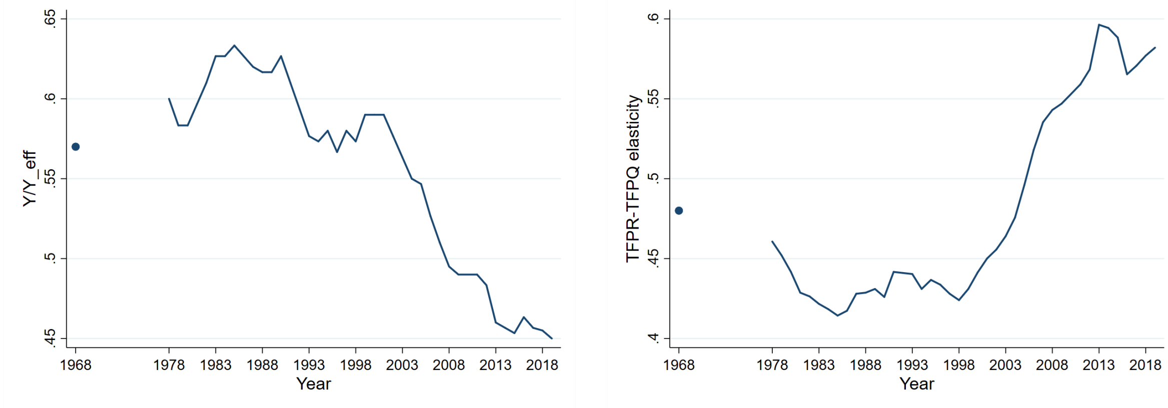
where θ_s is the value-added share of industry s.

We consider industries at the four-digit level of classification and define Y_{eff} as the output obtained when the TFPR of all establishments in a four-digit industry is equalized. The TFPR may still differ across industries, and we reallocate capital and labor only within industries but not across them. For each year, in each four-digit industry, we drop the top and bottom 1 percent of establishments to remove TFPR outliers.

The capital rental rate is set to 0.1, and the elasticity of substitution between plant output to 3 following Hsieh and Klenow (2009). We assume the elasticity of output to capital for each industry, α_s, to be 1 minus its labor share in 2015. The labor share is defined as the ratio of wages paid to value added in each industry. Since the labor shares constructed this way are much lower than the labor share in the national input-output table, we scale up the labor shares by a constant factor, 1.7.

Figure 6 shows the evolution of static resource misallocation from 1968 to 2019. We make two observations. First, resource misallocation within industries is estimated to be large. As shown in panel (a), Y/Y_{eff} has been between 0.45 and 0.64, which implies that a hypothetical equalization of TFPR within industries will increase aggregate output by 56 to 122 percent, using the same input. Second, the allocative efficiency in the Korean manufacturing sector improved somewhat between 1968 and 1983, but then worsened substantially afterward,

Figure 6: Allocative Efficiency



(a) Y/Y_{eff} (b) TFPR-TFPQ elasticity

Notes: Panel (a) plots Y/Y_{eff} in equation 4 in 1968 and from 1978 to 2019. Prior to 1978, the fixed asset data is available for only one year, 1968. Panel (b) plots the correlation between plant-level TFPR and TFPQ.

especially during the 2000s.[7] Panel (b) shows the correlation between TFRP and TFPQ. The correlation decreased slightly until 1983 and increased rapidly during the 2000s. A higher correlation indicates that more productive firms (high TFPQ) faced larger distortions (high TFPR), and vice versa. Therefore, a higher correlation is another sign of increased misallocation, which means the two measures of misallocation paint a similar picture.

The rising allocative efficiency in the earlier period coincided with the growth miracle. However, the declining allocative efficiency was not necessarily accompanied by a corresponding decline in manufacturing productivity. At best, one may be able to argue that the declining allocative efficiency after 2000 coincided with the slowdown in growth rate. Overall, the evidence does not suggest that static allocative efficiency is strongly correlated with the level or growth rate of manufacturing value-added per worker.

[7] These numbers are similar to what Kim, Oh and Shin (2017) calculated for the 1982–2007 period.

4 Dynamism

The data allow us to track individual plants from 1982 with anonymized IDs. In this section, we study the change in business dynamism from 1982 to 2019. Our measures of business dynamism are plant-level job creation/destruction and plants' responsiveness to productivity shocks.

4.1 Job Creation and Destruction

We first study the distribution of individual plant size growth, including the entry and exit margins. Following Davis, Haltiwanger and Schuh (1998), the employment growth rate of plant i from year t_0 to t_1 is defined as:

$$g_{i,t_1} = \frac{emp_{i,t_1} - emp_{i,t_0}}{0.5 \times emp_{i,t_1} + 0.5 \times emp_{i,t_0}} \ , \tag{5}$$

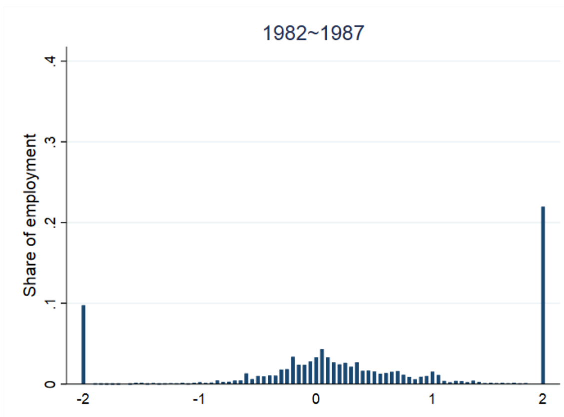
where $emp_{i,t}$ is the number of employees of plant i in year t. With this definition, an entry is recorded as +2 and an exit is recorded as -2.

Figure 7 shows the distribution of job creation and destruction for each five-year period.[8] On the horizontal axis, we have employment growth rates, ranging from -2 (exit) to +2 (entry). On the vertical axis, we have the employment share of all plants in each growth bin. This way, the plots show the employment-weighted distribution of plant-level growth rates over the given periods.

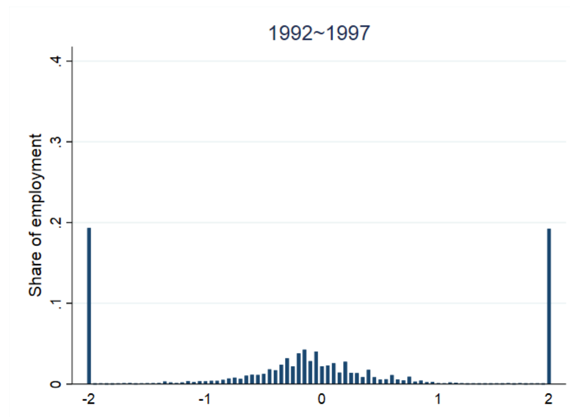
Comparing across the five-year windows, we find two notable trends. Firstly, job creation by entry (+2) was an important margin of employment reallocation in the earlier periods, but its importance dwindled over the years. The importance of entry explains the falling average plant size since the 1980s, as entrants tend to be smaller than incumbents. Second, job creation and destruction became more concentrated near zero. Under Schumpeterian

[8] We report four five-year windows: 1982-1987, 1992-1997, 2002-2007, and 2013-2018. In Appendix B, we show all seven five-year windows in our sample period.

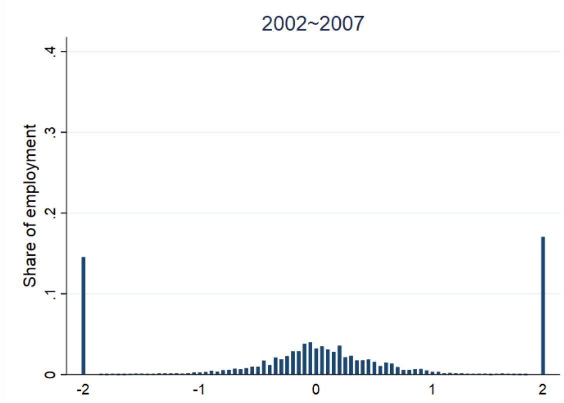
Figure 7: Distribution of Job Creation and Destruction



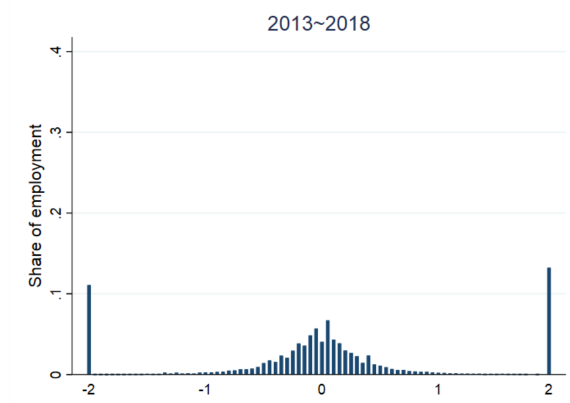
(a) 1982-1987



(b) 1992-1997



(c) 2002-2007



(d) 2013-2018

Notes: In panel (a), employment growth for a plant is defined as the change in plant employment between 1982 and 1987 divided by the plant's average employment in 1982 and 1987. The vertical axis is the employment share of all plants in each growth bin. The other panels are constructed in the same way. Note that entry is recorded as +2 and exit is recorded as -2.

endogenous growth model as in Garcia-Macia, Hsieh and Klenow (2019), this can be interpreted as the decline in creative destruction by entrants (reflected in entry and exit rates) and by incumbents through new varieties (reflected in large job creations and destructions away from zero). Such a reduction in business dynamism is conspicuous in panels (c) and (d), relative to panels (a) and (b). The diminished dynamism in the 2000s and the 2010s coincides with the productivity slowdown of the Korean manufacturing sector.

4.2 Responsiveness to Productivity

We estimate the responsiveness of plants to shocks following Decker, Haltiwanger, Jarmin and Miranda (2020). Allocative efficiency dictates that more productive plants should expand their production. Under the reasonable assumptions that labor cannot be instantaneously adjusted and that productivity shocks are persistent, responsiveness is a measure of dynamic allocative efficiency. The regression equation is

$$g_{jt+1} = \beta_0 + \beta_1 a_{jt} + T(a_{jt}, t) + \beta_2 e_{jt} + T(e_{jt}, t) + X'_{jt}\Theta + \epsilon_{jt+1} \ , \tag{6}$$

where g_{jt+1} is the employment growth rate of plant j in equation (5), a_{jt} is log productivity, e_{jt} is log employment, and X_{jt} is other controls, including detailed industry fixed effects, interacted with year effects and plant size bins.

The equation allows productivity responsiveness to vary over time via $T(a_{jt}, t)$. More specifically, we have:

$$\begin{aligned} T(a_{jt}, t) \in \{ & \delta a_{jt} Trend_t, \\ & \lambda_{80s} a_{jt} \mathbb{1}_{t\in[1982,1990)} + \lambda_{90s} a_{jt} \mathbb{1}_{t\in[1990,1999)} \\ & \lambda_{00s} a_{jt} \mathbb{1}_{t\in[2000,2009)} + \lambda_{10s} a_{jt} \mathbb{1}_{t\in[2010,2019)} - \beta_1 a_{jt} \} \ , \end{aligned} \tag{7}$$

where $\mathbb{1}$ is the indicator function. The first element introduces a simple linear trend with coefficient δ. The second element allows the responsiveness coefficient to vary by decade. By subtracting $\beta_1 a_{jt}$, we remove the main effect specified in equation (6), so the decade coefficients can be interpreted in a fully-saturated manner. Similarly, we permit the effects of initial employment to vary over time via $T(e_{jt}, t)$.

An ideal measure of productivity would be technological efficiency, that could be estimated from observable plant-level revenue, input, and price data. Because plant-level price data is not available, we use a revenue-based productivity measure instead. To the ex-

Table 1: Plant-level Growth Responsiveness Has Weakened

Dep. var.	Employment growth		Capital growth	
	(1)	(2)	(3)	(4)
Productivity (TFPR): β_1	0.0274***		0.2000***	
	(0.0047)		(0.0082)	
Prod × trend: δ	-0.0003		-0.0038***	
	(0.0002)		(0.0003)	
Prod × 1980s: λ_{80s}		0.0199***		0.1835***
		(0.0046)		(0.0087)
Prod × 1990s: λ_{90s}		0.0278***		0.1508***
		(0.0057)		(0.0097)
Prod × 2000s: λ_{00s}		0.0239***		0.1069***
		(0.0051)		(0.0064)
Prod × 2010s: λ_{10s}		0.0135***		0.0758***
		(0.0056)		(0.0051)
Observations	1,297,793	1,297,793	1,297,793	1,297,793
R-squared	0.1353	0.1356	0.1398	0.1401

Note: Dependent variable is annual employment growth in columns (1)-(2) and annual capital growth in columns (3)-(4). All regressions include controls described in equation (6) and related text. The measure of productivity is TFPR.

tent that plants should respond to demand shocks, using the revenue-based productivity measure is not necessarily a shortcoming because positive/negative demand shocks will increase/decrease prices, which pushes revenue-based productivity upward/downward. In our baseline results, we use TFPR as our measure of productivity (a_{jt}), as defined in Section 3.2, $TFPR_{si} = \frac{P_{si}Y_{si}}{K_{si}^{\alpha_s} L_{si}^{1-\alpha_s}}$. In Appendix C, we report the robustness of our findings using another productivity measure, TFPQ as defined in Section 3.2, $TFPQ_{si} = \frac{(P_{si}Y_{si})^{\frac{\sigma}{1-\sigma}}}{K_{si}^{\alpha_s} L_{si}^{1-\alpha_s}}$.

Table 1 reports the regression coefficients. Columns (1) and (2) use annual employment growth as the dependent variable. The first column specifies changing responsiveness with the linear time trend. We estimate a baseline responsiveness coefficient of $\beta_1 = 0.0274$, which is significant, but almost an order of magnitude smaller than what is found in the United States (Decker, Haltiwanger, Jarmin and Miranda, 2020). Column (2) is the result using the fully saturated decade indicators (λ). By decade, the coefficient peaks in the 1990s and then decreases afterwards.

Over the sample period, the average employment of the Korean manufacturing plants decreased (Figure 2), while the average tangible capital stock increased substantially. It is then possible that plants responded to shocks by adjusting capital rather than labor. We estimate the equation by replacing employment growth with capital growth as the dependent variable. Columns (3) and (4) show these results. We observe that tangible capital responded significantly to productivity, much more so than labor. Furthermore, the responsiveness decreased significantly over time, and shows a significant negative time trend in columns (3). By decade, in column (4), we see a monotonic decrease from 0.184 in the 1980s and 0.151 in the 1990s to 0.107 in the 2000s and 0.076 in the 2010s. The declining responsiveness to shocks at the plant level, especially since the 2000s, coincide with the pronounced slowdown in the growth of manufacturing value-added per worker.

Together with the results in Section 4.1, it suggests that business dynamism at the micro-level may be tightly connected to the aggregate productivity growth.

5 Concluding Remarks

We provide a first micro-level view of the evolution of the Korean manufacturing sector during its transformation from a poor economy into a highly-developed, mature economy. We focused on plant size distribution, static allocative efficiency, and business dynamism.

Our finding on the inverse-U pattern of the average plant size seems inconsistent with the common understanding in the literature, where it is noted that average plant size increases with economic development. Apart from the fact that our result comes from one sector in one country over time, the minimum employment cutoff (of at least five employees) may be a reason for this dissonance. It is possible that the cross-country result is driven by the prevalence of micro-enterprises with no or very few employees in less developed countries. A more systematic review of the evidence on establishment/firm size across countries and over time is needed.

Our second finding is that the evolution of static misallocation is not strongly correlated with either the level or the growth rate of the manufacturing sector's productivity. This raises the question of how one should compare this measure of misallocation across time periods and/or across countries. To the extent that misspecification may be an issue, one may want to dissect why this misallocation measure increased so much and so fast during the mid to late 2000s, in the absence of a corresponding decline in the manufacturing sector productivity.

Our findings on the close relationship between business dynamism and aggregate productivity growth suggest more fruitful research await in this area. More empirical research on business dynamism over time and across countries is needed, subject to the challenge that one needs micro panel data for this purpose. A further missing piece is a micro-founded dynamic model that can rationalize the magnitude and the time trends of the responsiveness. We speculate that adjustment costs, credit constraints, and idiosyncratic risks all play a role in such a model.

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APPENDIX

A Structural and Demographic Business Statistics (SDBS)

Cross-country data comes from OECD SDBS (Structural and Demographic Business Statistics, ISIC Rev.4). It offers information including turnover, value-added, production, operating surplus, employment, labor costs, investment, etc. They are available at a sectoral level and some of them can be broken down into size classes. For Figure 5, data from the manufacturing sector (ISIC 10-33) is used.

Table A.I: Sample selection for Panel (a)-(c) of Figure 5

Countries (47 countries in total)	Remarks
Columbia, Israel, Japan, Korea, Mexico, Brazil (6 countries)	Included as value-added (VA) at basic prices, total employment, and number of establishments by employment size class are available
New Zealand	Included in Figure 4-(a) and (b) but excluded in (c) as VA at basic prices by employment size is unavailable
Chile, Russia	Excluded as total employment by employment size class is unavailable
Costa Rica	Excluded as VA at basic prices is unavailable
United States	Excluded as VA at basic prices is only available for 2007
Australia, Austria, Belgium, Canada, Czech Rep., Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Norway, Poland, Portugal, Slovak Rep., Slovenia, Spain, Sweden, Switzerland, Türkiye, United Kingdom, Bulgaria, Croatia, Cyprus, Malta, North Macedonia, Romania, Serbia (36 countries)	Excluded as number of establishments is unavailable

For panels (a), (b), and (c) of Figure 5, all of the indicators are calculated for establishments that hire more than 10 employees. Thus, countries without the number of establishments data, or those with variables that cannot be categorized into size classes, are excluded as in Table A.I.

For panels (a) and (b) in Figure 5, the average employment is calculated using the number of establishments and total employment for establishments hiring more than 10. The share of employment of establishments hiring more than 250 is calculated for the countries selected for the average employment, by dividing the number of establishments hiring more than 250 by the number of establishments hiring more than 10.

For panel (c) of Figure 5, real value-added per worker is calculated using deflated value-added at a basic price[9] in USD and total employment for establishments hiring more than 10. To deflate value-added in local currency, the manufacturing deflators of each country from OECD national accounts are used. Then, they are converted into USD using the period-average exchange rate from IMF International Financial Statistics (IFS).

Table A.II: Sample selection for Panel (d) of Figure 5

Countries (47 countries in total)	Remarks
Austria, Belgium, Czech Rep., Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Norway, Poland, Portugal, Slovak Rep., Slovenia, Spain, Sweden, Switzerland, Türkiye, United Kingdom, Bulgaria, Croatia, Cyprus, North Macedonia, Romania, Serbia (33 countries)	Included as VA at factor costs, total employment, and number of enterprises by employment size class are available
Australia, Canada, Chile, Colombia, Costa Rica, Israel, Japan, Korea, Mexico, New Zealand, United States, Brazil, Russia (13 countries)	Excluded as VA at factor costs is unavailable
Malta	Excluded as total employment and number of enterprises by employment size are incomplete

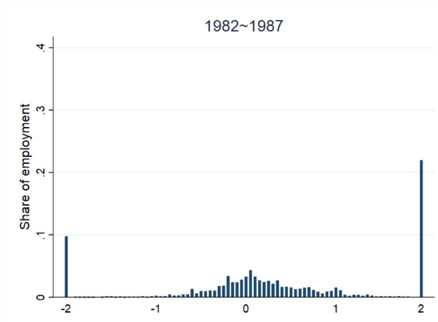
[9]Value-added at basic prices = value-added at factor costs + production taxes - production subsidies

For panel (d) of Figure 5, firm size is used instead of plant size, so we can utilize data from more countries. Additionally, value-added at factor costs is utilized over value-added at basic prices because only the former is mostly available for countries with the number of firm data while the latter is not as in Table A.II.

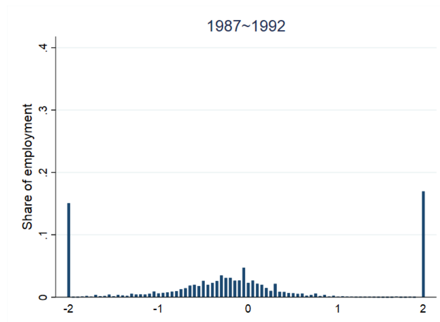
B Distribution of Job Creation and Destruction for All 5-year Windows

In Section 4.1, we report only four 5-year windows during our sample period: 1982-1987, 1992-1997, 2002-2007, and 2013-2018. Figure B.1 shows all seven 5-year windows during our sample period. Three 5-year windows in the middle (1987-1992, 1997-2002, and 2008-2013) resemble nearby periods.

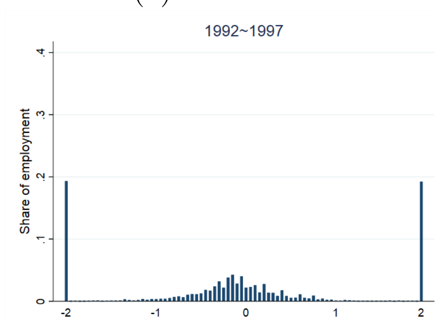
Figure B.1: Distribution of Job Creation and Destruction for All 5-year Windows



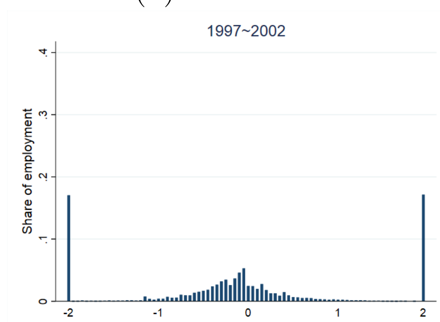
(a) 1982-1987



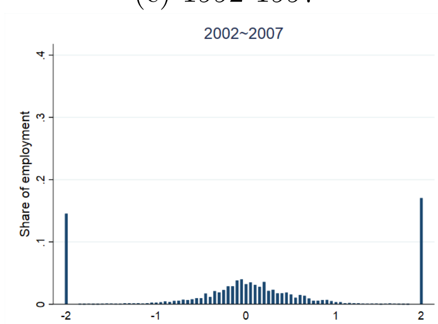
(b) 1987-1992



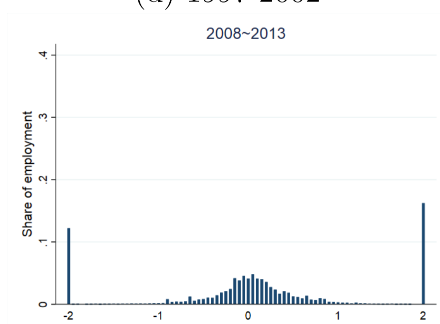
(c) 1992-1997



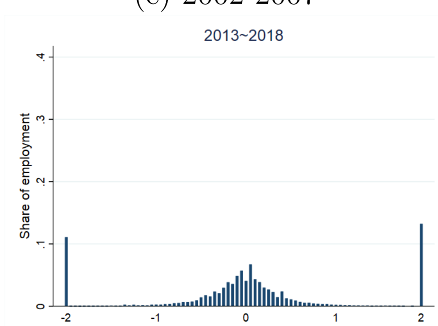
(d) 1997-2002



(e) 2002-2007



(f) 2008-2013



(g) 2013-2018

Notes: Employment growth for a plant is defined as the change in plant employment over (say) 1982 to 1987 divided by the plant's average employment in 1982 and 1987. The vertical axis gives the share of total job creation (destruction) associated with plants at each given level of employment growth. Note that entry is recorded as +2 and exit is recorded as -2.

C Robustness to Productivity with Another Measure

In Section 4.2, we use a model based TFPR ($TFPR_{si} = \frac{P_{si}Y_{si}}{K_{si}^{\alpha_s}L_{si}^{1-\alpha_s}}$) as a benchmark measure for productivity. In this Appendix section, we use a model based TFPQ ($TFPQ_{si} = \frac{(P_{si}Y_{si})^{\frac{\sigma}{1-\sigma}}}{K_{si}^{\alpha_s}L_{si}^{1-\alpha_s}}$) as a measure for productivity instead.

Table C.I reports results from plant-level regressions using a model-based TFPQ as a measure of productivity. Plant-level employment and capital growth responsiveness with respect to a model-based TFPQ has weekended from 1980s to 2010s, consistent to Table 1 where we used TFPR as a proxy for the productivity.

Table C.I: Plant-level Growth Responsiveness Has Weakened (Productivity = model-based TFPQ)

Dep. var.	Employment growth		Capital growth	
	(1)	(2)	(3)	(4)
Productivity (TFPQ): β_1	0.0418***		0.0963***	
	(0.0037)		(0.0063)	
Prod × trend: δ	-0.0003		−0.0019***	
	(0.0002)		(0.0002)	
Prod × 1980s: λ_{80s}		0.0352***		0.0872***
		(0.0035)		(0.0065)
Prod × 1990s: λ_{90s}		0.0410***		0.0734***
		(0.0042)		(0.0074)
Prod × 2000s: λ_{00s}		0.0363***		0.0541***
		(0.0037)		(0.0044)
Prod × 2010s: λ_{10s}		0.0313***		0.0345***
		(0.0077)		(0.0042)
Observations	1,297,793	1,297,793	1,297,793	1,297,793
R-squared	0.1447	0.1451	0.1226	0.1230

Note: Dependent variable is annual employment growth in columns (1)-(2) and annual capital growth in columns (3)-(4). All regressions include controls described in equation 6 and related text. Productivity is proxied by model-based TFPQ.