THE RISE OR THE FALL OF SUPERSTARS? PRODUCTIVITY SPILLOVERS AND FIRM DYNAMICS IN INDONESIA

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Abstract

Do industrial "superstars" help others up or crowd them out? We examine the relationship between the spillovers of superstar firms (the top market-share in the industry) and the productivity dynamics in Indonesia. Employing data on Indonesian manufacturing firms from 2001-2015, we find that superstar exposures in the market raises both the productivity level and growth on non-superstar firms through horizontal (within sector-province) and vertical (across-sector) channels. When we distinguish by ownership, foreign superstars consistently encourage productivity except via the horizontal channel, whereas domestic superstars generate positive spillovers through both horizontal and vertical linkages, showing positive externalities are not driven by foreign firms alone. Furthermore, despite overall productivity growth is positive in 2001-2015, the source of negative growth is mainly driven by within-group reallocation–evidence of misallocation among surviving firms–driven notably by domestic superstars. It contrasts with *the Rise of Superstar Firms* hypothesis arguing reallocation to the most productive firms. Although Indonesian superstar firms are more efficient in their operations, their relatively modest growth rates point to a potential stagnation, plausibly attributed to limited innovation activity or a slow pace in adopting new technologies.

Keywords: Superstar Spillovers, Productivity, Indonesian manufacturing firms.
JEL Classification: F23, L60, D24.

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1 Introduction

The declining share of labour income since 1980s has been significantly attracted much concern from economists. Both developed and developing economies experiencing this decline have devoted attention to identify the causes of this decline, mainly focusing on the trade-off between physical capital and labour in the production process (Barkai, 2020). Instances of trade-off causes are whether through the mechanism of lower relative cost of capital to labour and technological change (Firooz et al., 2025), globalization and trade liberalization (Xu et al. (2018), Damiani et al. (2020), Perugini et al. (2017), Leblebicioğlu and Weinberger (2021)), as well as, recent hypothesis, the reallocation process to the most productive firms, known as superstar firms (Autor et al., 2020). Among these causes of labour share decline, the rise of superstar firms might devote attention the most as it integrates other causes such as how superstar firms are able to optimally utilize technology revolution and cause reallocation among firms in the open economy (Aghion and Howitt (2023), Aghion et al. (2019)).

In the literature, most studies discussing superstar firms focused on advanced economies, such as US (Ciliberto and Jäkel (2021), Cheng et al. (2024), Ayyagari et al. (2024), Firooz et al. (2025)), Belgium (Amiti et al. (2024), Abraham and Bormans (2020)), and European countries (Bormans and Theodorakopoulos, 2023), where the adoption of advanced technologies and automation is well-documented in the data. Moreover, in developed countries, such as US, industries have become more concentrated on firms with better performance, i.e. superstar firms (Autor et al., 2020). Since superstar firms mainly utilize high-technology in production, such as robots, the rise in automation occurred (Firooz et al., 2025). Although the fact that the rise of automation through robot utilization also needs more skilled workers (Firooz et al., 2025), it may then also cause decreasing unskilled labour which are evidently abundant in many developing countries (Amiti and Cameron, 2007). This question leaves a significant gap in understanding how superstar firms operate and exert influence in developing economies.

Scrutinizing the relationship between superstar firms and productivity is essential for developing countries. Superstar firms may cause the direct effects for economy by generating

demands in their supply chain, creating new markets, and offering surpluses for workers' benefits (Ciani et al., 2020). Moreover, superstar firms may also create indirect effects through productivity and knowledge spillovers stemming from intensive innovation, agglomeration, and extending linkages with their trade partners as they connect both domestically and internationally which thus possibly propagating aggregate shocks for their economic instability (Di Giovanni et al., 2017). Evidently, in developing countries, superstar firms contributed by about 1.4% in Vietnam, 1.5% in Indonesia, and 0.8% in Morocco, by the year of 2005, compared with small medium enterprises (SMEs) which showed negative contribution (Ciani et al., 2020). Meanwhile, in Indonesian economy supported by more than 61% of small economy (Widita et al., 2024), superstar firms are used as a trailblazer for government policy. For instance, in early 1990s, Indonesian government introduced the program of Foster Father (*Bapak Angkat*) which encouraged superstar firms to cooperate with smaller firms in terms of providing parts and components in supply chain[1]. This program is also simultaneously implemented with the Indonesian rule number 176/2009 about Import Duty Exemption on The Imported Machinery, which leads superstar firms to establish partnership with domestic firms as they obtain import duty reduction provided that at least 30% of the machinery they utilize is sourced domestically. According to this evidence, it is worth to scrutinize how superstar firms affect productivity in the economy[2].

This study aims to fill the gaps of the nexus between superstar spillovers and productivity on developing economies by examining manufacturing firms in Indonesia using panel data in 2001-2015. Indonesia deserves more attention on the issue of superstar firms due to several reason. First, in terms of macroeconomic evidence, Indonesia has experienced a long episode of economic fluctuation since 1980s, where the year of 1998 is the worst period due to Asian Financial Crisis. In the post 1998 periods, Indonesian manufacturing sector remains the largest drivers of the economy, despite the trend declines over years (see Figure 1).

However, although the contribution toward Gross Domestic Products (GDP) declines, in terms of productivity, Indonesian manufacturing sector shows rebounding trend after 2000.

[1]This strategy has also been implemented by Korea in 1970s for heavy and chemical industries, see Pyo and Lee (2018)

[2]The rules had been in effect since 2000 with The Decree of Minister of Finance number 135 in 2000 about Import Duty Relief on the Importation of Machinery, Goods, and Materials for the Development/Expansion of Industry/Service Industry

According to the Figure 2, Total Factor Productivity (TFP) index in relative to 2017 shows that Indonesia shows rebounding trend in early 2000s after Asian Financial Crisis in 1998. It is inline with the labour productivity growth in relative to 2001 between superstar firms and non-superstar firms, shown in Figure 3. According to Figure 3, superstar firms has higher productivity growth in early 2000 until 2006. However, Non-superstar firms then caught up and outweighed superstar firms until 2015. This evidence is interesting on how the catching-up process occurred.

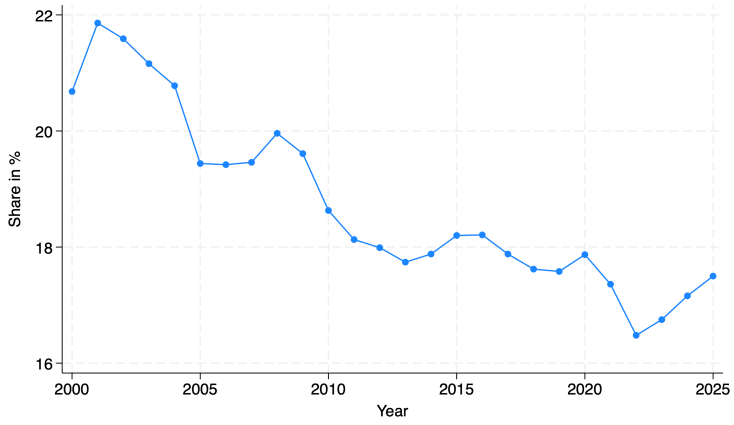


Figure 1: Share of Manufacturing Sector to GDP
Source: BPS-Statisctis

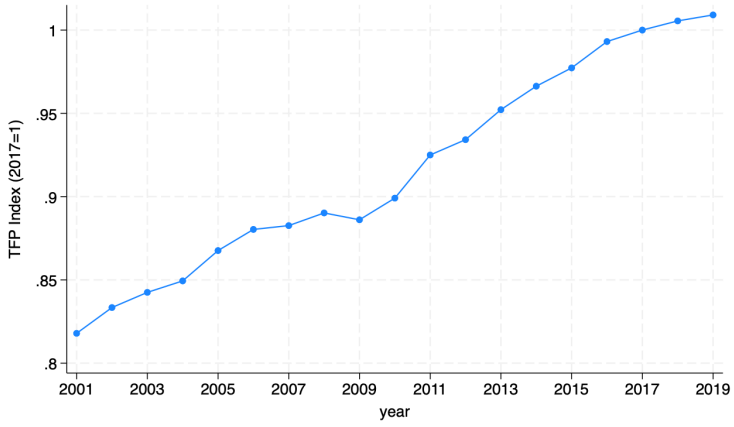


Figure 2: Total Factor Productivity Index Relative to 2017
Source: Groningen Growth and Development Centre - GGDC (2023)

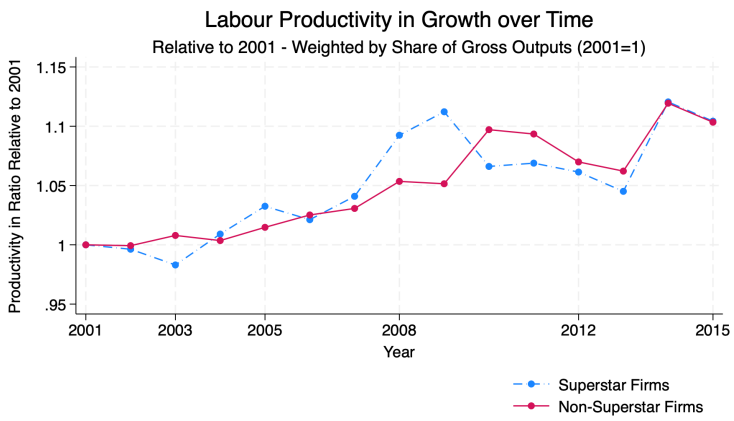


Figure 3: Labour Productivity Growth Relative to 2001

Source: BPS Statistics Indonesia

Another evidence is that how superstar firms dominate the market share. Data from BPS-Statistics of Indonesia in 2001-2015 reports that superstar firms dominates more than 76%, shown in Figure 4. This evidence implies that there is significant market concentration in the Indonesian manufacturing industry, mainly possessed by superstar firms.

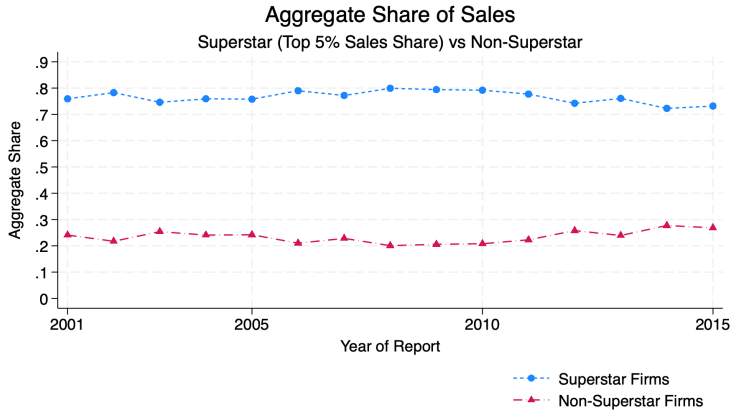


Figure 4: Aggregate Share of Sales: Superstar and Non-Superstar Firms

Source: BPS Statistics Indonesia

The rise of superstar firms in Indonesia can also be seen from the rise trend of automation, as suggested by Firooz et al. (2025). In the Indonesian evidence, we show the ratio of machine capital to production workers in Figure 5. According to Figure 5, there is increasing trend of the automation level since 2001. Since 2001, the level of automation is dominated by superstar firms, while non-superstar firms increase their automation level and converge into the level of superstar automation.

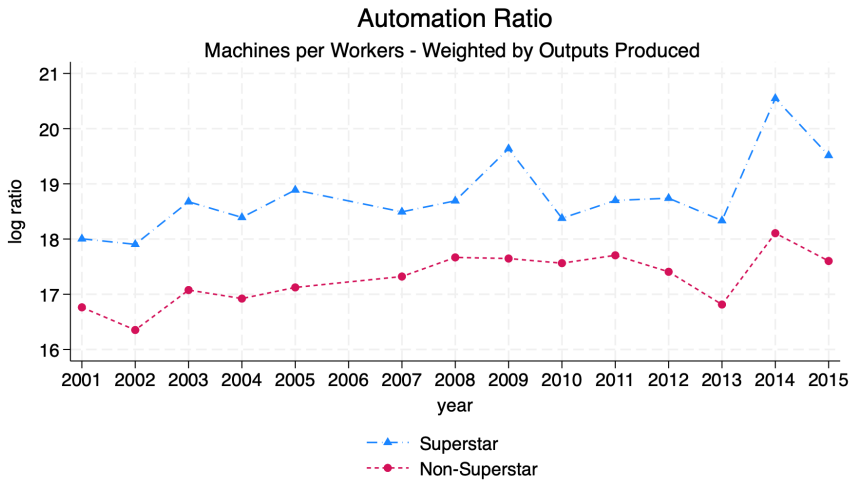


Figure 5: Automation between Superstar and Non-superstar

Source: BPS-Statistics

As suggested by Autor et al. (2020), automation in US occurred mainly in subsector with high concentration. Hence, it is essential to look at the relationship between automation and market concentration. We report the nexus between automation with two types of concentration namely labour-share (log of labour cost per workers) and market-share (share of outputs produced). The relationship between automation and concentration is shown in Figure 6.

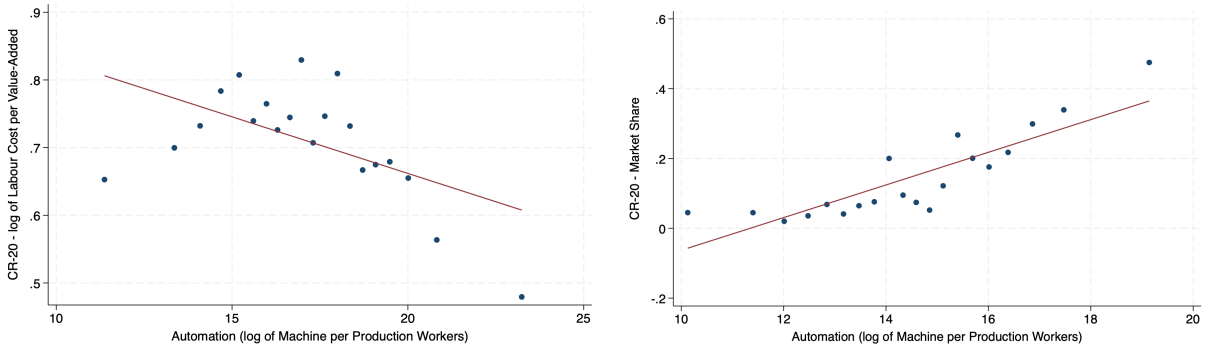


Figure 6: Correlation between Automation and Labour and Market Share

Source: BPS-Statistics

According to Figure 6, it is obvious that there are contradictory behaviour between the correlation of automation with labour-share and market-share. The hypothesis of "the rise of superstar firms" in US from Autor et al. (2020) is indicated by the decline of labour share, implying that there is a substitute mechanism for automation. In the Indonesian evidence,

the correlation also reveals similar behaviour. It is strengthened by the positive correlation between automation and market share for CR20 (top 20 firms for each subsector), implying that firms with higher automation are associated with higher market share.

In terms of historical policy trajectory, Indonesian economy embarked on market liberalization in the 1960s, which significantly influenced inward foreign direct investment (FDI), where the inward FDI growth obtained more than 50% from 2005-2007 (Uttama and Peridy, 2010). A major reformation of FDI policy occurred in 1966 under the New Order regime of President Soeharto (Genthner and Kis-Katos, 2022). The reformation led to massive structural economic changes compared to the preceding Old Order regime, such as deregulation policy in banking sector, trade, investment, and capital market, which culmunated in Indonesia becoming a member of the World Trade Organization (WTO) in January 1995. Under the New Order regime, FDI inflows were encouraged to establish production facilities, primarily in the form of multinational corporations (MNCs), with the aim of driving high-technology intensification for local firms. However, as suggested by Amiti et al. (2024), FDI in the form of MNCs may not be the only or even the most effective mechanism for generating positive economic spillovers. Their finding indicate that large domestic firms create similiar spillovers while having stronger local linkages. Hence, it suggests that instead of prioritizing subsidies and incentives for MNCs, there is an essential need to foster a more level playing field for all large firms, including domestic superstar firms. In this regard, rather than focusing on FDI spillovers in Indonesia on which many studies have devoted attention, there is a need to examine how superstar firms, not only MNCs, create spillovers for Indonesian economy.

In this study, there are two strategies in capturing how superstar spillovers associates to the firm's productivity. The first strategy is by examining correlation between superstar firms exposure and productivity. A higher exposure of superstar firms within the sector and region may cause spillovers from the mechanism of demonstration, labour migration, and competition, as suggested by Orlic et al. (2018). Demonstration channel takes place through observation and mimicking by which non-superstar firms aimed to copy technology or production managements from superstar firms, labour mobility occurred when non-superstar firms hire workers migrating from superstar firms, while the channel of competition occurred when the presence of superstar firms stimulate non-superstar firms to compete to be more

efficient. The second strategy is by looking at the superstar firm's contribution towards aggregate productivity considering the firm dynamics entry-exit behaviour. The idea is that whether productivity changes solely stems from within firm productivity improvements, or also are supported by entry-exit behaviour of the firms. Evidently, data from BPS-Statistics Indonesia in 2001-2015 shows that the entry-exit rate from manufacturing firms reached by about 8%, which is essential in determining the productivity composition of the country. Hence. this study decomposes to which degree superstar firms contribute to the aggregate productivity over time, complementing the findings from correlation test in the first strategy. The standard decomposition from Olley-Pakes (Olley and Pakes, 1996) has been extended by Melitz and Polanec (2015) and Collard-Wexler and De Loecker (2015) by incorporating entry and exit firms. This study extends these strategies to incorporate superstar firms' dynamics.

This study contributes to the literature in three main-folds. First, this study re-evaluates the literature on productivity spillovers that claimed mainly coming from foreign firms. In early 2000s, several studies have explored firms with characteristics resembling superstar firms and their spillover effects on productivity. For instance, incoming foreign direct investment (FDI) in a form of multinational companies (MNCs), assumed more superior than domestic companies (Helpman et al., 2004), was often associated with increased productivity among local firms through spillover mechanism (see Javorcik (2004), Suyanto et al. (2009), and Sari et al. (2016)). This findings are mainly relevant for developing countries with inward FDI share on world total FDI by 16.69% in 1990 growing to 55.47% in 2014 (Sahu, 2021). Under this statistical data, prior studies claimed productivity spillovers from FDI for domestic economy.

However, the fact that whether this spillovers also truly come from MNCs needs more investigation. A recent findings from Amiti et al. (2024) argued that productivity spillovers from MNCs should be re-assessed as it is not obvious whether productivity spillovers is anchored truly by MNCs or, additionally, other types of firms such as large or exporting firms. This hypothesis is plausible as domestic firms with characteristics large and exporter can also create productivity spillovers to their counterparts as they also deal with global value chains as MNCs. Likewise, a finding from Herzer and Donaubauer (2018) reveals that FDI

might cause negative spillovers on productivity in the long-term, implying that a country could not keep relying on MNCs in stimulating economy. In this sense, it is essential redefine which firm's characteristics causing productivity spillovers, namely through superstar firm depicting more relevant characteristics of top firms as they are not necessarily MNC.

The second contribution stems from the perspectives by which spillovers are addressed. This study tests intensive margins among firms with higher domination of superstar firms in their subsector and province through several horizon namely horizontal (within subsector and province) and vertical (across subsector). Prior studies have devoted attention on examining FDI spillovers through this perspective (see Bournakis and Tsionas (2022), Sari et al. (2016), and Vujanović et al. (2021)), but, to the best of our knowledge, the study investigating the superstar spillovers from horizontal and vertical networking is strictly limited. Recent study from Amiti et al. (2024) examined the firm-to-firm channel in Belgium using difference-in-difference (DiD) design, but it did not address the degree of superstar firms' exposure towards productivity and spatial proximity. We aim to fill this gap by examining whether larger share of superstar firms in each industry stimulates productivity from spillover process and being amplified under spatial proximity.

Moreover, in this study, we define our definition of superstar firms which are more fundamental and relevant for the evidence of Indonesia as a developing country. Prior studies have some limitation in classifying superstar firms. For instance, Autor et al. (2020) defined superstar firms as top-500 firms in the industry, which is arbitrary in the context of Indonesia[3]. Likewise, the definition of superstar firms from Amiti et al. (2024) taken from whether firms are either foreign-owned, exporter, or large firms results the large number firms called as superstar, which is no longer relevant with the term "super" in this context[4]. Conversely, the study of Rowley (2024) defined superstar firms too strict by using top 3 domestic and foreign firms in terms of export. This strategy is also difficult to capture the spillovers effect across different horizon[5].

Still in the second contribution, prior studies, in FDI spillovers, treated the spillovers

[3]Since the number of firms in Indonesia for each year is dynamically changed, it is not possible to employ the quantitative strategy, as suggested by Firooz et al. (2025)

[4]Also, this strategy is alike with FDI spillovers literature

[5]For comparison, we report the number of superstar firms from these literature for the context of Indonesia in the Appendix

indicator exogenously and independently from productivity by measuring the share of superior firms in the sub-sector (see Spithoven and Merlevede (2023) and Bournakis (2021)). This strategy causes the interaction between endogeneous external knowledge, proximate for spillovers, and selection of capital and labour are unclear and misleading the true effect of productivity spillovers (Bournakis and Tsionas, 2022). We aim to fill this gap by endogenizing spillovers indicators using import tariff of sectoral level and road density of provincial level.

The third contribution is the decomposition strategy to capture the contribution of productivity growth. Prior studies of Melitz and Polanec (2015) and Collard-Wexler and De Loecker (2015) decomposed productivity from Olley and Pakes (1996), known as Dynamic Olley-Pakes Decomposition (DOPD), for Survivors, Exiters, and Entrants. We apply this strategy by decompose TFP into two groups, superstar and nonsuperstar firms. This strategy enables us to explore the degree to which superstar firms contribute to the aggregate TFP growth. It is essential to distinguish such decomposition for the contribution of TFP growth. In the standard DOPD from Melitz and Polanec (2015), this feature is generalized as either Survivors, Exiters, and Entrants.

The findings of this study are as follows. First, we capture positive spillovers from both horizontal and vertical channel on TFP level and growth, implying a higher share of superstar firms within province and subsector causes non-superstar firms more productive. The positive relationship of superstar spillovers in horizontal direction implies that horizontal linkages on the TFP may stimulate competition from the outset, putting pressure on non-superstar firms and leading to lower productivity; firms unable to survive this pressure may exit the market, leaving only those with a certain level of productivity. Likewise, we found positive association between vertical channels, both backward spillovers (who superstar firms purchasing from) and forward spillovers (who superstar firms selling to), on the TFP level and growth. It implies that acting as suppliers to superstar firms or purchasing intermediate inputs from superstar firms improves the productivity growth of non-superstar firms.

In terms of heterogeneity of the superstar firms by distinguishing it into foreign and domestic superstars, we found that foreign superstars consistently show positive effects on non-superstar productivity, except for horizontal channels showing insignificant effect. A plau-

sible reason is the technology protection from their parent company which hinder spillovers from demonstration and mimicking channels. However, domestic superstar show positive results for entire channels, implying that domestic superstars generate spillovers more than that foreign superstars do. This findings are robust across different specification strategies such as medium-large size samples, alternative instrumental variables, as well as different alternatives productivity measurements.

Moreover, the results from decomposition strategy shows that although overall TFP growth is positive in 2001-2015, the source of negative aggregate productivity growth is mainly driven by within-group reallocation, which implies misallocation within survivors in the markets. Interestingly, the negative growth of survivors group is mainly driven by domestic superstar firms. More specifically, superstar firms in Indonesia exhibit slower growth compared to their non-superstar counterparts. Accordingly, this finding contrasts with the "Rise of Superstar Firms" hypothesis commonly observed advanced economies, as in Autor et al. (2020) and Amiti et al. (2024). Although Indonesian superstar firms are more efficient in their operations, their relatively modest growth rates point to a potential stagnation. Such stagnation could be attributed to limited innovation activity or a slow pace in adopting new technologies. While productivity spillovers to non-superstar firms are evident, they may largely stem from the existing wide TFP gap between superstar firms and their competing, supplying, and purchasing partners.

The following Section 2 discusses institutional background of Indonesia, followed by literature review of superstar firms in Section 3 and outlines the data and methodology in Section 4. Section 5 presents our findings and discussion. Section 6 concludes the study and presents some policy implications.

2 Literature Review

2.1 Theoretical Literature

2.1.1 Heterogenous Firm Model Theory

Theoretical literature have devoted attention to delve into heterogeneous firm theories in differentiated products markets to account for disaggregated data. Different with homogeneous firm theories assuming uniform firms' decision to enter the market and exogenous productivity shocks, heterogeneous firm model account for endogenous firm's decision to enter and exit the market, which thus determines aggregate productivity distribution (Melitz and Redding, 2013). In early 1970, this dynamic models of entry and exit have been theoretically introduced by Brock (1972) and Smith (1974). For instance, Brock (1972) proposed an equilibrium model based on producers' expectation on price of outputs before they enter the markets. Under this expectation, the producer incorporates the (sunk) cost of entry and predict the size of industry to enter the market at a proportional rate of profits. This decision ultimately determines the actual size of the industry as the industry converges to the equilibrium in which supernormal profits do not exist. This model was then corroborated by Hopenhayn (1992) building tractable model about how economic determinants affect entry and exit decisions due to firm-idiosyncratic uncertainty, i.e. productivity shocks. This uncertainty led to the resource reallocation from exit firms to the incumbents enhancing their scale.

In early 2000, the models have been developed to account for real-world firm's behavior, two of which were proposed by Melitz (2003) and Melitz and Ottaviano (2008). Different with Hopenhayn (1992) demonstrating competitive firms, Melitz (2003) elaborated the heterogeneous model by applying the monopolistic competitive markets in the general equilibrium settings. In the model of Melitz (2003), the heterogeneous productivity of firm and industry is obtained from the process of entry-exit mechanism with international trade a shock. The model suggested that international trade leads to reallocation across firms in the industry through the stimulation to export for more productive firms while force to exit for least productive firms. The reallocation process then encourages aggregate productivity

in the industry as market share and profits are shifted to the more productive firms. This model also postulated that international trade enclosed higher opportunity for productive firms while also enforce least productive firms to shutdown from the industry, although some government policy tends to prevent least productive firms to exit by protection scheme.

One of the key innovations in Melitz (2003) is the introduction of a dynamic and forward-looking market entry decision by firms facing sunk entry costs for both domestic and export markets, perspective for which Brock (1972) and Hopenhayn (1992) did not emphasize. Costs of entry explain the phenomenon of hysteresis in the export market participation: once firms enter export markets, they tend to remain, even during market fluctuation, as the initial entry costs are considered "sunk" and non-recoverable. In particular, firms wishing to enter an industry must pay a fixed entry costs (treated as sunk cost). After firms enter the industry, they will receive an initial productivity level randomly drawn from general distribution. Firms with low productivity may decide to exit immediately without producing anything, while firms with sufficiently high productivity will produce and earn positive profits as long as they are not hit by a bad shock, a fixed risk that forces them to exit. Exporting firms have higher survival probabilities, even after controlling for their higher productivity.

The model of Melitz (2003) was then elaborated by Melitz and Ottaviano (2008) by combining the perspective of Melitz (2003) for productivity uncertainty before entry the market and Ottaviano et al. (2002) for linear demand system with horizontal market differentiation to determine markups. Melitz and Ottaviano (2008) addressed that the distribution of markup can be endogenously determined by several factors, one of which is the toughness of competition in the market. When competition is tougher, markup tend to decrease. Conversely, when competition is less intense, firms can set higher markups. This distribution of markups becomes endogenous and varies across countries, depending on the number and productivity of competing firms. First, larger markets tend to have more firms and tougher competition. Additionally, trade integration increases the level of competition in local markets as foreign firms enter and compete. Secondly, tougher competition forces less productive firms out of the market, leaving only highly productive firms able to survive and grow. Third, trade introduces an additional selection mechanism, where only the most productive firms can bear the trade costs and become exporters.

2.1.2 Heterogeneous Firm Model with Superstar Spillovers

The notion of heterogeneous firm model with spillovers was proposed in a strand of literature, such as from Anwar and Sun (2019) who postulated the idea for FDI spillovers based on the cutoff criteria as in Melitz (2003). However, the model introduced by Anwar and Sun (2019) generalized the behaviour of spillovers. Hence, we introduce the heterogeneous model with superstar firms by adjusting generalized FDI spillovers model of Anwar and Sun (2019). The model is based on the constant elasticity substitution as follows:

$$q = \Theta p^{1/\rho - 1} \tag{1}$$

where q is the total demands, p denotes the price, Θ represents a given aggregate demand, and ρ is the parameter of the consumer utility function where $\rho \in (0, 1)$. In this model, when a non-superstar firm enters the market, it possesses and explore its capability (λ) with continuous distribution in density function $g(\lambda)$ where $\lambda \in (0, +\infty)$.

The composition of cost can be decomposed from the production function as follows:

$$q = \varphi . L \tag{2}$$

where q is total outputs, φ is average productivity of input L, and L is an index of inputs. The nexus of left-side and right-side in equation 2 is that the total output is not only determined by the level of inputs L, but also average productivity of inputs L. From equation 2, I may obtain the information of the inputs utilization from $L = \frac{q}{\varphi}$. And, I gain the information of variable cost by multiplying it with the cost of inputs L, w. Hence, I obtain the total cost composition as follows:

$$TC = \underbrace{f}_{\text{fixed cost}} + \underbrace{w\frac{q}{\varphi}}_{\text{variable cost}} \tag{3}$$

where TC denotes total cost, f is the fixed cost incurred by each domestic firm, and variable cost consisting of w as the price of input L, q as the total outputs, and φ as the firm's

productivity. By following Anwar and Sun (2019) who endogenized φ to capture spillover behaviour, we arrange:

$$\varphi = \lambda e^{\alpha\gamma} c(Z) \tag{4}$$

where φ is the productivity, α and γ represent the productivity spillovers from superstar firm and the degree to which superstar firms create spillovers (mostly the share of sales), respectively, and Z is a vector of firm characteristics as control. In equation 4, the value of α captures whether the spillovers are positive ($\alpha > 0$)), negative ($\alpha < 0$)), or have no effects ($\alpha = 0$)), for non-superstar firms. In this regard, the productivity of non-superstar firms firms is determined by three components: capability level λ, the exponential value of spillovers α and the share of superstar firms γ, as well as firm's characteristics.

We can also distinguish spillovers into some channels namely horizontal and vertical (backward and forward) direction. Horizontal spillovers occur within subsector involving competition and demonstration such as mimicking. Meanwhile, vertical spillovers occur across subsector through the networking with suppliers (backwards) and purchasers (forward). Equation 4 can then be extended into:

$$\varphi = \lambda e^{\alpha HSpill} e^{\tau BSpill} e^{\psi FSpill} c(Z) \tag{5}$$

We then can arrange the profit function as follows:

$$\pi = p.q - (f + w\frac{q}{\varphi}) \tag{6}$$

where π is the profit. Under monopolistic market, the first order condition (FOC) of equation 6 requires marginal revenue to equal with marginal cost. We re-arrange equation 1 into: $q = \Theta p^{1/\rho - 1}$ and $p = \frac{q^{\rho-1}}{\Theta^{\rho-1}}$, we then obtain:

$$TR = \frac{q^{\rho}}{\Theta^{\rho-1}} \tag{7}$$

Hence, we obtain Marginal Revenue (MR)= ρp

Meanwhile, using the function from cost in equation 3, we obtain Marginal Cost (MC)= $\frac{w}{s}$. Hence, we obtain the pricing rules under $MR = MC$ as:

$$p = \frac{MC}{\rho} = \frac{w}{\rho s} \tag{8}$$

We then apply the pricing rule in equation 8, demand function in 1, and average productivity of inputs in equation 4 for optimal profit (π^*) function in equation 6 as follow[6]:

$$\pi^* = (1-\rho)w^{\frac{\rho}{\rho-1}}\rho^{\frac{\rho}{1-\rho}}\lambda^{\frac{\rho}{1-\rho}}e^{\frac{\alpha HSpill\rho}{1-\rho}}e^{\frac{\tau BSpill\rho}{1-\rho}}e^{\frac{\psi FSpill\rho}{1-\rho}}c^{\rho/1-\rho}\Theta - f \tag{9}$$

According to equation 9, we identify that π^* is monotonically increasing function of the firm capability (λ). As firm capability converges to zero, profit will converge to $-f$. In this regard, there is a need for cut-off of firm capability to prevent firms obtaining negative profit. Hence, in the condition of non-negative profit non-superstar firms ($\pi = 0$), we may obtain optimal firm capability cut-off (λ^*) as follows:

$$\lambda^* = f^{\frac{1-\rho}{\rho}}(1-\rho)^{\frac{\rho}{1-\rho}}w^{-1}e^{-\alpha HSpill}e^{-\tau BSpill}e^{-\psi FSpill}c\Theta^{\frac{\rho}{1-\rho}} \tag{10}$$

According to equation 10, the cutoff capability of the market depends on the degree of superstar firm's exposure ($HSpill$, $BSpill$, and $FSpill$). If positive horizontal spillover occurs ($\alpha > 0$), an increase of $HSpill$ leads to lower cut-off capability level, implying that the market is getting less strict in terms of productivity performance, which in turn enables non-superstar firms that were not originally capable for surviving in the industry to re-enter. It may cause aggregate productivity to decrease afterwards. Meanwhile, if negative spillovers occurs ($\alpha < 0$), a higher share of superstar firms in the industry leads to higher level of cut-off capability, which causes crowding out effects for less productive firms.

The channel of vertical spillovers is alike. If positive vertical spillovers occur (either $\tau > 0$

[6]The optimization process is explained in the appendix

or $\psi > 0$), an increase of $BSpill$ or $FSpill$ (i.e. superstar firms purchase more intermediate inputs from other subsectors, or sells more to other subsectors), the lower the cutoff becomes because superstar firms may become increasingly dependent on other sectors (their product sales are dominated by sales to other sectors rather than to final consumers). This situation leads to less strict productivity requirements, so any firm can potentially become a supplier to superstar firms since superstar firms require more suppliers, while existing suppliers may not be able to meet superstar firms' demands. As a result, more firms can enter the market and may become suppliers or purchasers of superstar firms. It will then lower overall productivity because superstar firms still have to purchase intermediate goods from suppliers with lower productivity performance.

Therefore, we obtain (logged of) expected productivity from equation 5 given the capability level above the cut-off as follows:

$$E(ln(s)|\lambda > \lambda^*) = \alpha HSpill + \tau BSpill + \psi FSpill + \ln \mathrm{c} + \frac{\int ln\lambda g(\lambda)d\lambda}{\int_{\lambda^*}^{\infty} g(\lambda)d\lambda} \tag{11}$$

According to equation 11, there are two channels of superstar spillovers to occur. First, the direct effect from α, τ, and ψ, and the second channel is through the cutoff level λ. We then can estimate the marginal effects with respect to superstar firm's share, as follow:

$$\frac{\partial E(ln(s)|\lambda > \lambda^*)}{\partial Spill} = \underbrace{\alpha + \tau + \psi}_{\text{Direct Effect}} + \underbrace{\frac{\int ln\lambda g(\lambda)d\lambda}{[\int_{\lambda^*}^{\infty} g(\lambda)d\lambda]^2} g(\lambda^*) \frac{\partial \lambda^*}{\partial Spill}}_{\text{Indirect Effect}} \tag{12}$$

Where $Spill$ denotes $HSpill$, $BSpill$, or $FSpill$. According to equation 12, there is contradictory nexus between direct and indirect effects. If spillovers positive occurs ($\alpha > 0$, $\tau > 0$, $\psi > 0$) the change of capability is negative ($\frac{\partial \lambda^*}{\partial HSpill} < 0$, $\frac{\partial \lambda^*}{\partial BSpill} < 0$, $\frac{\partial \lambda^*}{\partial FSpill} < 0$), so indirect effect is negative, *vice-versa*. The intuition of this opposite direction is that at the initial entry of superstar firms, the direct effect of spillover enable non-superstar firms–both survivors and those that have exited the market– to identify benchmark firms that serve as reference for their own production process. In this context, an increase in the share of superstar firms within sector ($HSpill$) accompanied by the rise in productivity may indicate

that non-superstar firms are directly responding through mechanism such as demonstration, labour migration, and competitive pressure, as suggested by Orlic et al. (2018). Meanwhile, an increase in the share of superstar firms across sector ($BSpill$, and $FSpill$) may indicate that non-superstar firms are directly responding through entering the market and become suppliers/purchasers.

However, there also exists an indirect channel of productivity spillovers. When the superstar firm's share increases and generates positive direct effects, the resulting shift can lower the capability cutoff (λ), thereby enabling a greater number of firms to enter the market. It implies that the increase in superstar firm share indirectly contribute to the lowering of the entry threshold. In the presence of such potentially conflicting direct and indirect effects, the initial magnitude of spillovers α, τ, and ψ becomes crucial, as it determines the extent of the shift in the cutoff and consequently the change in aggregate productivity.

It is possible that positive spillovers lead to a surge of less productive firms into the market, thereby reducing aggregate productivity due to a decline in the productivity threshold. Conversely, negative spillovers (rivalry effect and market stealing from superstar firms) may initially reduce productivity from non-superstar firms directly–possibly get them out from the market–but simultaneously raise the cutoff level, ensuring that only more capable firms survive, which could eventually increase aggregate productivity.

2.2 Empirical Literature on Superstar Firms

There are strand of literatures for superstar firms. For instance, study of Autor et al. (2020) aims to investigate the cause of labour share declining behaviour in US. The hypothesis takes the evidence that there is a decline on the Gross Domestic Product (GDP) share from labour in some countries, implying that the national income enjoyed by labour decreases compared to that from capital. Autor et al. (2020) defined superstar firms as those firms who are top 500 largest (also 25 and 50 robustness) in terms of sales (and employment and market value as robustness). The findings show consistency with US census. Sales concentration is increasing across a large set of industries, indicating that most sales is dominated by large firms, while smaller firms' share is relatively small. Moreover, industry with highest increase of concentration shows the largest decline of labour share. This decline stems mainly from

between-firm reallocation, which occurred is most firms with largest sales concentration.

Another literature discussing superstar firms is Amiti et al. (2024) that aims to reveal whether by having networking with superstar firms will increase firm's productivity. Amiti et al. (2024) argued that superstar firms may dominate market share significantly and own high efficiency in terms of operational, which may cause negative impacts such as monopoly and monopsony behaviors as well as lobbying power to the government to intervene economic policy. However, the positive effect stems from the spillovers of productivity occurred from channeling of supply chain in intermediate and raw materials with non-supertar firms. Amiti et al. (2024) defined superstar firms from three indicators: foreign-owned, exporters, and large firms and capture spillover behaviour between superstar and non-superstar firms through the firm-to-firm datasets in Belgium in 2002-2014 using DiD design and event study. The findings show that firms embarking the strong relation with superstar firms, for example by selling in high quantity goods, experience total factor productivity (TFP) growth by 8% in 3 years after the relation is established, regardless whether the firm is in the same area or industry with the superstar firms. Moreover, the relation with other types of superstars, large firms or exporter, also stimulate TFP growth for non-superstar firms, implying that a firm not necessarily should channel with foreign-owned superstar firms to stimulate TFP. Similar design of firm-to-firm behaviour to capture superstar spillovers is also shown in Alfaro-Urena et al. (2022) for Costa Rica evidence, while Li et al. (2024) capture the supplier-customer network from firms-to-countries evidence.

Study of Ciliberto and Jäkel (2021) scrutinizes the superstar firms from the perspective of exporter and define superstar firm as a firm with a share in industry-level exports of at least 5%. The findings show that the strong competitive effect significantly encourages firm' decision to export. Without this strong competitive effect, superstar firms are more likely to export by 53.2%, implying that competition discourages benefits and export participation of the firm. Furthermore, in terms of tariff effect, firms with large export portfolio (such as exporting to many countries or homogeneous products) obtain smaller negative effects compared to small firms with limited export.

Study of Cheng et al. (2024) aims to reveal whether superstar firms are associated with greater likelihood of financial distress for firms exposed to them in product market. By

using firm level analysis, Cheng et al. (2024) defined superstar firms as firm with markup at least top 5% of the total firms in the four digit classification and experiencing increases of markup share (from four digit industry) from the last three years. The finding shows that there is positive association between exposure towards superstars and the bankruptcies in the following years. Firms with the highest exposure towards superstars will be more likely to bankrupt by 42% higher than that firms without exposure at all. Moreover, firms with high exposure towards superstars may experience financial distress which implies "winner-takes-all" condition in which market domination of superstars alleviate opportunity of small firms or uncompetitive firms to survive.

Study of Ayyagari et al. (2024) aims to reveal the degree which the high return on invested capital (ROIC) of the superstar firms is caused by unmeasured differences from the invested intangible capital and not caused by how superstar firms exploit the markets. Ayyagari et al. (2024) defined superstar firm as the firm in the top 10% pretax ROIC in particular year. The finding reveals that superstar firms, notably in industries with high levels of intangible capitals, show increasing return to capital that diverges from other firms. In this sense, a firm with high technology spending heavily on R&D and organizational development may experience high ROIC as the invested intangible capital is not recognized in the financial reports. Meanwhile, a firm with traditional manufacturing investing mainly to the tangible capital, like machine, may obtain small return on capital as it is recorded in the financial reports. In this regard, it is essential to reconsidered literature on how high-performing firms, such as superstar firms, exploit market power by incorporating investment in intangible capital.

Study of Rowley (2024) compared the different granular of superstar Foreign-Funded-Firms (FFFs) and superstar Domestic-Funded-Firms (DFFs) in terms of export market and productivity in China. Rowley (2024) accounts superstar firms as top 3 both FFFs' and DFFs' exporters in the industry, known as each superstar FFFs and superstar DFFs. Rowley (2024) reveal that the combination of top 3 largest FFFs exporters and 3 largest DFFs covers more than 50% of the annual total exports from the industry. Moreover, superstar FFFs' and DFF' granularity show that the positive impact of market concentration depends on the knowledge gap between superstars and non-superstars. If the gap is absent, the granularity

effect might be weaker. This finding corroborates the theory in which GCA depends on the unique contribution or know-how of large firms. The finding also reveals that DFF might grow and ultimately possesses equal level of GCA as FFFs, shown by the horizontal spillovers investigation strategy. The finding of the horizontal spillovers test is that there is positive spillovers from FFF granularity towards TFP and labour productivity, concluding that it is the granular FFFs that benefit of the catalog update rather than FDI in general.

Study of Li et al. (2024) aims to examine whether FDI technology spillovers between firms in a supply chain and analyze the mechanism. Foreign firm in this study is recognized as a superstar firm. Foreign firm ratio is taken from the proportion of shares held by foreign initiators to the total share capital. Li et al. (2024) found that in China, FDI technology spillovers stems from the customer-sellers networks amongst the company through two main channels namely knowledge transfer and optimizing value chain. State-owned enterprises, high-tech firms, and risk taker firms benefit the most from these channels. Moreover, FDI from developed countries contribute more technical transfers through the customer-sellers channel than that FDI from developing countries and tax havens countries.

Moreover, the study of Firooz et al. (2025) aimed to examine the nexus between the rise of superstar and automation intensity in US manufacturing firms. In their study, the declining price of robots and automatic machines leads to better accessibility of firms in US, which in turn improve their labour productivity but raise industry concentration. Firooz et al. (2025) defined superstar firms as firm in the top 1% sales and employment share and suggested proportional level of robot subsidy to mitigate markup distortions and improves welfare by stimulating automation investment.

3 Data and Methodology

3.1 Data

This study uses the survey of Indonesian manufacturing firms from *Statistik Industri*, henceforth *SI*, published by BPS-statistics, in 2001-2015. The survey of SI was embarked in 1975 and selects firms with 20 or more workers (Márquez-Ramos, 2022). The survey is in the level

of firm/establishment/plant, so SI will use term "plant" and "establishment" interchangeably to refer to a firm. Although some firms may have more than one factory, Márquez-Ramos (2022) reports that less than 5% of Indonesian factories belong to multi-factory firms. The BPS-Statistics, represented by the field agents, aims to increase the compliance rate by visiting each non-respondents (Márquez-Ramos, 2022). It also ensures that a firm may end up its production activity. Nonetheless, the firm's response rate shows decreasing trend over years. Márquez-Ramos (2022) report that response rate was about 74% in 2004, about 63% in 2011, but it dropped into 47% in 2017. For the years of 2001-2015, the total observation reaches 356,057 with varying number of firms in each year, specifically the year of 2003 has the smallest number of firms by 20,310 firms, and 2006 has the largest number of firms by 29,468 firms.

The BPS-Statistics, known as Badan Pusat Statistik, provides the questionnaire for establishments to be filled out by themselves. In general, questionnaire in *SI* consists of several basic information, such as firm identification code, The International Standard Industrial Classification of All Economic Activities (ISIC), and production value. It also covers different information depending on the year, such as the information of innovation and research activity that is available in 2011 but not other years. Other information are also available such as ownership (public, private, or foreign), export status, total assets, electricity utilization, fuel consumption, output, expenses, and labour.

There are several adjustment of the industrial classification code in this data. The data of 2001-2005 follow the industrial classification code from The Indonesian Standard Industrial Classification (KBLI) 2000, the data of 2006-2009 refers to the KBLI 2005 and International Standard of Industrial Classification (ISIC) Rev. 3 (1990). Moreover, the years of 2010-2015 refers to ISIC Rev. 4 (2008) and KBLI 2009. In this regard, it is required concordance to merge the datasets to ensure comparability of the firms. This study refers to KBLI 2009 in analysing sectoral firm-panel behaviour in the datasets. Another important adjustment is that some firms are located in the province with limited number of firms, causing riskier condition to detect the firm. In this regard, BPS-Statistics merely use 3 digits or 2 digits classification for this firms, while the concordance also needs wise adjustment.

Another adjustment is the regional code for which some regions (province, regency, dis-

trict, or village) are merged and possess new identification. In this regard, it is important to check the consistency of the code over years. Likewise, some firms have no province code as there is limited number of firms in that code. There is no alternative, unlike the 5-digits to be 3-digits, for this case.

Most importantly, the information of total fixed assets in 2006 is not available. Some studies implement interpolating strategies, such as Amiti and Konings (2007). In this study, we apply interpolating strategy from Amiti and Konings (2007) for several variables such as capital, labour, materials, and energy by averaging the values from one year before and one year after (i.e. summing the values from the previous and subsequent year and dividing by two). In addition, a more advanced method was used specifically for the capital variable, as this variable is not available in 2006. This strategy involved estimating capital based on the lagged value of total output, labour, materials, and energy to obtain the relevant coefficients. The residuals were also predicted in this process.

Subsequently, the capital value was calculated by multiplying each coefficient by the lagged value of its corresponding variable (total output, labour, materials, and energy) and adding the residual. The inclusion of the residual component is necessary to avoid bias (Enders, 2010). This strategy aims to estimate the degree of correlation between capital and the input/output variables, rather than capturing causal relationship (Laksono and Patunru, 2024). Furthermore, following Sari et al. (2016), we use lagged values for all variables on the right-hand side to ensure that the values from the previous period are associated with the current value of capital, thus enabling us to predict current capital.[7] The distribution of logged of capital before and after interpolation is summarized in the Appendix in Figure A-1.

Another data used in this study is the Input-Output Table of Indonesia in 2010. Input-Output (I-O) Table aims to capture the relation among the sectors in the economy. In Indonesia, BPS-Statistics has released I-O Table in 1971, 1975, 1980, 1985, 1990, 1995, 2000, 2005, and 2010. The I-O Table was released every 5 years according to the economic

[7]For example, in 2006, all firms lack data on fixed assets. Therefore, values from other periods are used to predict the missing value in 2006 using the estimated coefficients. More specifically, the values of total output, labour, materials, energy, and the residual in 2006 will be associated with the value of fixed assets in 2007, and so on.

structure and technology utilization of the economic sectors in that time. The I-O table is then merged and adjusted based on the 3 digits ISIC from the *SI* datasets. However, some subsectors are not classified elsewhere. In this regard, we merge this subsectors altogether, for instance Computers (262) & Accessories and Communication Equipment (263) are merged into Computers and Communication Equipments. Finally, we have 51 3-digits subsectors to analyzed.

We also use sectoral and regional datasets for instrumental variables. For sectoral datasets, we use tariff data from World Integrated Trade Solution (WITS) of World Bank in 2001-2015. The tariff data is taken from 3 digits subsector in manufacturing, specifically for Most-Favour Nation (MFN) with simple average. Meanwhile, for regional datasets, we use road density measured from the ratio of length of road (country, province, and regency, in kilometer) to the size of the province (in kilometer squared), as suggested by Rodríguez-Pose et al. (2013). However, the data of length of road is only available for 2008-2015, but the size is available for 2001-2015 with some minor interpolation. Hence, we use the data of 2008 for the length of road for the year of 2001-2007, assuming the lenght of road did not change before 2008, as suggested by Rodríguez-Pose et al. (2013).

3.2 Variables

This study employs some variables, which are classified into two types: production function variables and productivity determinants variables. Production function variables consist of value-added, total workers, raw materials (intermediate inputs), and total fixed assets, and are used to estimate total factor productivity (TFP). We also include total (gross) outputs as indicator to measure market share. Some variables are in monetary value, such as total outputs, capital, and raw materials. Hence, we deflate this variables using Wholesale Price Index in 2-digits ISIC with the year of 2000 as a based year.

The second type is the determinants of TFP, consisting of spillovers variable and control variables. The control variables are dummy of superstar firms, foreign-owned, and exporters. Dummy of superstar firms refer to whether a firm a superstar firm, based on the top 5% total outputs share within 3-digits subsectors. The dummy of foreign-owned refers to the capital-ownership of the firms. If a firm possess by at least 10% foreign ownership, it means

that the firm is foreign-owned or multinational. This cutoff is also employed by prior studies such as Sari et al. (2016) and Suyanto et al. (2009). The dummy variable for exporter refers to the condition whether a firm export their outputs [8]. Some ratio variables are also included namely imported intensity (the ratio of imported materials to the total materials) and market concentration from Herfindahl-Hirsman Index (HHI). We also include absorptive capacity, measured by the ratio of labour cost per workers.

3.2.1 Superstar Firms Definition

This study proposed an indicator of superstar firms, namely the share of total outputs produced (gross outputs) to be in the top 5% in the three-digit ISIC, according to the stylized facts that this cutoff shows remarkable market share domination by more than 76%. To ensure the invariant market share, we use the mode of the share within the period of firms observed. Furthermore, a firm should be in the market by more than 10 years. Moreover, some firms may not consistently appear in the top 5% of the output share throughout the entire period of observation. For example, a firm that is observed from 2001 to 2005 may only be in the top 5% in 2001 and 2002. In such cases, we define a firm as a superstar if it belongs to the top 5% in more than 90% of the years during which it is observed[9].

The definition of superstar firms in this study shall not use arbitrary number as in Autor et al. (2020), capture too many firms as in Amiti et al. (2024), or capture too strict number of firms as in Rowley (2024)[10]. The criteria for identifying superstar firms from our definition, with 1% and 5% cutoff, are deliberately stringent, resulting a very limited selection of firms. Although the stricter approach ensures that the selected firms genuinely represent "superstar" firms, rather than merely "star" firms, the dynamic of entry and exit superstar firms with too strict cut-off, such as 1%, might be extremely limited. Hence, the cutoff of 5% is then used for further analysis.

[8] In the *SI*, there is an information for the degree to which firm exports their outputs, but this information has high missing value and is not available for entire years of 2001-2015.

[9] Our findings are not sensitive toward lower thresholds such as 75%.

[10] For the description of the number of superstar firms, we selected the top 5% of all firms without distinguishing subsectors. However, in the correlation analysis, we selected the top 5% from each subsector to ensure sufficient observation from a dynamic perspective, i.e. survivor-entry-exit. Consequently, the number of firms in the table remains as stated, but in the inferential analysis, the total number is necessarily higher

3.2.2 Superstar Spillovers and Its Economic Intuition

There is a strand of literature discussing how the process of superior firms create externalities for non-superior firms. Prior study from Javorcik (2004) introduced the spillover process from superior foreign-owned firms, while more recent one, such as Amiti et al. (2024), introduced spillovers from superstar firms. In general, the process through which spillovers occurred from superior firms (either superstar firms or multinational firms) are alike, namely how non-superior firms attempt to mimic them through various channels. The only difference of this mechanism is that superstar spillovers is not bounded to foreign-owned, as in FDI spillovers, but domestic firms can general spillovers as well, suggested by Amiti et al. (2024). In the context of superstar and non-superstar firms, spillovers occurs when presence of superstar firms increases productivity of non-superstar firms. Inward superstar firms may stimulate non-superstar firms by producing more efficiently.

In this study, we examine three types of superstar spillovers. The first one is Horizontal Spillovers capturing the degree to which superstar firms dominate the market, shown by the share of outputs produced within the three-digits ISIC, province, and year.

$$HSpill_{kjt} = \frac{\sum_{i \in k \in j} DProvi_j \times DSubsector_k \times DSuperstar_{it} \times Outputs_{it}}{\sum_{i \in k \in j} Outputs_{it}} \tag{13}$$

Where $HSpill_{kjt}$ denotes Horizontal Spillovers of three-digits ISIC subsector k in province j in year t, $DProvi_j$ denotes dummy of province j, $DSubsector_k$ denotes dummy of subsector k, $DSuperstar_{it}$ denotes dummy of superstar firms, $Outputs_{it}$ is the total outputs produced of firm i in year t. The numerator in Equation 13 captures the total outputs produced by superstar firms located in province j and operating in subsector k during year t. The dummy variables $DProvi_j$, $DSubsector_k$. and $DSuperstar_{it}$ ensure that only outputs from superstar firms in the specified province and subsector are counted. This values represents the production dominance of superstar firms within that local market. The denominator is the total outputs of all firms, both superstar and non-superstar, in the same province and subsector, providing benchmark againts which the superstar share is measured. A higher $HSpill$ means that superstar firms are more dominants in that local markets.

There are several economic intuition following the proxy of horizontal spillovers, as for-

malized by Orlic et al. (2018), namely demonstration, labour migration, and competition channels. Demonstration channel takes place through observation and mimicking by which non-superstar firms aimed to copy technology or production managements from superstar firms. In the case of superstar firm operates in similar subsector with non-superstar firms, competition might occur and prevent technology leakage and spillovers, such as by protecting intellectual property, known as rivalry effects Javorcik (2004). In this sense, $HSpill$ captures the demonstration channel of the productivity spillovers.

Other channels are labour mobility and competition. Sari et al. (2016) and Orlic et al. (2018) addressed the mechanism occurred between foreign-owned and domestic firms, while it is similar with superstar and non-superstar firms nexus. Labour mobility occurred when non-superstar firms hire workers migrating from superstar firms. High intensity of training and education for workers in terms of advanced technology from superstar firms will benefit non-superstar firms if the worker migrate, as workers who migrate have been familiar with sophisticated technology and possibly to implement it in the non-superstar firms. Meanwhile, the channel of competition occurred when the presence of superstar firms stimulate non-superstar firms to compete to be more efficient. Otherwise, inefficient firms may exit from the markets, known as crowding-out effects, as suggested by heterogeneous firm model from Melitz (2003) and Melitz and Ottaviano (2008)[11].

Another economic intuition of Horizontal Spillovers is that superstar spillovers capture the degree to which superstar firms create externalities for non-superstar firms. The mechanism works under the mechanism of Cournot model, as in Shen et al. (2021), where in the beginning superstar firms dominate market share, non-superstar firms then can react by adjusting costs more efficiently. Some non-superstar firms may be failed to adjust, imposing them to exit from the markets (crowding-out effects). However, as in Melitz (2003), some firms may be only able to produce for domestic markets if they are efficient enough, while other non-superstar firms with higher efficiency can serve for export markets. In this regard, we capture the degree to which superstar firms dominate markets from the share of outputs produced of superstar firms in certain subsector and province. This proxy is suitable as higher share

[11] Orlic et al. (2018) design the channels of labour and competition by interacting $HSpill$ with labour cost per workers and market concentration, respectively.

of outputs produced of superstar firms in a subsector and a province implies that superstar firms dominate market and are possible to impose high markup (Aghion and Howitt, 2023).

The second type of spillover is Backward Linkage Vertical Spillovers (who are firms purchasing from), capturing to which degree a firm in a subsector supplies intermediate inputs for superstar firms. In this case, superstar firms are in the downstream sector while non-superstar firms are in the upstream sector.

$$BSpill_{kjt} = \sum_{k} b_{kl} \times HSpill_{kjt} \tag{14}$$

where $BSpill_{kjt}$ denotes backward linkage (who are firms buying from), b_{kl} denotes the input–output matrix coefficient from Input-Output Table of Indonesia in 2010, that captures the amount of intermediate output used from industry l to produce one unit of output in the downstream industry k. The value of $BSpill_{kjt}$ measures to a certain degree derived demand from superstar firms in subsector k for subsector l. A higher value of $BSpill_{kjt}$ captures a higher demand of intermediate inputs from superstar firms in subsector k to the subsectors in the upstream industry, regardless it is superstar or non-superstar firms.

The economic intuition of the Backward spillovers strategy is that when superstar firms operate in different subsector with non-superstar firms, they may let spillovers to take place as it will benefit them through backward linkage (Amiti et al., 2024). If technology diffusion occurred from superstar firms in the downstream sectors to the non-superstar firms in the upstream sectors, superstar firms will obtain better quality of intermediate inputs, while non-superstar firms in the upstream will also upgrade their efficiency and productivity due to stringent standard for being superstar firm's suppliers and demand security (Amiti et al., 2024). Some superstar firms even provide mentoring to their suppliers to ensure that the required standards are met. This mentoring serves as a mechanism through which technology and knowledge diffusion can occur different subsectors (downstream vs upstream sectors).

The third spillover is The Forward Linkage Vertical Spillovers (who are firms selling to), depicting to which degree non-superstar firms purchasing intermediate inputs from superstar firms.

$$FSpill_{kjt} = \sum_{k} b_{km} \times HSpill_{kjt} \tag{15}$$

where $FSpill_{kjt}$ denotes forward linkage (who are firms selling to). b_{km} denotes the input–output matrix coefficient that captures the amount of intermediate output sold for industry m from upstream industry k. A higher degree of $FSpill_{kjt}$ implies a higher intermediate inputs of superstar firms in the subsector k sold for subsectors m in the downstream. The economic intuition of this strategy is that non-superstar firms may also benefit from purchasing intermediate inputs from superstar firms, as they gain access to higher-quality and more efficient inputs– representing a forward linkage. Additionally, superstar firms may offer supplementary services that would not be available if non-superstar firms were to import intermediate inputs instead, as suggested by Javorcik (2004) for multinational companies evidence. Moreover, the ability of non-superstar firms to import may limited, making it more advantageous for them to source inputs from domestic firms.

3.2.3 Total Factor Productivity

The variable of Total Factor Productivity (TFP) is the part of the production function. Total production may consist not only proportional input utilization, but also to which degree firm benefit from TFP. Seminal paper of Olley and Pakes (1996) introduced more robust estimates for productivity coming from unobserved shocks in the production function[12]. Meanwhile, Levinsohn and Petrin (2003) introduced the alternative for proxy variable. Rather than using investments that are prone to costly adjustment, Levinsohn and Petrin (2003) used intermediate inputs as the proxy for productivity shocks. The strategy is similar with Olley and Pakes (1996), namely by providing that there strictly increasing association between intermediate inputs and productivity, implying that more productive firms allocate more intermediate inputs for production[13]. This monotonicity assumption is then used to invert the productivity equation and show consistent parameters. The log of outputs as a function

[12]The mechanism of the Olley and Pakes (1996)'s TFP calculation is explained in the Appendix
[13]See empirical studies such as Olper et al. (2017) for imported inputs

of the log of inputs and the shocks in the standard Cobb-Douglas production function can be arranged as follows:

$$y_{it} = \beta_l l_{it} + \beta_k k_{it} + \beta_r r_{it} + \varphi_{it} + \varepsilon_{it} \tag{16}$$

where $k_i t$ is capital proximate from fixed-assets such as building, land, and other equipments. r_{it} denotes raw materials, φ_{it} denotes total factor productivity. Compared to Olley and Pakes (1996) who used investment as a shock of productivity, there is less drawbacks when we use raw materials for the context of Indonesia. As suggested by Rovigatti and Mollisi (2018), data for investments may be largely omitted. Evidently, this is also relevant for our data where the data of 2006 for capital is not available. Meanwhile, raw material is relevant under monotonicity assumption which imposes higher materials associates to higher productivity for all relevant capital Levinsohn and Petrin (2003).

In the first stage, we estimate equation 16 using Levinsohn and Petrin (2003)'s strategy to obtain expected value of outputs ($\hat{y}_{it}$) and estimate for ε_{it}, which is arranged as:

$$\hat{y}_{it} = \beta_k k_{it} + \beta_l l_{it} + \varphi_t(m_{it}, k_{it}, z_{it}) \tag{17}$$

Where z_{it} is exogenous control variables affecting φ_{it}. Then we can calculate TFP (φ_{it}) by subtracting $\hat{y}_{it}$ with all components in the right side of equation 17, as follows:

$$\varphi_{it} = \hat{y}_{it} - \beta_k k_{it} - \beta_l l_{it} \tag{18}$$

where φ_{it} Total Factor Productivity of firm i in time t in the logged-form. Other studies demonstrates the law of motion to capture the effect of prior period's productivity and some incorporate control variables in affecting current value of φ_{it}, i.e. $\varphi_{it} = g(\varphi_{it-1}, z_{it-1}) + \xi_{it}$ (Bournakis and Tsionas (2022), Ackerberg et al. (2015)).

In this study, we do not impose any control variables, such as z_{it} in TFP estimates. It is because we estimate the production function to calculate TFP in each three-digit subsector

separately as in Amiti and Konings (2007). It is not possible to disaggregated subsector into more specific digits, such as 4 to 5, as it may cause unreliable statistical outcomes. Moreover, some firms have no three digits classification due to the limited plants in the province where the firm is located, requiring BPS-Statistics to use a more general sectoral classification. In this case, we group the subsectors into "Others" based on each two digits with relatively similar technology. The descriptive statistics is of above-mentioned variables are reported in Table 1.

Table 1: Descriptive Statistics

Variables	Measurement	N	Mean	Standard Deviation
Gross Outputs (Constant, Million Rupiah)	Ratio	349,829	88619.23	919917.70
Value-Added (Constant, Million Rupiah)	Ratio	349,832	39955.99	548353.00
Fixed Assets (Constant, Million Rupiah)	Ratio	305,893	313266.20	66600000.00
Materials (Constant, Million Rupiah)	Ratio	349,832	47781.34	519040.40
Workers	Workers	349,834	195.43	740.02
TFP - LP 3 Digits	Ratio	230,526	13.21	1.94
TFP - LP 2 Digits	Ratio	230,526	13.16	1.74
TFP - ACF 3 Digits	Ratio	145,302	6.61	4.80
Dummy Superstar	Dummy	349,834	0.03	0.18
Dummy Foreign-Owned	Dummy	349,834	0.09	0.29
Imported Material Intensity	Dummy	334,421	0.09	0.24
Dummy Exporters	Dummy	349,834	0.12	0.32
Absorptive Capacity (Log)	Ratio	349,810	16.19	1.13
Market Concentration (HHI)	Ratio	349,834	0.06	0.08
Tariff MFN	Ratio	349,834	9.11	7.33
Road Density (Within-Province)	Ratio	349,711	0.95	1.49
Road Density (Neighboring-Province)	Ratio	349,762	1.28	1.00

Note: Some variables, such as Tariff and Road Density are explained in the Empirical Strategy section.

3.3 Empirical Strategy

3.3.1 The Nexus of Superstar Spillovers and Total Factor Productivity

In this study, after we estimate TFP from the first and second stage using Levinsohn and Petrin (2003) strategy, we then arrange the empirical specification for superstar firms on the TFP. We look at the association between share of superstar firms within subsector and province (horizontal spillovers) and across subsector (vertical spillovers), shown by the total outputs share of superstar firms within 3-digits ISIC. We test all these spillovers on the TFP for both level (φ) and growth ($\Delta\varphi$) and arrange the equations as follows:

$$\varphi_{it} = \beta_0 + \beta_{Spill} Spill_{kjt} + \beta_Z Z_{it} + \varepsilon_{it} \tag{19}$$

$$\Delta\varphi_{it} = \beta_0 + \beta_{Spill} Spill_{kjt} + \beta_Z Z_{it} + \varepsilon_{it} \tag{20}$$

where φ_{it} denotes Total Factor Productivity (TFP) from Levinsohn and Petrin (2003) in log-form, while $\Delta\varphi_{it}$ is the TFP growth for which the TFP level in each time t is compared to the initial period $t1$ $(\varphi_{i,t} - \varphi_{i,t1})$, $Spill_{kt}$ is spillover variables consisting of $HSpill$, $BSpill$, and $FSpill$. We split these three types of spillovers to capture average treatment effects (ATE) from each exogenous instruments.

Intuitively, how horizontal ($HSpill$) and vertical ($BSpill$ and $FSpill$) spillovers correlate with TFP occurs consists of two mechanism. First, a higher spillovers associating to a higher TFP for all firms (superstar and non-superstar) indicates an overall positive correlation between superstar firm's exposure to the productivity development. If $\beta_{Spill} > 0$, an increase of superstar firm's share within the subsector and province associates to increase of firm's productivity in general. This hypothesis may work under the mechanism of demonstration, labour migration, and market competition (Orlic et al., 2018). The second mechanism is by isolating the pure effects solely for non-superstar firms. The extent to which superstar firms in certain subsector and province create spillovers should address its association only for non-superstar firms. The positive magnitude of β_{Spill} from the first mechanism might overstate the true correlation magnitude as it shows both superstar and non-superstar inter-linkage. In this regard, we limit the nexus of spillovers and TFP only for non-superstar firms[14].

The notation of Z_{it} denotes the set of firm heterogeneous control variables namely dummy of foreign-owned, and exporter, as well as import intensity, market concentration from Herfindahl-Hirschman Index (HHI), and absorptive capacity. This set of dummy variables is

[14]This strategy has been implemented by prior studies such as Suyanto et al. (2009) and Yasin and Esquivias (2023).

essential to control any statistical difference associating firm's TFP level and growth. The dummy for foreign-owned (FOR) aimed to capture whether statistical difference between foreign firms and domestic firms matters in determining TFP. Prior studies argued that foreign firms perform better than domestic firms as they remain affiliated to their parents company, which thus bring them closer to the technology frontier Agovino et al. (2018). Ignoring the difference between these two groups may also cause coefficient biases. Another control is the dummy for exporter. A theoretical argument from Melitz (2003) postulated that exporter firms are more productive than non-exporter as they should face stringent standard on global demand. It impose them to learn to gain this standard, known as learning-by-exporting Loecker (2013). Meanwhile, the (sunk) fixed entry cost for which firms need to pay might lead them to work more optimally to compensate it, otherwise they may exit from the market with no profits. In other words, only firms who are more productive who can afford for this cost in the beginning, known as self-selection hypothesis (Haidar, 2012).

The degree of import intensity captured the extent to which firm import their raw materials. There are several mechanism how imported intensity may associate to better TFP. First, a higher imported intensity may enable firms to impose high quality of production in their operational, known as learning-by-importing as suggested by Vogel and Wagner (2010). Moreover, like exporting activity, importing activity is also associated with fixed sunk cost for searching process of potential foreign suppliers, negotiation, and contract formulation, which thus merely more productive firms that are able to import (Melitz (2003), Andersson et al. (2008)).

Market concentration is also essential to capture competition in the industry. Market concentration is essential to control whether more concentrated subsector is more productive. Likewise, market concentration can also capture to which degree market competition occurs (Amiti and Konings, 2007). If the structure of subsector's market is weak oligopoly and less concentrated, the competition will be more intense (Funakoshi and Motohashi, 2009). In this case, less productive firms will exit from the markets. This control variable also matters in avoiding bias of spillover effects occurred from superstar firms to non-superstar firms as it controls whether non-superstar firms will actively react or not towards the action from superstar firms by dominating share of outputs produced.

The last control variable is absorptive capacity, measured from labour cost per workers. Liu (2008) postulated that the spillover process does not occur automatically as the firm-specific's ability level matter in absorption external knowledge within the market from the process of spillovers. Prior studies also incorporate this proxy for absorptive capacity, such as Sari et al. (2016), under the assumption that higher labour cost per workers means that firm employed more skilled workers as they spent more on miscellaneous labour needs such as salary, bonus, and insurance for their workers. When a firm allocates more skilled workers, as suggested by Cohen et al. (1990), their absorptive capacity will be better as they can absorb, identify, examine, and digest new knowledge from external environment, which in turn boost their productivity.

We estimate equation 19 and 20 using two-stage least squared (2SLS) with fixed-effects in the industry, region, island, and year. All results are estimated using robust-standard errors and clustered in the firm level. Moreover, we also test the superstar firm's heterogeneity, i.e. foreign-owned and domestic superstars. Some interaction term between spillovers and firm heterogeneity in control variables are also examined for robustness test.

The estimation of each spillovers is conducted separately due to the measurements of Backward and Forward Spillovers that also stem from Horizontal Spillovers. Theoretically, spillover processes can be interpreted from multiple perspectives, two of the most commonly studied being horizontal (within-sector and within-province) and vertical (across sectors) spillovers. Each of these spillover channels is associated with distinct mechanisms and thus relies on its own set of instrumental variables. To ensure clarity in identifying the effects of each spillover type, and given that vertical spillovers are mechanically constructed as deterministic functions of horizontal spillovers (as shown in Equation 14 and 15), which may induce multicollinearity, a separate strategy is more appropriate. This approach offers a more transparent interpretation of each channel's effect and avoids potential identification issues arising from their structural correlation.

3.3.2 Potential Endogeneity

Prior studies on FDI spillovers have treated spillovers indicators as exogenous, typically by measuring the share of superior firms within a sub-sector (see Sari et al. (2016), Spithoven

and Merlevede (2023) and Bournakis (2021)). Intuitively, the share of superstar firms located in a province may also be determined by sectoral and regional specific factors, such as import tariff, national shocks, and regional infrastructure. As a result, it may lead to a misleading interpretation of the true effects of productivity spillovers (Bournakis and Tsionas, 2022).

While prior studies on FDI Spillovers do not address endogeneity concerns, we aim to construct a proxy for endogenous superstar firm presence. We identify several potential endogeneity for using share of superstar as a spillover proxy. First, a higher share of superstar firm in subsector k in province j may be associated with higher productivity, suggesting that spillovers occur from superstar to non-superstar firms. However, it is also possible that superstar firms increase their share in response to productivity improvements among non-superstar firms, raising concerns about reverse causality. Moreover, the decision of firms to expand their production in certain province may also be determined by sectoral-specific dynamics in the national level as well as province-specific characteristics.

Another potential endogeneity is the selection bias. We aim to capture the effect of horizontal and vertical spillovers from superstar firms specifically on the non-superstar firms. Meanwhile, for being superstar firms, there is potential selection criteria which may cause selection bias if we directly isolate non-superstar firms on the sample. However, evidently, in our datasets, more than 92% of superstar firms have existed since the beginning of the period. It implies the dominant pre-determined non-superstar samples. However, we still use inverse probability weighting (IPW) as robustness to check whether the selection issue occurred if we only include non-superstar firms in the estimation. IPW approach can reduce bias due to self-selection by eliminating the correlation between observed/unobserved factors and non-superstar firms (Petersen et al., 2024)[15].

In addition to applying standard approach like fixed-effects, which already mitigate potential endogeneity bias (Amiti and Konings, 2007), we implement an alternative estimation using instrumental variables (IV). It is well-known that selecting instrumental variables are difficult, notably the mechanism for which spillovers in our proxy has different dimensions. Hence, we refer to prior studies of spillovers such as Du et al. (2014) and Xu and Sheng

[15]Another way to tackle selection problem is by using Heckman selection criteria (Heckman (1976) and Heckman (1979)) to determine whether a firm is non-superstar. However, Heckman selection does not accommodate other endogeneity problem such as reverse causality between spillovers and productivity.

(2012) in selecting the instrumental variables. In our design, the instrumental variables should correlate with spillovers but not directly with non-superstar TFP level and growth. Most importantly, the IV should not correlate with errors terms from the second stage. Some prior studies on spillovers solely use the lag of endogeneous spillovers under the assumption that delayed reaction of productivity from non-superstar firms (see Njikam and Leudjou (2019) and Barrios et al. (2011)). However, the lagged of endogeneous spillovers may not be a strong instrument if there is persistent dynamic error process, causing sample bias and imprecision (Blundell and Bond, 1998).

3.3.3 Bartik Instruments: Output Growth and Tariff

In construction our instrumental variables, we apply Bartik instrument, known as Shift-Share IV, originally introduced by Bartik (1991), popularized by Blanchard et al. (1992), and formally evaluated by Goldsmith-Pinkham et al. (2020) and Borusyak et al. (2025). The design of our Bartik-IV is different across spillover dimensions. First, we design Bartik-IV from labour-based and Output Growth for Horizontal Spillovers ($HSpill$). As suggested by Amiti and Konings (2007), we construct the instrument using the initial share of unskilled-worker of superstar firms of subsector k in province j in the baseline year, 2001, combined with the subsequent national output growth of sector k, excluding the related province, as follows.

$$LabSh^{S}_{jk,2001} = \frac{\sum_{k\in\mathcal{K}} Unskilled^{S}_{jk,2001}}{\sum_{k\in\mathcal{K}} Unskilled_{jk,2001}} \tag{21}$$

$$G^{-j}_{kt} = \frac{\sum_{m\in\mathcal{M}\setminus j} Y_{m,k,t} - \sum_{m\in\mathcal{M}\setminus j} Y_{m,k,t-1}}{\sum_{m\in\mathcal{M}\setminus j} Y_{m,k,t-1}} \tag{22}$$

$$LabBartikIV^{S}_{kt} = \sum_{k\in\mathcal{K}} LabSh^{S}_{j,k,t=2001} \times G^{-j}_{kt} \tag{23}$$

where $LabSh^{S}_{j,k,2001}$ is the share of superstar firms' unskilled workers in province j from subsector (3-digits) k in 2001, G^{-j}_{kt} denotes the growth of outputs of subsector k in national level excluded subsector k in province j, so $m \in \mathcal{M}$ denotes national level excluding related subsector and province. $LabBartikIV^{S}_{kt}$ is the exogeneous Bartik Instrument, an instrument for $HSpill$. We follow a shift-share approach that endogenizes spillovers variation while also ensuring the exogeneity of the instrument–a key requirements for instrumental variable validity. Specifically, we implement a *leave-one-out* strategy (Goldsmith-Pinkham et al., 2020), whereby the 3-digit subsector in province j of interest is excluded when aggregating sectoral growth at the national level.

The economic intuition of this Bartik-IV is to capture how the initial superstar share in province j and subsector k determines the extent to which the production expansion of superstar firms from subsector k in a given provinces is influenced by the initial share of unskilled labour employed by these superstar firms[16]. The use of unskilled workers as a component of the $LabBartikIV$ share is intended to capture how the proportion of workers directly involved in production activities can determine whether a superstar firm will choose to expand or not, given a sector-specific shock at the national level. If subsector k experiences a shock in the form of high national-level growth, which is exogenous to firms in subsector k located in provinces j, then subsector k in province j with a high initial share of unskilled workers, becomes a target for expansion by these superstar firms. This expansion will lead to an increase in the superstar firms' output share, which is captured by the proxy for Horizontal Spillovers. As suggested by Trefler (2004) and Amiti and Konings (2007), unskilled workers influence the propensity of an industry to become organized. In other words, the extent to which subsector k in province j is organized by superstar firms, through efforts to dominate market share, is determined by the initial condition of unskilled labour in that province and subsector. For robustness test, we construct this labour-based $LabBartikIV$ using both skilled and unskilled workers.

We design another Bartik-IV using the share of superstar from outputs-based (gross

[16]In the Indonesian manufacturing data, unskilled workers are assumed as workers for production activities, while unskilled workers are for non-production activities. These arguments are assumed by Amiti and Cameron (2012) and Matsuura and Saito (2023) under the evidence that in 2006 data, about 10% of non-production workers are university-graduate, and 63% are high-school graduates. Meanwhile, 1% production workers have graduated from university, and 42% have completed high school.

outputs) as the share component and the change of tariff (Most Favored Nation, MFN) for vertical spillovers (backward and forward). Although prior studies that have found significant effect of tariff of firm's productivity (Amiti and Konings (2007), Gupta (2023), Zhang et al. (2021)), our model rather argues that there is a strong potential for superstar firms to be more affected by tariff shocks at the subsector level. To ensure this assumption, rather than using tariff level as direct IV, we design Bartik-IV with tariff change as the shift component and the initial share of superstar as the weight components.

$$OutSh^{S}_{jk,2001} = \frac{\sum_{k\in\mathcal{K}} Y^{S}_{jk,2001}}{\sum_{k\in\mathcal{K}} Y_{jk,2001}} \tag{24}$$

$$\Delta Tariff_{k,t} = Tariff_{k,t} - Tariff_{k,t-1} \tag{25}$$

$$TarrBartikIV^{S}_{kt} = \sum_{k\in\mathcal{K}} OutSh^{S}_{j,k,t=2001} \times \Delta Tariff_{k,t} \tag{26}$$

where $OutSh^{S}_{j,k,2001}$ is the share of superstar firms outputs in province j from subsector (3-digits) k in 2001, $TarrBartikIV^{S}_{kt}$ denotes the change of tariff of subsector k in national level. $TarrBartikIV^{S}_{kt}$ is the exogeneous Bartik Instrument, an instrument for $BSpill$ and $FSpill$.

The intuition of $TarrBartikIV^{S}_{kt}$ as the IV for $BSpill$ and $FSpill$ is that the level of share of superstar firms in the initial period may subject to the decision of firms to purchase from the upstream sectors or selling to downstream sectors. When the superstar share is small and tariff decreases (tariff change is negative), superstar firms may enhance the connection with their suppliers in the upstream sectors and purchasers in the downstream sectors. When a superstar firm decides to expand its production, the change of import tariffs on intermediate inputs becomes a key determinant of whether the firm will proceed with such expansion and further increase its market connection. As superstar firms are typically more internationally

exposed compared to non-superstar firms, for example through larger import activities, a higher import tariff may be discouraged superstar firms from expanding, leading to a decline in their output and supply-chain domestic market networks.

In this framework, tariffs are hypothesized to be negatively associated with the market of superstar firms. This mechanism, in turn, has implication for the productivity dynamics of non-superstar firms. Specifically, if tariffs are high and rising, leading to a reduction in superstar firms' market share, and if negative spillovers from superstar firms present, then the productivity of non-superstar firms may improve, conditional on their import intensity (which is therefore controlled for in our empirical specification). Conversely, if tariffs decline and negative spillovers persist, superstar firms may further dominate the market, potentially suppressing the productivity of non-superstar firms within the same sector and province through the rivalry and market-stealing phenomenon. In the empirical study, for instance, Du et al. (2014) found that tariffs affect the magnitude and direction of spillovers. Specifically, they revealed that tariffs changes following China's accession to the World Trade Organization (WTO) strengthened FDI spillovers, particularly backward spillovers[17].

For robustness test, we use Road Density for the IV of $BSpill$ and $FSpill$. Road Density is measured from the total length of country, province, and regency divided by the province size (in kilometer squared). Prior study of Rodríguez-Pose et al. (2013) examined the effect of road density on the firm decision to firm's decision to export. It implies that road density can influence not only whether superstar firms choose to locate in a particular province, but also the extent of their market share within that province. We use road density as the robustness rather than the main IV due to the fact that road density merely capture province variation. Meanwhile, $TarrBartikIV$ captures both sectoral and provincial variation.

3.3.4 The Dynamic Olley-Pakes Decomposition

In addition to investigating superstar spillovers, we also aim to capture the dynamic of superstar firms productivity in overall. The idea is that whether productivity changes solely stems from within firm productivity improvements, or also are supported by entry-exit behaviour

[17]Some studies have also used tariff as instrumental variables, such as Pane and Patunru (2023) and Tsionas and Kumbhakar (2023).

of the firms. In this regard, we refer to the notion of Dynamic Olley-Pakes Decomposition (DOPD) that was introduced by several papers such as Baily et al. (1992), Griliches and Regev (1995), and Foster et al. (2001). The latest decomposition was proposed in Melitz and Polanec (2015) by elaborating firms entry and exit behaviour into the model of Olley-Pakes Decomposition from Olley and Pakes (1996) and Collard-Wexler and De Loecker (2015) decomposing TFP based on technology group. The decomposition notion was proposed in the mechanism by which firms are heterogeneous and thus contribute to its aggregate productivity growth in different extent (Karagiannis and Paleologou, 2018). In this study, we employ such decomposition in the application of superstar and non-superstar groups. We first look at the standard Olley-Pakes Decomposition (henceforth OP Decomposition) arranged as follows:

$$\begin{aligned}\Phi_t &= \bar{\varphi}_t + \sum_i (Sh_{it} - \bar{Sh}_t)(\varphi_{it} - \bar{\varphi}_t) \\ &= \bar{\varphi}_t + cov(s_{it}, \varphi_{it})\end{aligned} \tag{27}$$

where $\bar{\varphi}_t$ denotes unweighted firm productivity mean ($\bar{\varphi}_t = \frac{1}{n}\sum_{i=1}^{n} \varphi_{it}$) and $\bar{Sh}_t$ is the mean of market share ($\bar{Sh}_t = \frac{1}{n}\sum_{i=1}^{n} Sh_{it}$). The level of productivity growth over time ($\Delta\Phi$) is obtained by looking at the change of unweighted firm productivity mean ($\Delta\varphi_t$) and the change of covariance ($\Delta cov(s_{it}, \varphi_{it})$). The component of $\Delta\varphi_t$ captures the shifts in the productivity distribution, showing that firm's productivity improve over time. Meanwhile, the component of $\Delta cov(s_{it}, \varphi_{it})$ captures the process through which more dominant firms, shown from higher market share, are more productive, which thus contribute to their aggregate productivity. We prove this assumption in the Results section that market share is positively correlated with productivity.

The same decomposition can also be applied by different group, as introduced by Collard-Wexler and De Loecker (2015) for technology group evidence in US. In this case, we apply for the group of superstar (S) and non-superstar (NS) firms, noted by group ψ. This strategy enables the changes of productivity between superstar and non-superstar firms (within-firms) and substantial reallocation across firms to get captured. In this regard, we may note the market share of each group ψ denoted by $Sh_t(\psi) = \Sigma_{i\in\psi} Sh_{it}$. Hence, we may denote group-

specific aggregate productivity as $\Phi_t(\psi)$. while $\bar{\varphi}_t(\psi)$ as the average productivity within group ψ. By referring to the OP Decomposition, we may obtain static decomposition for within superstar-nonsuperstar as follows:

DEFINITION 1: *The Static Olley-Pakes Decomposition*

$$\begin{aligned}
\Phi_t &= \sum_{\psi \in S,NS} Sh_t(\psi)\Big(\bar{\varphi}_t(\psi) + cov_t(\psi)\Big) \\
&= \sum_{\psi \in S,NS} Sh_t(\psi)\Big(\bar{\varphi}_t(\psi) + \sum_i (Sh_{it}(\psi) - \bar{Sh}_t(\psi))(\varphi_{it}(\psi) - \bar{\varphi}_t(\psi))\Big) \\
&= Sh_t(\psi = S)\Bigg\{\bar{\varphi}_t(\psi = S) + \sum_{i \in \psi = S} [Sh_{it}(\psi = S) - \bar{Sh}_t(\psi = S)][\varphi_{it}(\psi = S) - \bar{\varphi}_t(\psi = S)]\Bigg\} + \\
&Sh_t(\psi = NS)\Bigg\{\bar{\varphi}_t(\psi = NS) + \sum_{i \in \psi = NS} [Sh_{it}(\psi = NS) - \bar{Sh}_t(\psi = NS)][\varphi_{it}(\psi = NS) - \bar{\varphi}_t(\psi = NS)]\Bigg\}
\end{aligned} \tag{28}$$

The concept of decomposition in equation 27 was also extended by Melitz and Polanec (2015) by incorporating entry and exit firms behaviuour (henceforth MP Decomposition). The standard form of MP Decomposition from Melitz and Polanec (2015) is as follows:

DEFINITION 2: *Dynamic Olley-Pakes Decomposition*

$$\Phi_1 = Sh_{Sur_1}\Phi_{Sur_1} + Sh_{Ex_1}\Phi_{Ex_1} = \Phi_{Sur_1} + Sh_{Ex_1}(\Phi_{Ex_1} - \Phi_{Sur_1}) \tag{29}$$

$$\Phi_2 = Sh_{Sur_2}\Phi_{Sur_2} + Sh_{En_2}\Phi_{En_2} = \Phi_{Sur_2} + Sh_{En_2}(\Phi_{En_2} - \Phi_{Sur_2}) \tag{30}$$

where $Sh_{G_t} = \Sigma_{i \in G} Sh_{it}$ represents the aggregate market share of a group G of firms and we define $\Phi_{Gt} = \Sigma_{i \in G}(Sh_{it}/Sh_{Gt})\varphi_{it}$ as that group's aggregate (average) productivity. The

group of Sur, Ex, and En denotes for Survivors, Exiters, and Entrants. Survivors refer to firms exist in both $t = 1$ and $t = 2$. For instance, in terms of $t_1 = 2001$ compared with $t_2 = 2002$, a firm is survivor if it exists in 2001 and 2002. When we compare non-respective behaviour, such as 2001 and 2003, a firm is called Survivor of 2003 if it exists in 2001, 2002, and 2003. If it does not exist in 2002, we exclude this firm as Survivor in 2003. Instead, we may capture this type of firm as Exiters in 2002. Meanwhile, Exiter firm is if a firm exist in $t = 1$ but does not exist in $t = 2$, while it is Entrant if the firm exist in $t = 2$ but does not exist in $t = 1$. In this regard, we may obtain equation identity based on the share for two period as $Sh_{Sur_1} + Sh_{Ex_1} = Sh_{Sur_2} + Sh_{En_2} = 1$. From equation (8) and (9), we can find the growth rate as follows:

$$\begin{aligned}
\Delta\Phi &= \Phi_{Sur_2} - \Phi_{Sur_1} + Sh_{En_2}(\Phi_{En_2} - \Phi_{Sur_2}) + Sh_{Ex_1}(\Phi_{Sur_1} - \Phi_{Ex_1}) \\
&= \underbrace{\underbrace{\underbrace{\Delta\varphi_{Sur}}_{\text{plant improvements}} + \underbrace{\Delta cov_{Sur}}_{\text{within reallocation}}}_{Survivors} + \underbrace{\underbrace{Sh_{En_2}(\varphi_{En_2} - \varphi_{Sur_2})}_{\text{plant improvements}} + \underbrace{Sh_{En_2}(cov_{En_2} - cov_{Sur_2})}_{\text{between reallocation}}}_{Entrants} +}_{} \\
&\qquad \underbrace{\underbrace{Sh_{Ex_1}(\varphi_{Sur_1} - \varphi_{Ex_1})}_{\text{plant improvements}} + \underbrace{Sh_{Ex_1}(cov_{Sur_1} - cov_{Ex_1})}_{\text{between reallocation}}}_{Exiters}
\end{aligned} \tag{31}$$

The component of $\Phi_{Sur_2} - \Phi_{Sur_1}$ shows the contribution of survivor firms consisting of productivity improvement from its own and market share reallocation. Meanwhile, the component of $Sh_{En_2}(\Phi_{En_2} - \Phi_{Sur_2})$ shows the contribution of entering firms, and $Sh_{Ex_1}(\Phi_{Sur_1} - \Phi_{Ex_1})$ captures the exiting firm dynamics.

4 Results

4.1 Stylized Facts

We first report the stylized facts of superstar firms in Indonesia by presenting Total Factor Productivity (TFP) level and growth estimation over time and across firm's characteristics. According to Figure 7, TFP level of superstar firms is relatively higher than non-superstar

firms, implying that superstar firms as the market leader within the sector operate production more efficiently than non-superstar firms. However, the TFP level trend for non-superstar firms converges into the level of superstar firms after the year of 2008. Meanwhile, TFP growth, measured by the change of TFP level relative to the year of 2001, shows conversely. The growth of non-superstars' TFP since 2002 are tight with superstar firms, but they outweigh superstar firms in 2010, implying that non-superstar firms' productivity grow faster since this year [18].

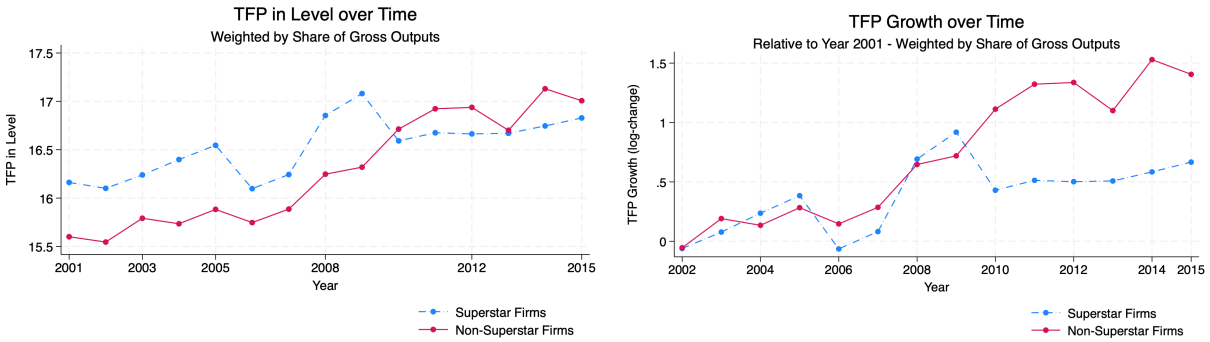


Figure 7: TFP Level and Growth over Time

We also report the distribution of superstar firms on average from 2001 to 2015, in Figure 8. According to Figure 8, on average during 2001 to 2015, Java island dominates the number of superstar firm presence, notably West Java which possesses more than 100 superstar firms from various subsectors. Meanwhile, provinces outside Java with large number of superstar is dominated from Sumatera and Kalimantan.

[18] This evidence also shows the catching-up behaviour of less productive firms towards more productive firms, as postulated by development studies such as Barro and Sala-i Martin (1992).

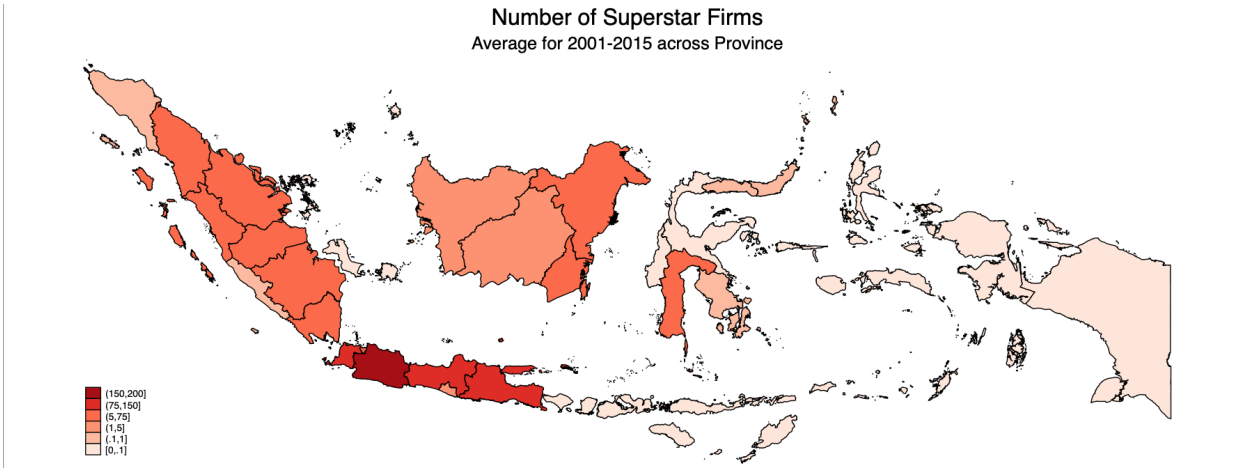


Figure 8: Superstar Distribution

4.2 Results and Discussion

The following result is to show the relationship of superstar spillovers to the productivity level and growth. To isolate the pure correlation on non-superstar firms, we also examine the relationship of spillovers exclusively on non-superstar firms. Moreover, the nexus is captured for both TFP level and growth, as well as the interaction with control variables to reveal its robustness.

First, Table 2 shows the results from Horizontal Spillovers. We capture positive relationship between horizontal spillovers and TFP level (φ) and growth ($\Delta\varphi$). The results are consistent across different designs namely interaction with controls, i.e. exporters and foreign-owned. It implies that a higher share of superstar firms within province and subsector causes non-superstar firms more productive. A plausible reason of this finding may stem from the spillovers through the automation production process that becomes pervasive among not only superstar firms but also non-superstar firms, based on the stylized facts in Figure 5. If we interpret this direction with the results in the First-Stage, reported in Table A-5 in the Appendix, it implies that a higher share of superstar firms in certain province and subsector shocked by the industrial national growth leads to the higher share of the superstar firms, which in turn enhance non-superstar firms productivity level and growth within the sector and province.

Meanwhile, in the case of vertical spillovers from backwards ($BSpill$), the results are

Table 2: Basic Results–Horizontal Spillovers

	(1) φ	(2) $\Delta\varphi$	(3) φ	(4) $\Delta\varphi$	(5) φ	(6) $\Delta\varphi$
HSpill	0.007***	0.004***	0.008***	0.004***	0.006***	0.004***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Foreign-Owned	0.438***	-0.213***	0.633***	-0.303*	0.437***	-0.213***
	(0.020)	(0.031)	(0.127)	(0.169)	(0.020)	(0.031)
Exporters	0.176***	-0.136***	0.177***	-0.136***	-0.095	-0.164
	(0.011)	(0.017)	(0.011)	(0.017)	(0.094)	(0.118)
Imports	0.400***	-0.061*	0.400***	-0.061*	0.392***	-0.062*
	(0.023)	(0.032)	(0.023)	(0.032)	(0.023)	(0.032)
Abs	0.502***	0.225***	0.502***	0.225***	0.499***	0.225***
	(0.004)	(0.005)	(0.004)	(0.005)	(0.005)	(0.005)
HHI	-0.044	-0.054	-0.036	-0.058	-0.044	-0.055
	(0.053)	(0.059)	(0.053)	(0.059)	(0.053)	(0.059)
HSpill × *Foreign-Owned*			-0.006	0.003		
			(0.004)	(0.005)		
HSpill × *Exporters*					0.009***	0.001
					(0.003)	(0.004)
Sector-Province-Island-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Kleibergen-Paap Wald F-stat	643.839	633.646	44.181	55.788	24.618	22.222
Cragg-Donald Wald F-stat	9125.236	8596.705	2143.587	2235.552	2158.813	2051.938
Observations	198665	180625	198665	180625	198665	180625

Note: Clustered-robust standard errors are in parentheses and in firm level. Bartik-IV from labour-based (*LabBartikIV*) is used as IV for *HSpill*. φ denotes dependent variable of TFP level, while $\Delta\varphi$ denotes dependent variable for TFP growth. All estimations use Sector-Province-Island-Year Fixed-Effects. Observations only consist of non-superstar firms. ***, **, * denote α at 1%, 5%, and 10%. *Abs* denotes absorptive capacity. *HHI* denotes market concentration from Herfindahl-Hirschman Index. φ and $\Delta\varphi$ denote total factor productivity in level and growth, respectively. The results with Inverse Probability Weighting are reported in the Appendix in Table A-8.

reported in Table 3, and Table A-6 for the First-Stage estimation. We capture positive correlation between Backward spillovers and productivity for both level and growth. It suggests that when non-superstar firms establish supply connection by acting as suppliers for superstar firms, their productivity level and growth are higher. Meanwhile, in the first stage, Tariff affects negatively towards the degree of superstar firms establish backward channels, suggesting that a high share of superstar firms within province followed by higher tariff rate–a positive tariff change–discourage superstar firms to expand their market shares. Conversely, when the share is low and followed by lower tariff, it stimulates superstar firms in connecting with their suppliers, which in turn stimulate productivity enhancement for non-superstar firms in the upstream sectors.

The results from Backward channels show similar direction with forward ($FSpill$) linkages in Table 4 and Table A-7 in the Appendix for the First-Stage estimates. The results show that by being a buyers of intermediate inputs from superstar firms associate to a better productivity level and growth. Accordingly, superstar firms act as stimulator that enhance the equality of outputs in the upstream and downstream industries. By becoming suppliers to superstar firms, non-superstar firms are compelled to raise their production standards, while they may gain high quality inputs by purchasing intermediate materials from superstar firms.

We then test superstar-heterogeneous characteristics by more specifically re-defining superstar firms into two groups: foreign-owned and domestic superstars. In this strategy, we may capture whether superstar spillovers occur from foreign enterprises. In this strategy, foreign superstar is superstar firms with foreign capital ownership with more than 10%. Meanwhile, for domestic superstar, we specifically define as non-foreign-owned superstar firms (capital ownership from foreign is less than 10%). In this test, both foreign and domestic superstars are non-exporters to isolate the real effect of superstar [19]. The results are reported in Table 5 for the second-stage, while the first-stage is reported in the Appendix in Table A-14.

According to Table 5, we found that there are robust effects of superstar firms across different types of ownership. First, foreign superstars consistently show positive effects on

[19]This two definitions of superstar firms are also used by Amiti et al. (2024).

Table 3: Basic Results–Backward Spillovers

	(1) φ	(2) $\Delta\varphi$	(3) φ	(4) $\Delta\varphi$	(5) φ	(6) $\Delta\varphi$
BSpill	0.153***	0.123***	0.140***	0.113***	0.153***	0.122***
	(0.023)	(0.021)	(0.022)	(0.020)	(0.023)	(0.022)
Foreign-Owned	0.131	-0.450***	0.141*	-0.448***	0.131	-0.451***
	(0.083)	(0.076)	(0.073)	(0.068)	(0.084)	(0.075)
Exporters	-0.001	-0.277***	0.030	-0.246***	-0.274	-0.012
	(0.050)	(0.046)	(0.046)	(0.041)	(0.797)	(0.956)
Imports	0.370***	-0.088	0.372***	-0.083	0.372***	-0.089
	(0.083)	(0.073)	(0.069)	(0.061)	(0.085)	(0.072)
Abs	0.434***	0.173***	0.480***	0.228***	0.429***	0.178***
	(0.017)	(0.015)	(0.023)	(0.020)	(0.023)	(0.023)
HHI	-1.789***	-1.354***	3.794*	5.166**	-1.826***	-1.317***
	(0.337)	(0.297)	(2.060)	(2.060)	(0.352)	(0.330)
BSpill × *High-Concentration*			-0.089***	-0.103***		
			(0.032)	(0.034)		
BSpill × *Exporters*					0.012	-0.012
					(0.036)	(0.043)
Sector-Province-Island-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Kleibergen-Paap Wald F-stat	112.188	139.418	37.224	112.672	57.896	55.168
Cragg-Donald Wald F-stat	13.445	17.045	8.908	10.932	6.409	7.672
Observations	200440	182093	200440	182093	200440	182093

Note: Clustered-robust standard errors are in parentheses and in firm level. Bartik-IV from output-based ($TarrBartikIV$) is used as IV for *BSpill*. φ denotes dependent variable of TFP level, while $\Delta\varphi$ denotes dependent variable for TFP growth. All estimations use Sector-Province-Island-Year Fixed-Effects. Observations only consist of non-superstar firms. ***, **, * denote α at 1%, 5%, and 10%. *Abs* denotes absorptive capacity. HHI denotes market concentration from Herfindahl-Hirschman Index. φ and $\Delta\varphi$ denote total factor productivity in level and growth, respectively. The results with Inverse Probability Weighting are reported in the Appendix in Table A-9.

Table 4: Basic Results–Forward Spillovers

	(1) φ	(2) $\Delta\varphi$	(3) φ	(4) $\Delta\varphi$	(5) φ	(6) $\Delta\varphi$
FSpill	0.222***	0.212***	0.140***	0.125***	0.222***	0.212***
	(0.043)	(0.049)	(0.024)	(0.028)	(0.043)	(0.048)
Foreign-Owned	0.133	-0.491***	0.228*	-0.389***	0.138	-0.482***
	(0.164)	(0.168)	(0.117)	(0.116)	(0.160)	(0.161)
Exporters	0.021	-0.297***	0.071	-0.239***	0.483	0.518
	(0.080)	(0.085)	(0.057)	(0.059)	(1.007)	(0.996)
Imports	0.291*	-0.150	0.326***	-0.114	0.268	-0.192
	(0.166)	(0.167)	(0.122)	(0.119)	(0.169)	(0.169)
Abs	0.498***	0.223***	0.485***	0.206***	0.504***	0.232***
	(0.021)	(0.021)	(0.017)	(0.017)	(0.026)	(0.025)
HHI	-0.224	-0.305	-4.208***	-4.501***	-0.236	-0.310
	(0.219)	(0.232)	(1.230)	(1.270)	(0.220)	(0.229)
FSpill × *High-Concentration*			0.066***	0.069***		
			(0.020)	(0.020)		
FSpill × *Exporters*					-0.027	-0.047
					(0.059)	(0.058)
Sector-Province-Island-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Kleibergen-Paap Wald F-stat	41.300	35.443	49.095	42.874	21.379	18.488
Cragg-Donald Wald F-stat	4.885	4.347	3.910	3.505	2.487	2.218
Observations	200440	182093	200440	182093	200440	182093

Note: Clustered-robust standard errors are in parentheses and in firm level. Bartik-IV from output-based ($TarrBartikIV$) is used as IV for $FSpill$. φ denotes dependent variable of TFP level, while $\Delta\varphi$ denotes dependent variable for TFP growth. All estimations use Sector-Province-Island-Year Fixed-Effects. Observations only consist of non-superstar firms. ***, **, * denote α at 1%, 5%, and 10%. *Abs* denotes absorptive capacity. HHI denotes market concentration from Herfindahl-Hirschman Index. φ and $\Delta\varphi$ denote total factor productivity in level and growth, respectively. The results with Inverse Probability Weighting are reported in the Appendix in Table A-10.

Table 5: Heterogeneous Superstars: Foreign and Domestic

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Foreign		Domestic		Foreign		Domestic		Foreign		Domestic	
	φ	$\Delta\varphi$	φ	$\Delta\varphi$	φ	$\Delta\varphi$	φ	$\Delta\varphi$	φ	$\Delta\varphi$	φ	$\Delta\varphi$
HSpill	0.004	0.004	0.019***	0.010***								
	(0.004)	(0.005)	(0.002)	(0.003)								
BSpill					0.012**	0.007**	0.113***	0.113***				
					(0.005)	(0.004)	(0.016)	(0.019)				
FSpill									0.037**	0.020**	0.129***	0.125***
									(0.016)	(0.010)	(0.017)	(0.020)
Foreign-Owned	0.447***	-0.211***	0.455***	-0.204***	0.429***	-0.214***	0.380***	-0.274***	0.396***	-0.231***	0.464***	-0.182***
	(0.021)	(0.031)	(0.021)	(0.030)	(0.020)	(0.030)	(0.039)	(0.047)	(0.029)	(0.033)	(0.056)	(0.060)
Exporters	0.176***	-0.135***	0.193***	-0.127***	0.170***	-0.137***	0.157***	-0.149***	0.175***	-0.134***	0.206***	-0.107***
	(0.011)	(0.017)	(0.012)	(0.017)	(0.011)	(0.017)	(0.022)	(0.026)	(0.012)	(0.017)	(0.028)	(0.031)
Imports	0.399***	-0.065*	0.422***	-0.049	0.388***	-0.059*	0.514***	0.063	0.349***	-0.079**	0.472***	0.020
	(0.023)	(0.033)	(0.024)	(0.032)	(0.023)	(0.032)	(0.046)	(0.053)	(0.034)	(0.035)	(0.062)	(0.067)
Abs	0.503***	0.226***	0.509***	0.229***	0.501***	0.224***	0.491***	0.214***	0.501***	0.225***	0.504***	0.223***
	(0.004)	(0.005)	(0.005)	(0.005)	(0.004)	(0.005)	(0.008)	(0.009)	(0.005)	(0.005)	(0.010)	(0.011)
HHI	0.056	-0.001	-0.239***	-0.153**	0.008	-0.010	-1.741***	-1.662***	0.141**	0.063	-1.460***	-1.417***
	(0.049)	(0.056)	(0.066)	(0.075)	(0.051)	(0.056)	(0.276)	(0.318)	(0.069)	(0.063)	(0.221)	(0.259)
Sector-Province-Island-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Kleibergen-Paap Wald F-stat	394.891	369.157	350.564	339.332	235.571	426.651	195.089	169.255	46.902	140.173	348.729	320.436
Cragg-Donald Wald F-stat	956.510	879.831	2721.304	2426.539	179.371	461.061	39.217	33.050	29.471	95.254	20.725	19.115
Observations	198665	180625	198665	180625	200440	182093	200440	182093	200440	182093	200440	182093

Note: Clustered-robust standard errors are in parentheses and in firm level. Bartik-IV from labour-based and output growth ($LabBartikIV$) is used as IV for $HSpill$, while Bartik-IV from output-based and tariff ($TarrBartikIV$) is used as IV for $BSpill$ adn $FSpill$. $Foreign$ denotes foreign superstar spillovers, while $Domestic$ denotes domestic foreign spillovers. Both foreign and domestic superstars are non-exporters. φ denotes dependent variable of TFP level, while $\Delta\varphi$ denotes dependent variable for TFP growth. All estimations use Sector-Province-Island-Year Fixed-Effects. Observations only consist of non-superstar firms. ***, **, * denote α at 1%, 5%, and 10%. *Abs* denotes absorptive capacity. HHI denotes market concentration from Herfindahl-Hirschman Index. φ and $\Delta\varphi$ denote total factor productivity in level and growth, respectively.

non-superstar productivity, except from horizontal channel. It implies that competing with foreign superstar firms have no significant effects for non-superstar firms. However, domestic superstar show positive results for entire channels, implying that domestic superstars generate spillovers more than that foreign superstars do.

Our finding is consistent with Amiti et al. (2024) arguing that there are heterogeneous relationship between the type of superstar firms, not necessarily the foreign firm that cause positive spillovers. When domestic firms also involve in the international markets by being exporters, they may obtain global technological knowledge, which in turn possibly causes spillovers for non-superstars. Although in early 2000 not many firms in Indonesia could afford automation, except for foreign superstar firms that have gained access advanced technology from their parent company, after the implementation of the Indonesian rule number 176/2009 about Import Duty Exemption on The Imported Machinery, there is indication that it may encourage the productivity of non-superstar firms. Recently, in early 2022, the Indonesian government, through Ministerial Regulation (*Peraturan Pemerintah*) Number 1 of 2022, also promulgated a regulation requiring large or superstar firms to establish cooperation with smaller firms, specifically Small and Medium Enterprises (SMEs). This regulation also complements previous foreign investment regulations, such as the Negative Investment List, which specifically regulates foreign entry into Indonesia since early 2000, as discussed by Genthner and Kis-Katos (2022). This finding aligns with our findings, which indicate that acting as suppliers for superstar firms (domestic and foreign) enhances the productivity of non-superstar firms.

Moreover, superstar firms may also function as a dating agency, facilitating connections between non-superstar firms and other firms in downstream industries (both superstar or non-superstar). Once a non-superstar firm meets the high production standard required to become a superstar suppliers, it builds a strong portfolio, making it more attractive to other superstar firms or non-superstar firms in the downstream sectors. Moreover, being a supplier to a superstar firm requires a company to focus and specialize in a specific product category. For instance, in packaging, superstar firms prefer suppliers that are solely dedicated to packaging production, ensuring that the quality standards remain exceptionally high.

The automation process in superstar firms, which leads to an increase in their outputs pro-

duced share and creates rivalry effects for non-superstar firms, is an inevitable phenomenon. Superstar firms drive production through automation; if non-superstar firms are unable to keep up with this production speed, their market share will decline. In this context, if the government intervenes by supporting technology adoption for non-superstar firms, the strategy will be quite challenging due to the limited availability of skilled workers in these firms. On the other hand, superstar firms can receive incentive in the form of import tax discount from importing advanced machines, if they collaborate with non-superstar firms. Although the government has promulgated this regulation, major obstacles remain–superstar firms struggle to find smaller firms that can meet their demands, which in turn the regulation may merely be recognized as a barrier to entry for superstar firms.

Meanwhile, a plausible reason for insignificant effects of horizontal spillovers ($HSpill$) from foreign superstars is the protection of technology from the parents company to which foreign superstars are affiliated. Although non-superstar firms can imitate production technology from foreign superstar firms, they cannot solely mimic the technology to produce similar outputs if the parent-company of this foreign superstar firms protects their technology. In this regard, vertical spillovers from horizontal channel cannot occur. This mechanism is different in the case of domestic spillovers. Domestic superstar and non-superstar firms may already be familiar with local markets, stimulating fair competition and encouraging non-superstar's productivity improvements.

We then look at the results from productivity decomposition to strengthen whether productivity dynamics are determined by entry-exit behaviour of the firms. We first show the assumption by which there is positive association between share and productivity. There are three components, namely correlation from covariance of OP Decomposition in each 2001-2005, 2006-2010, and 2011-2015, which are reported in The Appendix in Figure A-3. According to Figure A-3, it is proven that there are positive association between TFP and market share in the first two panels. Specifically, the assumption of Olley and Pakes (1996) by which an increase of share correlate positively to the TFP is proven and captures market reallocation into more productive firms.

We then reveal the productivity decomposition in our study. We explore the contribution for 3 time window (2015, 2010, and 2005) with 2001 as a base year. First, the result from

the static OP Decomposition with superstar and non-superstar groups, excluding entry-exit behaviors are reported in Table 6. According to Table 6, the average overall TFP growth is positive for all time windows, contributed mainly from plant improvements, while Reallocation component mainly contributes negatively on the aggregate TFP change in 2001-2015. It implies that TFP change is mainly supported by the improvements within firms, while the reallocation process occurred towards less productive firms.

If we compare the components between Superstar and Non-superstar, it is clear that the aggregate TFP growth of non-superstar outweighs superstar firms, with plant improvements being the dominant component for both group. This decomposition corroborates the results in Figure 7. This finding also implies that although superstar firms possess a higher TFP level, indicating that they are more efficient, they do not necessarily grow faster than non-superstar firms.

Table 6: TFP Change from Static OP Decomposition

Component	**Period**	**Overall**	**Superstar**	**Non-superstar**
Aggregate TFP Change	2001-2015	1.059	0.667	1.406
	2001-2010	0.780	0.430	1.113
	2001-2005	0.377	0.384	0.283
Plant Improvements	2001-2015	1.294	0.865	1.313
		(1.222)	(1.298)	(0.934)
	2001-2010	0.665	0.716	0.671
		(0.852)	(1.667)	(0.603)
	2001-2005	0.318	0.363	0.305
		(0.844)	(0.945)	(1.081)
Reallocation	2001-2015	-0.235	-0.199	0.093
		(-0.222)	(-0.298)	(0.066)
	2001-2010	0.116	-0.287	0.442
		(0.148)	(-0.667)	(0.397)
	2001-2005	0.059	0.021	-0.023
		(0.156)	(0.055)	(-0.081)

Note: Shares of each components to the aggregate TFP change are in parentheses. Plant improvement refers to the change of unweighted average productivity ($\Delta\bar{\varphi}_t$) while reallocation is the covariance component between market share and productivity.

Furthermore, we present the results from the Dynamic OP Decomposition, a-la Melitz and Polanec (2015), with the extension for heterogeneous superstar firms (foreign and do-

mestic)[20]. The results are reported in Table 7. According to Table 7, there is a consistent finding with the static decomposition where reallocation process contributes negatively towards aggregate productivity, notably in the period of 2010 and 2015. However, in this dynamic approach, we can address that the reallocation within survivors that causes worsened productivity, implying the market share is reallocated towards survivors who are less productive. This finding also indicates misallocation among survivors firms. Meanwhile, the reallocation between survivors and exiters-entrants gain positive drivers.

If we look at the components by group of General Superstar, it can be seen that non-superstar firms outperform in the productivity improvement component for 2001-2005 and 2001-2015 time windows. Meanwhile, superstar firms experience a severe negative within-group reallocation component for all time window, which is much higher in magnitude compared to the non-superstar group. It indicates a negative contribution from the survivors within the superstar group. An intriguing result is shown by the Heterogenous Superstar group where the negative reallocation within survivors is mainly driven by domestic superstar with negative growth for all time window, although domestic superstar grow faster than foreign superstar in terms of plant improvements. On the other hand, reallocation from exiters and entrants component shows a better contribution for superstar firms, although only in 2001-2005 do superstar firms outperform non-superstar firms, and even then only by a moderate margin.

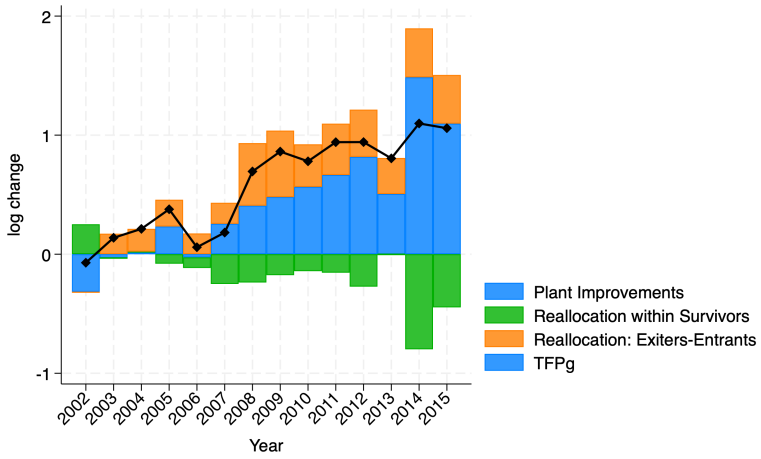
We also report the dynamic decomposition from overall group, superstar, and non-superstar for 2001-2015 in Figure 9. According to Figure 9, in panel (i), it is obvious that in 2001-2015, the largest drivers of the productivity growth stems from Plant-Improvements from survivor firms. More specifically, Plant-Improvements within superstar survivors are relatively stable between 2007-2012, although the components of Within-Reallocation is negative. It implies that there is reallocation into less productive firms within superstar survivors during 2007-2015. Meanwhile, the group of non-superstar firms is also driven mostly by Plant-Improvements, where some periods show negative contribution from Within-Reallocation.

[20]The robustness test for Dynamic OP Decomposition of superstar firms is reported in A-20 by referring to Amiti et al. (2024)'s definition.

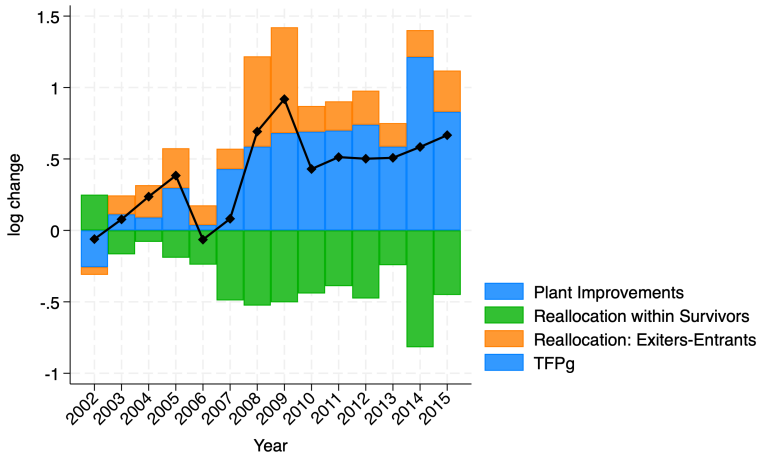
Table 7: TFP Change from Dynamic OP Decomposition: Survivors, Exiters, and Entrants

Component	**Period**	**Overall**	**General Superstar**		**Heterogeneous Superstar**		
			Superstar	Non-superstar	Foreign	Domestic	Non-superstar
Aggregate TFP Change	2001-2015	1.059	0.667	1.406	0.603	0.203	0.252
	2001-2010	0.780	0.430	1.113	0.838	0.068	0.825
	2001-2005	0.377	0.384	0.283	1.321	-0.187	1.492
Plant Improvements	2001-2015	1.096	0.830	1.113	0.332	0.311	0.233
		(1.036)	(1.245)	(0.792)	(0.551)	(1.534)	(0.922)
	2001-2010	0.565	0.691	0.559	0.503	0.756	0.562
		(0.724)	(1.608)	(0.502)	(0.600)	(11.089)	(0.682)
	2001-2005	0.233	0.296	0.230	0.695	0.880	1.129
		(0.617)	(0.771)	(0.814)	(0.526)	(-4.700)	(0.756)
Reallocation within Survivors	2001-2015	-0.446	-0.452	-0.122	-0.056	-0.251	-0.319
		(-0.422)	(-0.678)	(-0.087)	(-0.093)	(-1.238)	(-1.265)
	2001-2010	-0.142	-0.441	0.120	0.651	-0.875	-0.192
		(-0.182)	(-1.027)	(0.108)	(0.777)	(-12.842)	(-0.233)
	2001-2005	-0.080	-0.191	-0.043	0.274	-0.905	-0.303
		(-0.212)	(-0.498)	(-0.152)	(0.207)	(4.834)	(-0.203)
Reallocation: Exiters-Entrants	2001-2015	0.409	0.289	0.415	0.326	0.143	0.339
		(0.386)	(0.433)	(0.295)	(0.541)	(0.704)	(1.343)
	2001-2010	0.357	0.180	0.434	-0.316	0.188	0.455
		(0.458)	(0.419)	(0.390)	(-0.377)	(2.753)	(0.552)
	2001-2005	0.224	0.279	0.095	0.353	-0.162	0.667
		(0.595)	(0.727)	(0.338)	(0.267)	(0.866)	(0.447)

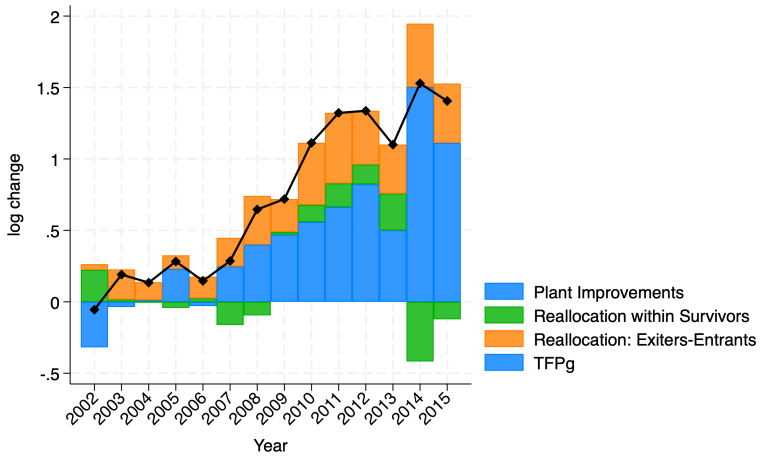
Note: The value is in the log-change. Shares of each components to the aggregate TFP change are in parentheses. Plant improvement refers to the change of unweighted average productivity for survivors ($\Delta\bar{\varphi}_t$), while Reallocation within Survivors refers to the change of covariance component within survivors, and Reallocation of Exiters-Entrants is the plant improvements and covariance component across group of survivors with entrants and exiters.



i. Overall



ii. Superstar



iii. Non-superstar

Figure 9: Productivity Growth Decomposition

The finding that superstar firms have higher TFP level compared to non-superstar firms (as shown in Figure 7 and Table 2, Table 3, and Table 4), and generate positive spillover effects for non-superstar firms but nevertheless exhibit lower growth rates than non-superstar firms, indicates that superstar firms in Indonesia behave differently from the "Rise of Superstar Firms" hypothesis observed in advanced economies, as discussed by Autor et al. (2020) or Amiti et al. (2024). While Indonesian superstar firms indeed operate more efficiently than non-superstar firms, their lower growth suggests stagnation among these firms. This stagnation may reflect a lack of innovation or limited adoption of new technologies within Indonesian superstar firms. Although positive productivity spillovers occur, it may simply be a consequence of the already substantial TFP gap between superstar firms and their non-superstar competitions, suppliers and purchasers (as seen in the considerable TFP gap at the level presented in Figure 7).

Furthermore, when superstar firms account for more than 75% of market share and experience TFP growth, this evidence may also contribute to the premature de-industrialization discussed by Rodrik (2016). In line with Autor et al. (2020), superstar firms may be regarded as "winners-take-all"; however, in the Indonesian context, market-dominating superstar firms do not outperform in terms of growth–in fact, what is observed could be characterized as "The Fall of Superstar Firms". This stagnation or even decline in TFP growth among superstar firms may be one of the reasons why, at the aggregate national level, the manufacturing subsector's contribution has declined significantly: the market leaders themselves are stagnating or regressing in terms of productivity growth.

Considering other characteristics, such as automation and market share (see Figure 5), Autor et al. (2020) notes that a rise in superstar firms is typically associated with increased market concentration. Similar with Indonesian evidence, figure 5 shows that an increase in automation–indicating a rise in superstar firms– is also associated by an increase in market concentration. It further supports the finding that Indonesian superstar firms primarily seek to stimulate market competition within the sector and province, sourcing and selling from non-superstar suppliers in upstream and downstream sectors, thereby resulting in positive backward and forward spillovers. At the same time, despite superstar firms may not be engaging in innovation, shown by their slower productivity growth, their rate of automation

adoption has increased and is relatively higher than that of non-superstar firms. It may explain why their TFP level remain higher compared to non-superstar firms.

The findings also imply that although we observe an increasing trend of TFP growth and levels over 2001-2015, the decomposition result showing that the market mechanism failed to work well due to misallocation, even though firm-level upgrading improved. It also corroborates the evidence that the share of manufacturing output in GDP decreases, as the increase in TFP levels and growth was not accompanied by the reallocation of production toward most productive firms, i.e. misallocation. Meanwhile,regarding positive spillovers, although spillovers firm superstar to non-superstar occurred, they only affected within plant improvement and does not necessarily determine how market misallocation unfolded. In this sense, TFP level and growth might have been even lower without these spillovers, given that misallocation worsened aggregate productivity. Therefore, while TFP did increase, it failed to support structural upgrading of manufacturing by raising its share of GDP.

Furthermore, the findings from heterogeneous superstar decomposition that reveals negative for domestic superstar firms implies misallocation within domestic superstar survivors firms in Indonesia. This finding is plausible when the contribution of state-ownership on the domestic superstar firms reaches about 13% on average in 2001-2015, which is 4 times higher than foreign superstar firms that possesses about 3% ownership from Indonesian central and regional governments. Among this domestic superstar firms, about 4% is state-owned enterprises (SOE) and 7% is regional-owned enterprises (ROE)[21]. In this regard, there is any possibility that the misallocation occurred mainly from this SOE and ROE[22].

Moreover, the findings that misallocation occurs among domestic surviving firms implies that domestic firms in Indonesia, possibly including SOEs, have not experienced technological progress due to privileges from the government, such as better access to the financial system (Zhao, 2019). In this context, although they hold a large market share of sales and operate efficiently (so they become superstar), thereby creating positive spillovers for non-superstar firms, they are reluctant for technology-upgrading. Consequently, their TFP

[21]SOE and ROE with foreign-ownership more than 10% are less than 1.5% in 2001-2015

[22]Prior studies, such as Han et al. (2021) and Bach (2019) have also found economic distortion due to misallocation of state-owned enterprises in China, while De Nicola et al. (2024) scrutinize misallocation of Indonesia, Vietnam and Malaysia and found the distortion due to misallocation which hinders them to grow

growth stagnates and is even slower than that of non-superstar firms. When misallocation occurs, resources are not reallocated from less productive superstar firms to more productive ones, but rather the opposite, due to distortion.

4.3 Robustness Tests

We conduct several strategies for additional robustness tests. First, we re-sample the observation into two groups, namely medium and large firms based on the definition of BPS-statistics. Medium firms are those firms with workers less than 100, while large firms possesses at least 100 workers. This robustness test also aims to reveal homogeneous treatment effects of each instrument on the endogenous spillovers. The results are reported in The Appendix in Table A-15. According to Table A-15, the results are relatively consistent with main estimation, where there are positive spillovers from all channels.

Another strategy for robustness test is by using alternative instrumental variables. We re-design $LabBartikIV$ from equation 23 by changing the share component into the initial share of all workers. We use this IV for $HSpill$. Meanwhile, we use the average of Road Density for the IV of $BSpill$ and $FSpill$. The results are reported in Table A-16, A-17, and A-18. According these tables, all results are relatively consistent where we capture positive effects of spillovers from all dimensions.

Another robustness test is for heterogeneous superstar spillovers from the results in Table 5. In this result, we test the robustness by using different productivity indicator namely the simple ratio of value added to the total workers (in log form). The results are reported in Table A-19. According to Table A-19, the results are consistent where both foreign and domestic superstar generate positive spillovers for non-superstar, except for horizontal spillovers from foreign superstars.

5 Conclusion and Further Development

We provide empirical evidence that firms dominating the market exhibit key characteristics of superstar firm behaviour. In this regard, we aim to reveal the relationship of superstar spillovers on productivity and look at the contribution of superstar firms on the productivity.

Our findings capture positive relationship between productivity level and growth on the horizontal spillovers and and vertical spillovers, implying that a higher share of superstar firms within province and subsector causes non- superstar firms more productive andlead them to grow faster. In the case of vertical spillovers from backwards and forward linkages, the results show positive relationship, suggesting that when non-superstar firms establish supply connection by acting as suppliers or purchasers, their productivity is higher and faster. In terms of the decomposition strategy, the results show that the negative aggregate productivity growth occurred is mainly driven by within-group reallocation, which implies misallocation within survivors in the markets.

Our study leaves at least three policy implication. First, the strategy for superstar firms to bridge with non-superstar firms is essential in stimulating TFP growth. With the results showing that becoming suppliers to foreign superstar firms increases productivity level and growth, government policy should focus on improving the upstream and downstream sectors. This strategy could include initiatives such as providing training for companies that have not yet become superstar's suppliers and developing strategies to help them meet higher industry standards. By enhancing the capabilities of these firms, the government can facilitate their integration into the supply chains of superstar firms, ultimately boosting overall industrial productivity. Furthermore, the training program aims to equip workers with expert skills in technology. It is inevitable that superstar firms may replace repetitive tasks in their plants with machines to maintain consistent production volumes. However, they still require skilled workers to operate advanced technology, which, in turn, necessitates that human resources keep up with technological advancements. Additionally, it is also inevitable that superstar firms are more likely to involve in the global economic frontier, leading them to provide high quality intermediate inputs for downstream industry in the country. However, it is essential to maintain the price remain affordable for downstream industry due the fact that superstar firms might impose high markups. Furthermore, although superstar firms dominate the market in Indonesia, if they focus solely on maintaining their dominance without making efforts to innovate, they may not be able to drive TFP growth. In other words, it is essential for government to ensure that superstar firms continue to invest in R&D so that innovation occurs, enabling them to contribute to economic growth.

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Appendices

Appendix 1: Optimal Profit Function

$$\begin{aligned}
\pi^* &= \Big(\frac{w}{\rho\varphi}\Theta\Big[\frac{w}{\rho\varphi}\Big]^{1/\rho-1}\Big) - \Big(f + w\frac{\Theta\Big[\frac{w}{\rho\varphi}\Big]^{1/\rho-1}}{\varphi}\Big) \\
&= \frac{w}{\rho\varphi}\Theta\Big[\frac{w}{\rho\varphi}\Big]^{1/\rho-1} - f - \frac{w}{\varphi}\Theta\Big[\frac{w}{\rho\varphi}\Big]^{1/\rho-1} \\
&= \frac{w}{\varphi}\Theta\Big[\frac{w}{\rho\varphi}\Big]^{1/\rho-1}\Big(\frac{1}{\rho} - 1\Big) - f \\
&= \frac{w}{\varphi}\Theta\Big[\frac{w}{\rho\varphi}\Big]^{1/\rho-1}\Big(\frac{1-\rho}{\rho}\Big) - f \\
&= \frac{w^{\rho/\rho-1}}{\varphi^{\rho/\rho-1}\rho^{\rho/\rho-1}}\Theta(1-\rho) - f \\
&= (1-\rho)w^{\rho/\rho-1}\rho^{\rho/1-\rho}\varphi^{\rho/1-\rho}\Theta - f \\
&= (1-\rho)w^{\rho/\rho-1}\rho^{\rho/1-\rho}\lambda^{\rho/1-\rho}e^{\rho\alpha\gamma/1-\rho}c^{\rho/1-\rho}\Theta - f
\end{aligned} \tag{32}$$

Appendix 2: Total Factor Productivity from Olley-Pakes

In the Olley and Pakes (1996), we may arrange standard Cobb-Douglas production function for panel setting as follows:

$$y_{it} = \beta_0 + \beta_X X_{it} + \varepsilon_{it} \tag{33}$$

where y_{it} denotes total outputs, either gross outputs or value-added, for firm i in year t. X_{it} denotes set of adjustable and dynamic inputs over time. These variables are transformed in a logged-form. Meawnhile, ε_{it} denotes error terms capturing Hicks neutral productivity shocks. Under Ordinary Least Squared (OLS) properties, we impose strict exogeneity assumption namely $E(\varepsilon|X) = 0$ and $cov(\varepsilon_i, X_i) = 0$. However, there is simultaneity problem when contemporaneous correlation between inputs and shocks occurred ($E(\varepsilon|X) \neq 0$ and $cov(\varepsilon_i, X_i) \neq 0$) in a way that the decision to allocate inputs (X_{it}), such as for labour and capital, are determined by shocks captured by ε_{it}, which in turn causes endogeneity (Levinsohn and Petrin, 2003). We demonstrate how this simultaneity problem occurred. First, we

may arrange a production function with two inputs setting, namely labour and capital as follows:

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \varepsilon_{it} \tag{34}$$

Where y_{it} denotes value-added of firm i in year t. Inputs are divided into a freely variable, namely number of workers employed (l_{it}) and the state variable capital (k_{it}) (also known as quasi-fixed input). Freely variable is the variable assumed free from adjustments costs [23]. Meanwhile, the state variable is the dynamic variable prone to adjustment costs. We may obtain estimated parameters of β_l for $\hat{\beta}_l$ and β_k for $\hat{\beta}_k$ from 34 from least-squared mechanism as follows:

$$\begin{aligned} y_{it} &= \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \varepsilon_{it} \\ \hat{\beta}_l &= \beta_l + \frac{var(k).cov(l,\varepsilon) - cov(l,k).cov(k,\varepsilon)}{var(l).var(k) - cov(l,k)^2}, \\ \hat{\beta}_k &= \beta_k + \frac{var(l).cov(k,\varepsilon) - cov(l,k).cov(l,\varepsilon)}{var(l).var(k) - cov(l,k)^2}, \end{aligned} \tag{35}$$

where $var(a)$ and $cov(a,b)$ denote variance and covariance sample between a and b. There will be biases from if we use OLS based on this properties. First, we know that the denominator in 35 is always positive since $var(l) > 0$ and $var(k) > 0$, and the bias comes from numerator. If only labour reacts to the shocks, for example more labour is hired in response to a productivity shock, so $cov(l,\varepsilon) > 0$, and capital is not correlated with labour, we then know that $\hat{\beta}_l$ is biased up, albeit $\hat{\beta}_k$ is unbiased. However, if labour is correlated with capital and it has strong association with productivity shocks, $\hat{\beta}_l$ may capture overestimate magnitude as most shocks are trapped by labour, while $\hat{\beta}_k$ will be underestimate. Some studies tackled this issue by providing instrumental variable (IV) strategies, such as setting up input prices and lagged of value of input uses as instruments. However, input prices for firm level is rarely observed. Hence, Olley and Pakes (1996) introduced a novel approach namely utilizing investment as a proxy of productivity shocks. We now set the production

[23] Later studies have assumed that labour can also be non free variable as there are adjustment costs for training and costs of hiring, see Ackerberg et al. (2015)

function by disentagling the productivity shocks from ε as follows:

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \varphi_{it} + \eta_{it} \tag{36}$$

where $\varphi_{it}+\eta_{it} = \varepsilon_{it}$ from 34, specifically φ_{it} captures productivity shock affecting decision rules, while η_{it} has no impact for firm's decision. We then arrange the function of investment as follow:

$$i_{it} = i_{it}(\varphi_{it}, k_{it}) \tag{37}$$

where i_{it} denotes investment of firm i in time t. This function stems from the empirical evidence that more productive firms with higher capital associates to higher investments[24]. In other words, more positive productivity shocks in present time implies that more investments will occur later, which ultimately accumulates capital. Under monotonicity between these three variables, we may invert the function into:

$$y_{it} = \beta_l l + \phi(i_{it}, k_{it}) + \eta_{it} \tag{38}$$

where $\phi(i_{it}, k_{it}) = \beta_0 + \beta_k k_{it} + \varphi_{it}(i_{it}, k_{it})$. The equation 38 can be estimated using various methods, such as polynomial degree $n-$th or instrumental variables[25]. We then set up 38 in terms of conditional expectation as follow:

$$E(y_{it}|i_{it}, k_{it}) = \beta_l E(l_{it}|i_{it}, k_{it}) + \phi_{it}(i_{it}, k_{it}) \tag{39}$$

Since η_{it} is uncorrelated with l_{it} and k_{it}, we can subtract 39 from 38 yielding:

[24]See for example Siliverstovs et al. (2016) for research and development (R&D) investment evidence

[25]See for example Olley and Pakes (1996) for fourth-degree polynomial and De-Loecker and Warzynski (2012) for Generalized Methods of Moments (GMM) estimates.

$$y_{it} - E(y_{it}|i_{it}, k_{it}) = \beta_l \Big(l_{it} - E(l_{it}|i_{it}, k_{it}) \Big) + \eta_{it} \tag{40}$$

Under strict exogeneity assumption, again, η_{it} is mean independent of l_{it}, so we may use OLS strategy without intercept to estimate β_l. Some studies define this process as the first stage estimate, such as (Ackerberg et al., 2015).

Meanwhile, in the second step, we need to identify the coefficient of capital (β_k) in more comprehensive ways. Since capital affects productivity twice, i.e. from investments channel causing capital accumulation and its own channel, more complete model is needed (Levinsohn and Petrin, 2003). Some studies assume that productivity follows a first-order Markov process minus its change from last period (ξ_{it}), i.e. $E(\varphi_{it}|\varphi_{it-1}) = \varphi_{it} - \xi_{it}$, while at the same time capital does not respond directly to the change of it. Hence, we may arrange the output net of labour's contribution ($y*$) as:

$$y^*_{it} = y_{it} - \beta_l l_{it} = \beta_0 + \beta_k k_{it} + \underbrace{E(\varphi_{it}|\varphi_{it-1}) + \xi_{it}}_{\varphi_{it}} + \eta_{it} \tag{41}$$

Hence, we may obtain consistent β_k by regressing y^*_{it} on k_{it} under assumption of orthogonality of ξ_{it} and η_{it} on k_{it}. This approach might be more applicable under limited information of price for IV strategy.

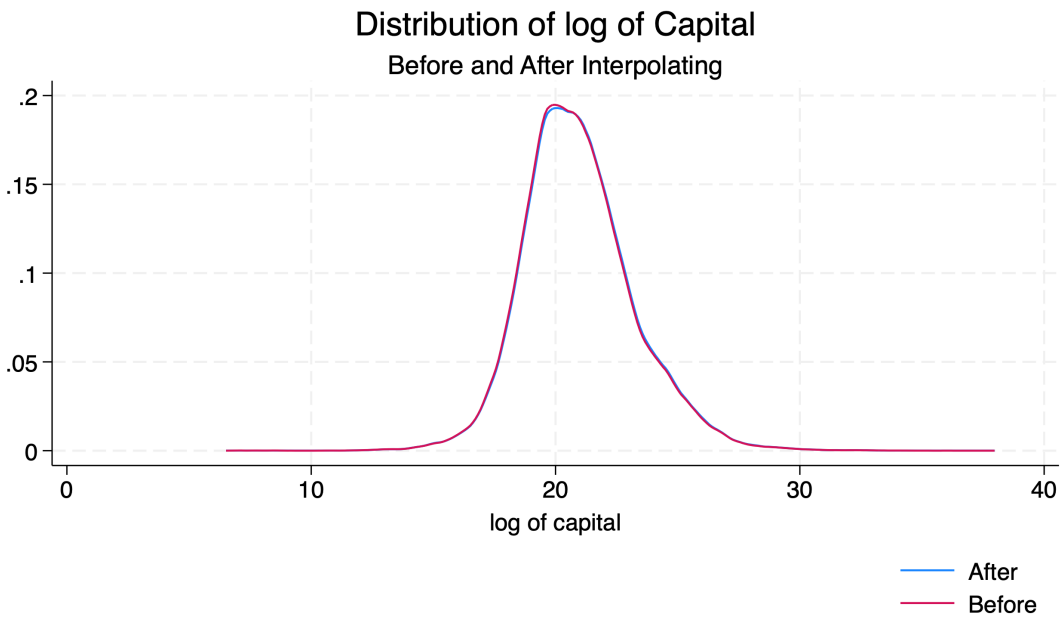


Figure A-1: Distribution of Log of Capital: Before and After Interpolation

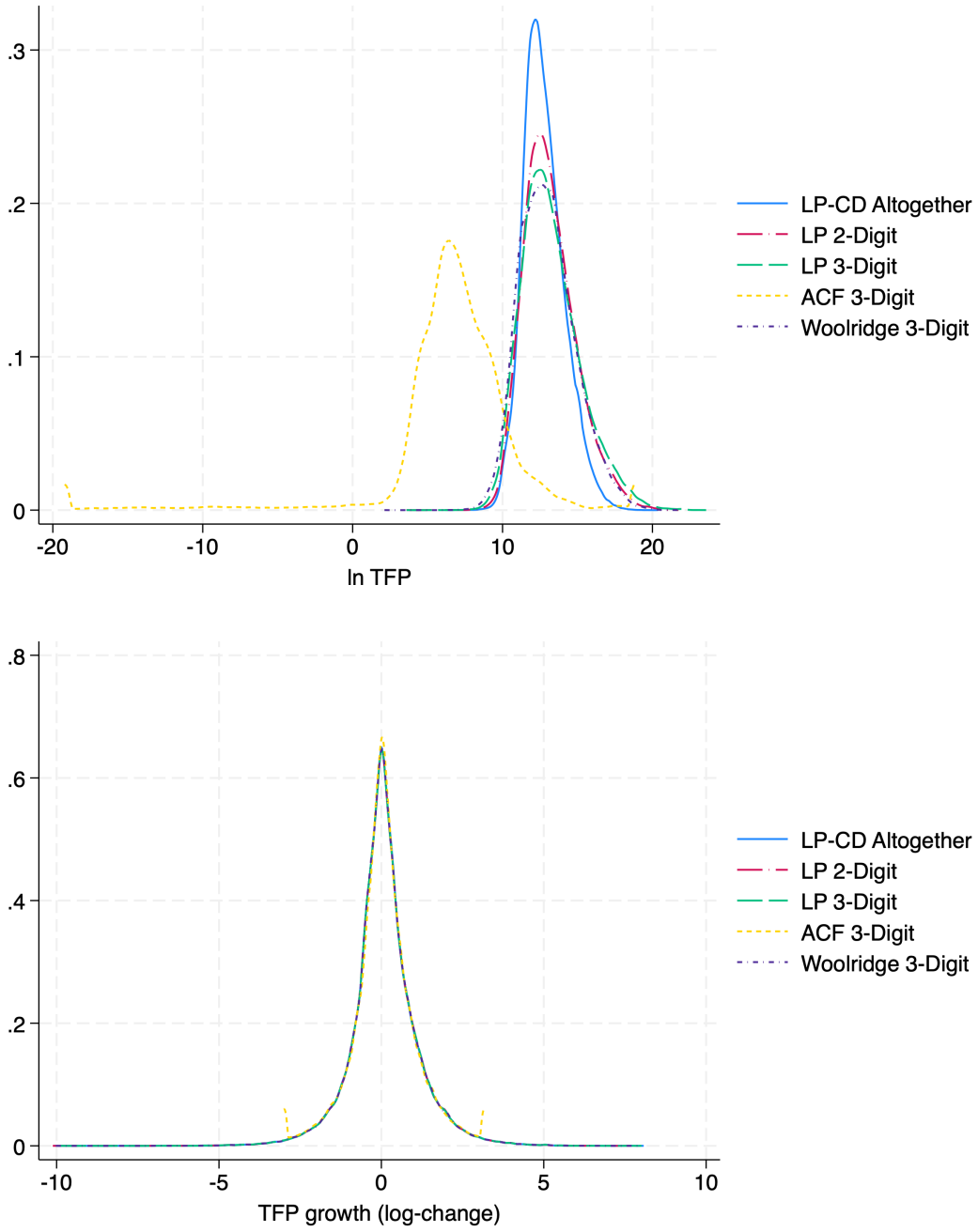
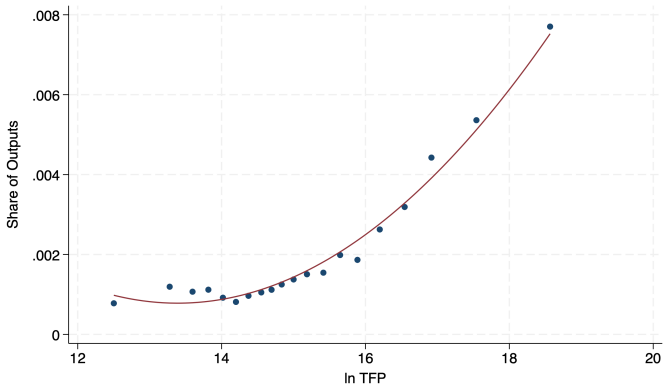
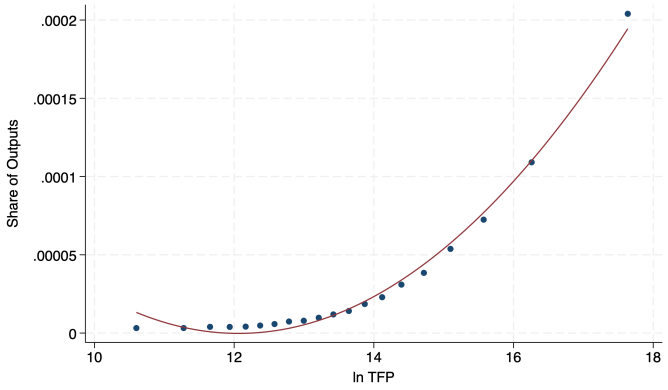


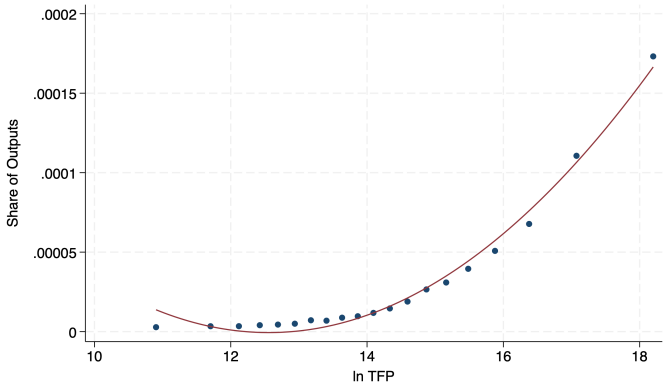
Figure A-2: TFP level and Growth across Methodologies



i. 2001-2005



ii. 2006-2010



iii. 2011-2015

Figure A-3: Correlation between TFP and Share of Outputs

Table A-1: Summary of Studies on Superstar Firms

Study	Criteria	Ratio	Notes
Amiti et al. (2024)	Foreign Firm (cutoff 10% capital ownership)	7.39%-10.1%	Less limited number of superstar firms and similar with traditional definition of FDI spillovers
	Exporter (cutoff 10% percentile exports)	8.47%-13.76%	Less limited number of superstar firms and export proportion data is not entirely available
	Large Firm (cutoff 10% sales)	4.68%-21.13%	Less limited number with the cutoff 10%
Autor et al. (2020)	Top 500 Sales	0.12%-11.95%	The number of firms can be fluctuated in each year
Cheng et al. (2024)	Markup (cutoff top 5% and positive growth)	1.52%-3.45%	Limited to positive growth
Firooz et al. (2025)	Sales (cutoff top 1%)	1%	Limited Number
	Employment Share (cutoff top 1%)	1%	Not suitable as larger employment share may indicate less capital intensive
Rowley (2024)	Top 3 Export for Domestic and Foreign	<0.1%	Strictly limited number and export proportion data is not entirely available

Table A-2: Labour and Capital Elasticities by 2-Digit ISIC Subsector

	LP	
Subsector	Labour	Capital
Food	0.46	0.34
Beverages	0.56	0.26
Tobacco	0.23	0.34
Textile	0.38	0.28
Apparel	0.52	0.29
Leather	0.48	0.28
Wood	0.40	0.37
Paper	0.44	0.19
Recording Media	0.43	0.30
Coal Products	0.38	0.45
Chemical	0.36	0.27
Pharmaceutical	0.49	0.21
Rubber	0.42	0.28
Non-Metallic	0.44	0.29
Basic Metal	0.56	0.18
Metals	0.47	0.28
Computer & Electronics	0.47	0.21
Electrical Equipment	0.48	0.22
Machinery	0.43	0.26
Motor Vehicle	0.27	0.19
Other Transportation	0.38	0.25
Furniture	0.35	0.32
Other Manufacturing	0.61	0.21
Machinery Repairment	0.44	0.29

Note: LP denotes Levinsohn-Petrin approach.

Table A-3: Labour and Capital Elasticities by 3-digit ISIC Sector (1)

Subsector	**LP**		**ACF**		**WRDG**	
	Labour	Capital	Labour	Capital	Labour	Capital
Animal Feed	0.31	0.29	0.80	0.02	0.32	0.29
Apparel	0.52	0.30			0.62	0.30
Beverages	0.56	0.26			0.63	0.31
Cables	0.46	0.15	0.99	0.44	0.65	0.16
Chemicals	0.37	0.25	0.95	0.29	0.44	0.24
Coal and Petroleum	0.38	0.45	0.75	0.40	0.56	0.45
Computers & Communication Equipments	0.40	0.06	1.22	0.28	0.48	0.12
Dairy & Ice Cream	0.52	0.14			0.59	0.21
Edible Oils & Fats	0.35	0.23			0.42	0.29
Electric Motors & Controls	0.44	0.23	0.77	0.55	0.56	0.21
Electronic Components	0.45	0.20	0.82	0.42	0.64	0.14
Fish & Aquatic Processing	0.35	0.37			0.52	0.32
Footwear	0.43	0.31	0.82	0.51	0.56	0.25
Fruit & Vegetable Processing	0.37	0.29			0.46	0.30
Furniture	0.35	0.32	0.89	0.54	0.49	0.28
General Machinery	0.49	0.28			0.62	0.28
Glass Products	0.36	0.20	0.59	0.55	0.31	0.23
Grain & Flour Milling	0.50	0.38	0.69	0.46	0.52	0.39
Household Appliances	0.50	0.30	0.56	0.46	0.60	0.32
Iron & Steel	0.47	0.21			0.57	0.32
Jewelries	0.64	0.19			0.76	0.18
Knitted & Embroidered Wear	0.47	0.18	0.85	0.62	0.61	0.16
Leather & Artificial Leather	0.50	0.24	1.01	0.21	0.62	0.20
Lighting Equipment	0.54	0.22			0.67	0.25

Note: LP denotes Levinsohn-Petrin approach, ACF denotes Ackenbeigh approach, and WRDG denotes Woolridge approach.

Table A-4: Labour and Capital Elasticities by 3-digit ISIC Sector (2)

Subsector	**LP**		**ACF**		**WRDG**	
	Labour	Capital	Labour	Capital	Labour	Capital
Meat Processing	0.57	0.19	0.72	0.48	0.68	0.29
Metal & Machinery Repair	0.44	0.29	9.43	-0.02	0.57	0.30
Motor Vehicles	0.42	0.20			0.67	0.26
Other Basic Metals	0.61	0.15	1.02	-0.02	0.72	0.20
Other Chemicals	0.38	0.28	0.90	0.39	0.47	0.27
Other Electrical Devices	0.47	0.10	1.20	0.11	0.86	0.14
Other Electronic Equipments	0.48	0.27			0.59	0.19
Other Food Products	0.38	0.36	0.97	0.59	0.44	0.37
Other Manufacturing	0.67	0.21			0.75	0.18
Other Metal Goods	0.46	0.28			0.57	0.30
Other Non-Metal Minerals	0.44	0.29	1.30	0.44	0.46	0.32
Other Textiles	0.42	0.28	1.01	0.42	0.52	0.26
Other Transport Equipment	0.40	0.26			0.55	0.17
Paper Products	0.44	0.19	5.41	0.09	0.51	0.20
Pharmaceuticals Medicine	0.49	0.21			0.59	0.23
Prefabricated Metal Goods	0.56	0.27	10.60	0.06	0.74	0.29
Printing & Media Reproduction	0.43	0.30	1.03	0.45	0.56	0.25
Rubber & Plastic Products	0.42	0.28			0.51	0.27
Ship & Boat Building	0.48	0.34	-26.48	0.88	0.55	0.39
Special Machinery	0.33	0.25	2.71	0.33	0.42	0.26
Spinning & Finishing of Textile	0.35	0.28	0.86	0.38	0.46	0.25
Sports Equipment	0.40	0.16	0.93	0.20	0.62	0.20
Tobacco Processing	0.23	0.34			0.31	0.30
Toys & Games	0.40	0.18			0.58	0.20
Vehicle Bodies & Trailers	0.19	0.24	0.83	0.50	0.40	0.24
Vehicle Parts and Others	0.23	0.14	1.01	0.50	0.32	0.20
Woods	0.40	0.37	0.78	0.50	0.53	0.32

Note: LP denotes Levinsohn-Petrin approach, ACF denotes Ackenbeigh approach, and WRDG denotes Woolridge approach.

Table A-5: First-Stage: Basic Results–Horizontal Spillovers

	(1) φ	(2) $\Delta\varphi$
LabBartik-IV	18.917***	19.060***
	(0.746)	(0.757)
Foreign-Owned	1.938***	1.817***
	(0.469)	(0.489)
Exporters	-0.673**	-0.611**
	(0.264)	(0.281)
Imports	0.878	0.959*
	(0.559)	(0.580)
Abs	0.002	-0.025
	(0.079)	(0.082)
HHI	11.083***	10.598***
	(1.403)	(1.487)
Constant	35.392***	35.816***
	(1.264)	(1.326)
Sector-Province-Island-Year FE	Yes	Yes
F-statistics	130.184	125.061
Observations	198665	180625

Note: Clustered-robust standard errors are in parentheses and in firm level. Bartik-IV from labour-based ($LabBartikIV$) is used as IV for $HSpill$. φ denotes dependent variable of TFP level, while $\Delta\varphi$ denotes dependent variable for TFP growth. All estimations use Sector-Province-Island-Year Fixed-Effects. ***, **, * denote α at 1%, 5%, and 10%. *Abs* denotes absorptive capacity. HHI denotes market concentration from Herfindahl-Hirschman Index.

Table A-6: First-Stage: Basic Results–Backward Spillovers

	(1) φ	(2) $\Delta\varphi$
TarrBartik-IV	-0.365***	-0.421***
	(0.034)	(0.036)
Foreign-Owned	2.034***	1.978***
	(0.438)	(0.458)
Exporters	1.117***	1.138***
	(0.270)	(0.288)
Imports	0.190	0.304
	(0.517)	(0.537)
Abs	0.439***	0.410***
	(0.084)	(0.088)
HHI	11.944***	11.051***
	(1.359)	(1.444)
Constant	26.263***	26.937***
	(1.348)	(1.417)
Sector-Province-Island-Year FE	Yes	Yes
F-statistics	42.992	42.916
Observations	200440	182093

Note: Clustered-robust standard errors are in parentheses and in firm level. Bartik-IV from output-based ($TarrBartikIV$) is used as IV for $BSpill$. φ denotes dependent variable of TFP level, while $\Delta\varphi$ denotes dependent variable for TFP growth. All estimations use Sector-Province-Island-Year Fixed-Effects. ***, **, * denote α at 1%, 5%, and 10%. *Abs* denotes absorptive capacity. HHI denotes market concentration from Herfindahl-Hirschman Index.

Table A-7: First-Stage: Basic Results–Forward Spillovers

	(1) φ	(2) $\Delta\varphi$
TarrBartik-IV	-0.251***	-0.244***
	(0.039)	(0.041)
Foreign-Owned	1.393**	1.341*
	(0.655)	(0.692)
Exporters	0.670**	0.752**
	(0.337)	(0.357)
Imports	0.487	0.467
	(0.730)	(0.766)
Abs	0.010	0.003
	(0.094)	(0.098)
HHI	1.170	1.454
	(0.954)	(1.029)
Constant	21.066***	21.238***
	(1.516)	(1.592)
Sector-Province-Island-Year FE	Yes	Yes
F-statistics	10.423	9.059
Observations	200440	182093

Note: Clustered-robust standard errors are in parentheses and in firm level. Bartik-IV from output-based ($TarrBartikIV$) is used as IV for $FSpill$. φ denotes dependent variable of TFP level, while $\Delta\varphi$ denotes dependent variable for TFP growth. All estimations use Sector-Province-Island-Year Fixed-Effects. ***, **, * denote α at 1%, 5%, and 10%. *Abs* denotes absorptive capacity. HHI denotes market concentration from Herfindahl-Hirschman Index.

Table A-8: Basic Results–Horizontal Spillovers with Inverse Probability Weighting (IPW)

	(1) φ	(2) $\Delta\varphi$	(3) φ	(4) $\Delta\varphi$	(5) φ	(6) $\Delta\varphi$
HSpill	0.007***	0.004***	0.008***	0.004***	0.006***	0.004***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Foreign-Owned	0.436***	-0.213***	0.634***	-0.306*	0.435***	-0.213***
	(0.020)	(0.030)	(0.124)	(0.168)	(0.020)	(0.030)
Exporters	0.175***	-0.136***	0.175***	-0.136***	-0.094	-0.165
	(0.011)	(0.017)	(0.011)	(0.017)	(0.093)	(0.117)
Imports	0.398***	-0.063**	0.398***	-0.063**	0.390***	-0.064**
	(0.023)	(0.032)	(0.023)	(0.032)	(0.023)	(0.032)
Abs	0.502***	0.225***	0.502***	0.225***	0.499***	0.225***
	(0.004)	(0.005)	(0.004)	(0.005)	(0.005)	(0.005)
HHI	-0.047	-0.056	-0.039	-0.060	-0.048	-0.056
	(0.053)	(0.059)	(0.053)	(0.059)	(0.053)	(0.059)
HSpill × *Foreign-Owned*			-0.006	0.003		
			(0.004)	(0.005)		
HSpill × *Exporters*					0.009***	0.001
					(0.003)	(0.004)
Sector-Province-Island-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Kleibergen-Paap Wald F-stat	642.907	632.546	45.756	56.611	25.076	22.615
Cragg-Donald Wald F-stat	9131.718	8604.306	2178.942	2265.609	2173.753	2066.671
Observations	198665	180625	198665	180625	198665	180625

Note: Clustered-robust standard errors are in parentheses and in firm level. Bartik-IV from labour-based ($LabBartikIV$) is used as IV for $HSpill$. φ denotes dependent variable of TFP level, while $\Delta\varphi$ denotes dependent variable for TFP growth. All estimations use Sector-Province-Island-Year Fixed-Effects. Observations only consist of non-superstar firms. ***, **, * denote α at 1%, 5%, and 10%. *Abs* denotes absorptive capacity. HHI denotes market concentration from Herfindahl-Hirschman Index. φ and $\Delta\varphi$ denote total factor productivity in level and growth, respectively.

Table A-9: Basic Results–Backward Spillovers with Inverse Probability Weighting (IPW)

	(1) φ	(2) $\Delta\varphi$	(3) φ	(4) $\Delta\varphi$	(5) φ	(6) $\Delta\varphi$
BSpill	0.153***	0.123***	0.140***	0.114***	0.154***	0.123***
	(0.023)	(0.022)	(0.022)	(0.020)	(0.023)	(0.022)
Foreign-Owned	0.129	-0.450***	0.138*	-0.450***	0.130	-0.451***
	(0.083)	(0.076)	(0.073)	(0.068)	(0.084)	(0.075)
Exporters	-0.002	-0.276***	0.029	-0.246***	-0.273	-0.003
	(0.049)	(0.046)	(0.047)	(0.041)	(0.794)	(0.950)
Imports	0.374***	-0.085	0.374***	-0.083	0.376***	-0.086
	(0.083)	(0.073)	(0.069)	(0.061)	(0.084)	(0.072)
Abs	0.435***	0.173***	0.481***	0.229***	0.429***	0.178***
	(0.017)	(0.015)	(0.023)	(0.020)	(0.023)	(0.023)
HHI	-1.817***	-1.375***	3.786*	5.208**	-1.853***	-1.335***
	(0.341)	(0.301)	(2.091)	(2.089)	(0.356)	(0.334)
BSpill × *High-Concentration*			-0.089***	-0.104***		
			(0.033)	(0.034)		
BSpill × *Exporters*					0.012	-0.012
					(0.036)	(0.043)
Sector-Province-Island-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Kleibergen-Paap Wald F-stat	111.055	138.292	37.522	113.606	57.459	56.091
Cragg-Donald Wald F-stat	13.287	16.868	8.732	10.703	6.345	7.620
Observations	200440	182093	200440	182093	200440	182093

Note: Clustered-robust standard errors are in parentheses and in firm level. Bartik-IV from output-based ($TarrBartikIV$) is used as IV for $BSpill$. φ denotes dependent variable of TFP level, while $\Delta\varphi$ denotes dependent variable for TFP growth. All estimations use Sector-Province-Island-Year Fixed-Effects. Observations only consist of non-superstar firms. ***, **, * denote α at 1%, 5%, and 10%. *Abs* denotes absorptive capacity. HHI denotes market concentration from Herfindahl-Hirschman Index. φ and $\Delta\varphi$ denote total factor productivity in level and growth, respectively.

Table A-10: Basic Results–Forward Spillovers with Inverse Probability Weighting (IPW)

	(1) φ	(2) $\Delta\varphi$	(3) φ	(4) $\Delta\varphi$	(5) φ	(6) $\Delta\varphi$
FSpill	0.225***	0.215***	0.142***	0.127***	0.226***	0.216***
	(0.045)	(0.050)	(0.025)	(0.029)	(0.045)	(0.050)
Foreign-Owned	0.125	-0.497***	0.222*	-0.393***	0.129	-0.488***
	(0.169)	(0.173)	(0.120)	(0.120)	(0.165)	(0.165)
Exporters	0.016	-0.300***	0.068	-0.242***	0.483	0.518
	(0.081)	(0.086)	(0.058)	(0.060)	(1.018)	(1.000)
Imports	0.291*	-0.149	0.325***	-0.115	0.267	-0.192
	(0.168)	(0.169)	(0.123)	(0.121)	(0.171)	(0.171)
Abs	0.498***	0.222***	0.485***	0.205***	0.505***	0.232***
	(0.022)	(0.022)	(0.018)	(0.017)	(0.026)	(0.025)
HHI	-0.221	-0.298	-4.274***	-4.552***	-0.234	-0.305
	(0.222)	(0.236)	(1.259)	(1.299)	(0.224)	(0.233)
FSpill × *High-Concentration*			0.067***	0.070***		
			(0.020)	(0.021)		
FSpill × *Exporters*					-0.027	-0.047
					(0.060)	(0.058)
Sector-Province-Island-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Kleibergen-Paap Wald F-stat	39.272	33.784	45.121	39.465	20.298	17.612
Cragg-Donald Wald F-stat	4.686	4.175	3.754	3.366	2.385	2.131
Observations	200440	182093	200440	182093	200440	182093

Note: Clustered-robust standard errors are in parentheses and in firm level. Bartik-IV from output-based ($TarrBartikIV$) is used as IV for $FSpill$. φ denotes dependent variable of TFP level, while $\Delta\varphi$ denotes dependent variable for TFP growth. All estimations use Sector-Province-Island-Year Fixed-Effects. Observations only consist of non-superstar firms. ***, **, * denote α at 1%, 5%, and 10%. *Abs* denotes absorptive capacity. HHI denotes market concentration from Herfindahl-Hirschman Index. φ and $\Delta\varphi$ denote total factor productivity in level and growth, respectively.

Table A-11: First-Stage: Basic Results–Horizontal Spillovers with Inverse Probability Weighting (IPW)

	(1) φ	(2) $\Delta\varphi$
LabBartik-IV	18.896***	19.042***
	(0.745)	(0.757)
Foreign-Owned	1.936***	1.811***
	(0.469)	(0.488)
Exporters	-0.667**	-0.604**
	(0.264)	(0.281)
Imports	0.825	0.912
	(0.558)	(0.578)
Abs	-0.001	-0.026
	(0.079)	(0.082)
HHI	11.188***	10.716***
	(1.410)	(1.495)
Constant	35.361***	35.778***
	(1.268)	(1.330)
Sector-Province-Island-Year FE	Yes	Yes
F-statistics	130.067	124.938
Observations	198665	180625

Note: Clustered-robust standard errors are in parentheses and in firm level. Bartik-IV from labour-based ($LabBartikIV$) is used as IV for $HSpill$. φ denotes dependent variable of TFP level, while $\Delta\varphi$ denotes dependent variable for TFP growth. All estimations use Sector-Province-Island-Year Fixed-Effects. ***, **, * denote α at 1%, 5%, and 10%. *Abs* denotes absorptive capacity. HHI denotes market concentration from Herfindahl-Hirschman Index.

Table A-12: First-Stage: Basic Results–Backward Spillovers with Inverse Probability Weighting (IPW)

	(1) φ	(2) $\Delta\varphi$
TarrBartik-IV	-0.363***	-0.420***
	(0.034)	(0.036)
Foreign-Owned	2.024***	1.968***
	(0.438)	(0.458)
Exporters	1.110***	1.132***
	(0.269)	(0.287)
Imports	0.147	0.267
	(0.515)	(0.535)
Abs	0.435***	0.407***
	(0.084)	(0.088)
HHI	12.071***	11.189***
	(1.367)	(1.453)
Constant	26.212***	26.886***
	(1.350)	(1.420)
Sector-Province-Island-Year FE	Yes	Yes
F-statistics	42.493	42.463
Observations	200440	182093

Note: Clustered-robust standard errors are in parentheses and in firm level. Bartik-IV from output-based ($TarrBartikIV$) is used as IV for $BSpill$. φ denotes dependent variable of TFP level, while $\Delta\varphi$ denotes dependent variable for TFP growth. All estimations use Sector-Province-Island-Year Fixed-Effects. ***, **, * denote α at 1%, 5%, and 10%. *Abs* denotes absorptive capacity. HHI denotes market concentration from Herfindahl-Hirschman Index.

Table A-13: First-Stage: Basic Results–Forward Spillovers with Inverse Probability Weighting (IPW)

	(1) φ	(2) $\Delta\varphi$
TarrBartik-IV	-0.248***	-0.240***
	(0.040)	(0.041)
Foreign-Owned	1.397**	1.344*
	(0.662)	(0.699)
Exporters	0.676**	0.758**
	(0.338)	(0.358)
Imports	0.472	0.450
	(0.730)	(0.765)
Abs	0.012	0.004
	(0.095)	(0.099)
HHI	1.124	1.403
	(0.959)	(1.035)
Constant	21.004***	21.195***
	(1.529)	(1.605)
Sector-Province-Island-Year FE	Yes	Yes
F-statistics	10.086	8.769
Observations	200440	182093

Note: Clustered-robust standard errors are in parentheses and in firm level. Bartik-IV from output-based ($TarrBartikIV$) is used as IV for $FSpill$. φ denotes dependent variable of TFP level, while $\Delta\varphi$ denotes dependent variable for TFP growth. All estimations use Sector-Province-Island-Year Fixed-Effects. ***, **, * denote α at 1%, 5%, and 10%. *Abs* denotes absorptive capacity. HHI denotes market concentration from Herfindahl-Hirschman Index.

Table A-14: Heterogeneous Superstars: Foreign and Domestic–First Stage

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Foreign		Domestic		Foreign		Domestic		Foreign		Domestic	
	φ	$\Delta\varphi$	φ	$\Delta\varphi$	φ	$\Delta\varphi$	φ	$\Delta\varphi$	φ	$\Delta\varphi$	φ	$\Delta\varphi$
LabBartik-IV	2.952***	2.923***	8.373***	8.128***								
	(0.149)	(0.152)	(0.447)	(0.441)								
TarrBartik-IV					-2.454***	-4.130***	-0.413***	-0.391***	-0.770***	-1.472***	-0.363***	-0.353***
					(0.160)	(0.200)	(0.030)	(0.030)	(0.112)	(0.124)	(0.019)	(0.020)
Foreign-Owned	1.509***	1.402***	-0.155	-0.112	0.977***	0.884***	0.544*	0.599*	1.182***	1.166***	-0.176	-0.194
	(0.284)	(0.293)	(0.320)	(0.337)	(0.282)	(0.292)	(0.291)	(0.307)	(0.265)	(0.281)	(0.407)	(0.431)
Exporters	-0.483***	-0.490***	-1.140***	-1.112***	-0.031	-0.055	0.112	0.108	-0.141	-0.127	-0.278	-0.241
	(0.127)	(0.134)	(0.168)	(0.180)	(0.134)	(0.143)	(0.167)	(0.178)	(0.112)	(0.123)	(0.200)	(0.208)
Imports	1.378***	1.514***	-0.752**	-0.749**	0.960***	1.107***	-1.018***	-1.009***	1.337***	1.358***	-0.568	-0.566
	(0.351)	(0.365)	(0.363)	(0.380)	(0.350)	(0.365)	(0.325)	(0.341)	(0.311)	(0.325)	(0.448)	(0.468)
Abs	0.025	0.001	-0.385***	-0.420***	0.025	-0.024	0.088	0.079	0.027	-0.019	-0.025	0.005
	(0.046)	(0.049)	(0.064)	(0.067)	(0.049)	(0.051)	(0.059)	(0.062)	(0.036)	(0.039)	(0.072)	(0.074)
HHI	0.020	-0.500	14.161***	13.760***	2.299***	1.844***	15.695***	14.767***	-2.834***	-2.900***	11.594***	11.381***
	(0.641)	(0.666)	(1.150)	(1.210)	(0.479)	(0.495)	(1.185)	(1.255)	(0.405)	(0.411)	(0.871)	(0.929)
Constant	7.446***	7.807***	22.623***	23.285***	6.777***	7.617***	15.483***	15.819***	3.255***	4.017***	10.690***	10.192***
	(0.747)	(0.786)	(1.033)	(1.087)	(0.790)	(0.825)	(0.945)	(1.001)	(0.590)	(0.636)	(1.168)	(1.199)
Sector-Province-Island-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-statistics	77.202	71.628	98.873	92.317	45.986	75.754	56.495	47.097	30.399	51.396	77.139	67.759
Observations	198665	180625	198665	180625	200440	182093	200440	182093	200440	182093	200440	182093

Note: Clustered-robust standard errors are in parentheses and in firm level. Bartik-IV from labour-based and output growth ($LabBartikIV$) is used as IV for $HSpill$, while Bartik-IV from output-based and tariff ($TarrBartikIV$) is used as IV for $BSpill$ adn $FSpill$. $Foreign$ denotes foreign superstar spillovers, while $Domestic$ denotes domestic foreign spillovers. Both foreign and domestic superstars are non-exporters. φ denotes dependent variable of TFP level, while $\Delta\varphi$ denotes dependent variable for TFP growth. All estimations use Sector-Province-Island-Year Fixed-Effects. Observations only consist of non-superstar firms. ***, **, * denote α at 1%, 5%, and 10%. *Abs* denotes absorptive capacity. HHI denotes market concentration from Herfindahl-Hirschman Index. φ and $\Delta\varphi$ denote total factor productivity in level and growth, respectively.

Table A-15: Robustness Results–Large and Medium Observations

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	φ		$\Delta\varphi$		φ		$\Delta\varphi$		φ		$\Delta\varphi$	
	M	L	M	L	M	L	M	L	M	L	M	L
HSpill	0.004***	0.009***	0.002	0.006**								
	(0.001)	(0.002)	(0.001)	(0.003)								
BSpill					0.165***	0.105**	0.120***	0.129**				
					(0.027)	(0.042)	(0.024)	(0.060)				
FSpill									0.216***	0.174*	0.195***	0.222*
									(0.044)	(0.091)	(0.049)	(0.134)
Foreign-Owned	0.432***	0.205***	-0.313***	-0.180***	-0.096	0.133**	-0.674***	-0.263***	-0.369	0.323**	-1.056***	0.007
	(0.030)	(0.022)	(0.051)	(0.037)	(0.142)	(0.064)	(0.121)	(0.088)	(0.292)	(0.144)	(0.303)	(0.207)
Exporters	0.031**	-0.093***	-0.155***	-0.179***	-0.236***	-0.161***	-0.345***	-0.272***	-0.076	-0.126	-0.278***	-0.223*
	(0.014)	(0.016)	(0.021)	(0.024)	(0.076)	(0.050)	(0.064)	(0.071)	(0.098)	(0.085)	(0.098)	(0.116)
Imports	0.233***	0.272***	-0.000	-0.156***	-0.004	0.329***	-0.175	-0.088	0.272	0.188	0.049	-0.273
	(0.026)	(0.029)	(0.042)	(0.046)	(0.136)	(0.078)	(0.110)	(0.103)	(0.202)	(0.187)	(0.193)	(0.256)
Abs	0.449***	0.396***	0.244***	0.170***	0.366***	0.376***	0.187***	0.142***	0.452***	0.362***	0.247***	0.128**
	(0.004)	(0.011)	(0.005)	(0.012)	(0.021)	(0.022)	(0.017)	(0.030)	(0.024)	(0.043)	(0.022)	(0.058)
HHI	0.117**	-0.346***	-0.004	-0.170	-1.181***	-2.380**	-0.738***	-2.781**	0.007	-0.723*	-0.123	-0.757
	(0.055)	(0.103)	(0.071)	(0.123)	(0.325)	(0.931)	(0.254)	(1.327)	(0.267)	(0.420)	(0.269)	(0.596)
Sector-Province-Island-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Kleibergen-Paap Wald F-stat	745.526	181.960	717.617	176.984	80.562	42.798	104.028	37.075	38.471	7.369	31.459	5.766
Cragg-Donald Wald F-stat	6822.894	2192.120	6392.581	2112.548	10.763	3.439	14.330	2.907	4.861	0.872	4.219	0.684
Observations	148091	50574	133532	47093	148943	51497	134243	47850	148943	51497	134243	47850

Note: Clustered-robust standard errors are in parentheses and in firm level. Bartik-IV from labour-based and output growth ($LabBartikIV$) is used as IV for $HSpill$, while Bartik-IV from output-based and tariff ($TarrBartikIV$) is used as IV for $BSpill$ adn $FSpill$. $Foreign$ denotes foreign superstar spillovers, while $Domestic$ denotes domestic foreign spillovers. Both foreign and domestic superstars are non-exporters. φ denotes dependent variable of TFP level, while $\Delta\varphi$ denotes dependent variable for TFP growth. All estimations use Sector-Province-Island-Year Fixed-Effects. Observations only consist of non-superstar firms. ***, **, * denote α at 1%, 5%, and 10%. *Abs* denotes absorptive capacity. HHI denotes market concentration from Herfindahl-Hirschman Index. φ and $\Delta\varphi$ denote total factor productivity in level and growth, respectively.

Table A-16: Robustness Test: Alternative IV–Horizontal Spillovers

	(1) φ	(2) $\Delta\varphi$	(3) φ	(4) $\Delta\varphi$	(5) φ	(6) $\Delta\varphi$
HSpill	0.007***	0.004***	0.007***	0.003**	0.006***	0.003***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Foreign-Owned	0.439***	-0.212***	0.614***	-0.343**	0.438***	-0.212***
	(0.020)	(0.030)	(0.125)	(0.172)	(0.020)	(0.030)
Exporters	0.176***	-0.136***	0.176***	-0.136***	-0.104	-0.174
	(0.011)	(0.017)	(0.011)	(0.017)	(0.093)	(0.117)
Imports	0.400***	-0.061*	0.400***	-0.061*	0.391***	-0.062*
	(0.023)	(0.032)	(0.023)	(0.032)	(0.023)	(0.032)
Abs	0.502***	0.225***	0.502***	0.225***	0.499***	0.225***
	(0.004)	(0.005)	(0.004)	(0.005)	(0.005)	(0.005)
HHI	-0.039	-0.049	-0.032	-0.055	-0.040	-0.050
	(0.052)	(0.059)	(0.052)	(0.059)	(0.053)	(0.059)
HSpill × *Foreign-Owned*			-0.006	0.004		
			(0.004)	(0.005)		
HSpill × *Exporters*					0.010***	0.001
					(0.003)	(0.004)
Sector-Province-Island-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Kleibergen-Paap Wald F-stat	620.648	610.174	40.020	49.453	23.678	21.473
Cragg-Donald Wald F-stat	9169.872	8649.320	2188.689	2283.008	2189.000	2083.583
Observations	198665	180625	198665	180625	198665	180625

Note: Clustered-robust standard errors are in parentheses and in firm level. Bartik-IV from labour-based (both skilled and unskilled) ($LabBartikIV$) is used as IV for $HSpill$. φ denotes dependent variable of TFP level, while $\Delta\varphi$ denotes dependent variable for TFP growth. All estimations use Sector-Province-Island-Year Fixed-Effects. Observations only consist of non-superstar firms. ***, **, * denote α at 1%, 5%, and 10%. *Abs* denotes absorptive capacity. HHI denotes market concentration from Herfindahl-Hirschman Index. φ and $\Delta\varphi$ denote total factor productivity in level and growth, respectively. The results with Inverse Probability Weighting are reported in the Appendix in Table A-8.

Table A-17: Robustness Test: Alternative IV–Backward Spillovers

	(1) φ	(2) $\Delta\varphi$	(3) φ	(4) $\Delta\varphi$	(5) φ	(6) $\Delta\varphi$
BSpill	0.025***	0.019***	0.024***	0.019***	0.030***	0.022***
	(0.006)	(0.007)	(0.006)	(0.006)	(0.008)	(0.008)
Foreign-Owned	0.397***	-0.242***	0.398***	-0.241***	0.392***	-0.244***
	(0.025)	(0.033)	(0.024)	(0.033)	(0.029)	(0.035)
Exporters	0.147***	-0.162***	0.148***	-0.160***	-0.350	-0.558**
	(0.014)	(0.019)	(0.014)	(0.019)	(0.243)	(0.262)
Imports	0.386***	-0.053	0.386***	-0.053	0.389***	-0.053
	(0.026)	(0.033)	(0.025)	(0.033)	(0.029)	(0.035)
Abs	0.500***	0.217***	0.502***	0.218***	0.489***	0.209***
	(0.005)	(0.006)	(0.005)	(0.006)	(0.009)	(0.009)
HHI	-0.272***	-0.180*	-0.127	-0.050	-0.374***	-0.256**
	(0.089)	(0.092)	(0.077)	(0.087)	(0.129)	(0.128)
BSpill times High-Concentration			-0.002*	-0.002		
			(0.001)	(0.001)		
BSpill times Exporters					0.023**	0.018
					(0.011)	(0.012)
Sector-Province-Island-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Kleibergen-Paap Wald F-stat	78.842	83.947	48.025	50.400	14.597	15.104
Cragg-Donald Wald F-stat	112.961	124.568	67.418	73.225	26.134	30.432
Observations	214620	183074	214620	183074	214620	183074

Note: Clustered-robust standard errors are in parentheses and in firm level. Average Road Density is used as IV for *BSpill*. φ denotes dependent variable of TFP level, while $\Delta\varphi$ denotes dependent variable for TFP growth. All estimations use Sector-Province-Island-Year Fixed-Effects. Observations only consist of non-superstar firms. ***, **, * denote α at 1%, 5%, and 10%. *Abs* denotes absorptive capacity. *HHI* denotes market concentration from Herfindahl-Hirschman Index. φ and $\Delta\varphi$ denote total factor productivity in level and growth, respectively. The results with Inverse Probability Weighting are reported in the Appendix in Table A-9.

Table A-18: Robustness Test: Alternative IV–Forward Spillovers

	(1) φ	(2) $\Delta\varphi$	(3) φ	(4) $\Delta\varphi$	(5) φ	(6) $\Delta\varphi$
FSpill	0.018***	0.014***	0.018***	0.014***	0.018***	0.015**
	(0.004)	(0.005)	(0.004)	(0.005)	(0.005)	(0.006)
Foreign-Owned	0.422***	-0.223***	0.422***	-0.223***	0.422***	-0.223***
	(0.023)	(0.032)	(0.023)	(0.032)	(0.023)	(0.032)
Exporters	0.165***	-0.149***	0.165***	-0.149***	0.155	-0.104
	(0.012)	(0.017)	(0.012)	(0.018)	(0.228)	(0.370)
Imports	0.380***	-0.056*	0.380***	-0.056*	0.381***	-0.058
	(0.025)	(0.033)	(0.025)	(0.033)	(0.027)	(0.037)
Abs	0.510***	0.224***	0.510***	0.224***	0.510***	0.225***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)	(0.007)
HHI	-0.001	0.005	-0.040	0.009	-0.001	0.005
	(0.051)	(0.058)	(0.077)	(0.094)	(0.051)	(0.058)
FSpill × *High-Concentration*			0.001	-0.000		
			(0.001)	(0.001)		
FSpill × *Exporters*					0.001	-0.003
					(0.014)	(0.022)
Sector-Province-Island-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Kleibergen-Paap Wald F-stat	162.107	154.517	79.508	75.566	7.041	2.881
Cragg-Donald Wald F-stat	175.538	174.592	86.419	84.925	54.279	37.561
Observations	214620	183074	214620	183074	214620.	183074

Note: Clustered-robust standard errors are in parentheses and in firm level. Average Road Density is used as IV for *FSpill*. φ denotes dependent variable of TFP level, while $\Delta\varphi$ denotes dependent variable for TFP growth. All estimations use Sector-Province-Island-Year Fixed-Effects. Observations only consist of non-superstar firms. ***, **, * denote α at 1%, 5%, and 10%. *Abs* denotes absorptive capacity. *HHI* denotes market concentration from Herfindahl-Hirschman Index. φ and $\Delta\varphi$ denote total factor productivity in level and growth, respectively. The results with Inverse Probability Weighting are reported in the Appendix in Table A-10.

Table A-19: Robustness Test: Heterogeneous Superstar – Simple Productivity (Value-added per Workers)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Foreign		Domestic		Foreign		Domestic		Foreign		Domestic	
	φ	$\Delta\varphi$	φ	$\Delta\varphi$	φ	$\Delta\varphi$	φ	$\Delta\varphi$	φ	$\Delta\varphi$	φ	$\Delta\varphi$
HSpill	-0.001	0.009*	0.020***	0.006**								
	(0.003)	(0.005)	(0.002)	(0.003)								
BSpill					0.021***	0.012**	0.109***	0.063***				
					(0.005)	(0.006)	(0.012)	(0.015)				
FSpill									0.105***	0.064*	0.126***	0.069***
									(0.036)	(0.037)	(0.012)	(0.016)
Foreign-Owned	0.320***	-0.103***	0.319***	-0.093***	0.295***	-0.107***	0.259***	-0.127***	0.203***	-0.164***	0.346***	-0.075**
	(0.016)	(0.028)	(0.016)	(0.028)	(0.016)	(0.028)	(0.030)	(0.033)	(0.048)	(0.051)	(0.043)	(0.036)
Exporters	-0.079***	-0.173***	-0.063***	-0.172***	-0.082***	-0.176***	-0.091***	-0.180***	-0.056***	-0.159***	-0.051**	-0.160***
	(0.010)	(0.016)	(0.010)	(0.016)	(0.010)	(0.016)	(0.019)	(0.018)	(0.017)	(0.020)	(0.024)	(0.020)
Imports	0.415***	-0.181***	0.434***	-0.161***	0.373***	-0.180***	0.517***	-0.100***	0.268***	-0.246***	0.424***	-0.155***
	(0.018)	(0.030)	(0.017)	(0.029)	(0.019)	(0.030)	(0.035)	(0.036)	(0.057)	(0.058)	(0.046)	(0.038)
Abs	0.630***	0.260***	0.635***	0.262***	0.628***	0.259***	0.619***	0.256***	0.620***	0.257***	0.631***	0.261***
	(0.004)	(0.005)	(0.004)	(0.005)	(0.004)	(0.005)	(0.007)	(0.006)	(0.006)	(0.006)	(0.009)	(0.007)
HHI	-0.245***	-0.119**	-0.553***	-0.220***	-0.304***	-0.131***	-2.156***	-1.207***	0.045	0.096	-1.468***	-0.788***
	(0.040)	(0.046)	(0.054)	(0.065)	(0.042)	(0.047)	(0.228)	(0.263)	(0.120)	(0.130)	(0.148)	(0.169)
Sector-Province-Island-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Kleibergen-Paap Wald F-stat	499.125	476.998	491.617	476.706	224.731	236.035	260.619	244.147	13.648	12.728	483.616	487.201
Cragg-Donald Wald F-stat	1575.424	1517.495	3922.154	3659.963	157.055	169.346	58.145	52.525	10.076	9.410	30.307	30.987
Observations	299497	275658	299497	275658	302461	278074	302461	278074	302461	278074	302461	278074

Note: Clustered-robust standard errors are in parentheses and in firm level. Bartik-IV from labour-based and output growth ($LabBartikIV$) is used as IV for $HSpill$, while Bartik-IV from output-based and tariff ($TarrBartikIV$) is used as IV for $BSpill$ adn $FSpill$. $Foreign$ denotes foreign superstar spillovers, while $Domestic$ denotes domestic foreign spillovers. Both foreign and domestic superstars are non-exporters. φ denotes dependent variable of labour productivity level (in log), while $\Delta\varphi$ denotes dependent variable for labour productivity growth. All estimations use Sector-Province-Island-Year Fixed-Effects. Observations only consist of non-superstar firms. ***, **, * denote α at 1%, 5%, and 10%. Abs denotes absorptive capacity. HHI denotes market concentration from Herfindahl-Hirschman Index. φ and $\Delta\varphi$ denote total factor productivity in level and growth, respectively.

Table A-20: TFP Change from Dynamic OP Decomposition: Survivors, Exiters, and Entrants (Robustness Test)

Component	**Period**	**Superstar**			**Non-Superstar**
		Foreign-Owned	**Exporter**	**Large Firm**	
Plant Improvements	2001–2015	1.025	0.847	0.930	1.190
	2001–2010	0.664	0.551	0.520	0.598
	2001–2005	0.182	0.138	0.167	0.260
Reallocation within Survivors	2001–2015	-0.301	-0.787	-0.496	-0.619
	2001–2010	0.313	-0.947	0.520	-0.497
	2001–2005	-0.014	-0.634	0.079	-0.494
Reallocation: Exiters–Entrants	2001–2015	0.527	0.056	0.354	0.503
	2001–2010	-0.658	0.975	0.067	0.111
	2001–2005	0.053	0.103	-0.032	0.208

Note: Plant improvement refers to the change of unweighted average productivity for survivors ($\Delta\bar{\varphi}_t$), while Reallocation within Survivors refers to the change of covariance component within survivors, and Reallocation of Exiters-Entrants is the plant improvements and covariance component across group of survivors with entrants and exiters. Robustness test is based on the definition of superstar firms from Amiti et al. (2024).