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Does market characteristic determine foreign direct investment spillovers?

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ABSTRACT

This study examines the significance of foreign direct investment (FDI) and market characteristics both within and across industries in determining the productivity and efficiency of firms. This study also measures the total factor productivity (TFP) growth and its components for both foreign and domestic firms. Using Indonesian annual medium and large manufacturing establishments surveys, wholesale price index, and input-output (I-O) table, the authors calculate the horizontal and vertical spillovers and undertake stochastic frontier analysis to estimate the production and inefficiency function. The results show that the less concentrated market of domestic firms within the industry and suppliers reduces productivity and efficiency, while domestic buyers' less concentrated markets could have the opposite effect. Most domestic and foreign firms still experience deterioration in TFP growth. The policy recommendation is to encourage firms to improve technological progress, such as upgrading machines and investing in human resources, by providing training workers aiming at mastering better managerial expertise. Policymakers should also ensure that the benefits of FDI spillovers outweigh their disadvantages.

IMPACT STATEMENT

This study contributes to extending recent empirical literature on the possibility of spillovers in the Indonesian automotive industry not only from foreign firms within the industry, but also from potential externalities arising from downstream and upstream markets using stochastic frontier analysis (SFA). Generally, studies on FDI spillovers examine the role of FDI in explaining the efficiency differences measured by the distance to the frontier; however, few studies consider the impact of efficiency improvement and technological progress on productivity gains from FDI. This study attempts to capture the sources of productivity gains through both channels. The other studies have never discussed, based on author knowledge, the impact of spillovers regarding domestic firms' specific market concentration as competitors, buyers, or sellers to foreign firms on efficiency and productivity. This study aims to fill this gap and analyze the importance of market characteristics in determining spillovers, VTI, trade openness, and foreign ownership. Previous studies on market concentration employ the Herfindahl-Hirschman Index (HHI), while this study utilizes the relative entropy coefficient (RE) to provide another approach to measure market concentration. In this study, the industry-specific characteristic is controlled using the inclusion of firm size and industrial dummy variables. The SFA estimation results are calculated to measure output elasticity with respect to each input and total factor productivity (TFP) growth. The discussion provides TFP decompositions, which are technical efficiency change (TEC), technological progress (TC), and scale efficiency change (SEC).

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1. Introduction

Indonesia has historically been a preferred place for foreign direct investment (FDI) in Southeast Asia due to its wealth of natural resources, large labor supply, and expanding domestic market (Lindblad, 2015).

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This has given multinational corporations (MNCs) numerous options for internalization when selecting a location for their overseas operations. As reported by Indonesian Bureau of Statistics (2024), FDI inflow to Indonesia increased steadily between 2010 and 2020. By 2022, it accounted for 11% of all FDI inflow to ASEAN, making Indonesia the country with the second-highest FDI inflow after Singapore. This figure amounts to USD 24.7 billion (World Bank, 2024). In addition to being the primary driver of economic development, foreign direct investment (FDI) has aided Indonesia's industrialization process (Aswicahyono et al., 2011; Narjoko, 2023). Industrial development plays a significant role, especially in developing countries as it aid in reducing poverty and achieving sustainable economic growth (Abdul, 2010).

Extensive research has been undertaken on the spillovers of foreign direct investment (FDI). There are conflicting and inconsistent findings in the empirical literature that looks at how multinational corporations (MNCs) affect domestic firms' productivity performance. The majority of the early evidence is negative (Aitken & Harrison, 1999; Bournakis et al., 2022; Djankov & Hoekman, 2000; Huynh et al., 2021). On the contrary, FDI is regarded as a catalyst for economic growth (see, Behera, 2017; Damijan et al., 2003; Fatima, 2016; Görg & Greenaway, 2004; Harris & Robinson, 2003; He et al., 2019; Kayani et al., 2021; Liu, 2002; Nguyen, 2022). Additionally, FDI has admitted to being one of the primary means of disseminating information internationally. Gains from FDI spillovers in domestic enterprises are reported empirically by Blomström & Sjöholm (1999), Li et al. (2001), Haskel et al. (2002), Keller & Yeaple (2003), and Liu & Wang (2022). Nonetheless, the majority of these research concentrate on horizontal spillovers, which quantify how the presence of foreign companies affects native companies in a certain industry. The impact of foreign firms on domestic firms across industries is determined as vertical spillovers. The vertical spillovers can occur in two different linkages, namely backward and forward linkage. The former is the impact of foreign firms on the domestic firms in the upstream market when those domestic firms supply intermediate inputs to foreign firms. The latter is the impact on the downstream industries in using the foreign firm's output as their intermediate inputs.

There are few studies on externalities between industries (Blomström et al., 2000). A notable exception in the literature on vertical spillovers found mixed results (see, Blalock & Gertler, 2008; Javorcik, 2004; Kugler, 2001; Le & Pomfret, 2011; Marcin, 2008; Schoors & Van Der Tol, 2002). The research conducted by Blalock & Gertler (2008) found that the MNC firms' externalities are beneficial to the local firms as the suppliers in Indonesian manufacturing industries. Schoors & Van Der Tol (2002) examine positive backward spillovers, and the opposite holds for forward spillovers in Hungarian companies. Aitken & Harrison (1991) discover the negative backward spillovers since foreign firms demand imported goods, which prevents domestic suppliers from gaining economic of scale. Nguyen et al. (2020) found that backward spillovers increase local productivity but horizontal and forward linkage spillovers have a detrimental effect on domestic firms' productivity. Research from Bournakis et al. (2022) suggest that only MNCs that are majority or fully owned produce monetarily minor horizontal spillovers. Rodriguez-Clare (1996) suggests that the effect of FDI would be more favorable when the MNC firms demand intensively the intermediate goods produced by the domestic firms in the upstream market, and the quality is at least equal to the home country's products. When these required conditions do not hold, the host country's economy could be harmed. The primary finding from the literature on FDI spillovers to date is that MNCs' effects on domestic firms' performance are complex, and one should carefully examine the different ways that MNCs affect the host nation's economic activity (Bournakis et al., 2018; Crespo & Fontoura, 2007; Hayakawa et al., 2012).

Studies on FDI spillovers in Indonesia's manufacturing sector have previously been carried out utilizing the stochastic production frontier such as Suyanto et al. (2021), Suyanto et al. (2014), and Suyanto & Salim (2010). These studies focus on estimating the externalities of FDI on firms' efficiency. However, FDI not only improves domestic firms' efficiency but also generates productivity gains for domestic firms through technological progress. Only studies from Sari et al. (2016) and Sugiharti et al. (2022) use a simultaneous model to examine how FDI spillovers affect productivity and efficiency. Therefore, this study would enhance the literature related to productivity and inefficiency.

One of the key factors influencing the benefits of spillover FDI is the industrial market characteristic of the host nation (Blomström et al., 2000). The efficient-structure (ES) and quiet-life (QL) hypotheses are two competing theories that address degree concentration and efficiency. Advocates of QL, Hicks (1935) contends that significant market concentration lessens competition and lessens the ability of enterprises

to receive incentives for efficiency. The ES hypothesis proposes that the excessive concentration may have been caused by efficient enterprises. Studies on market characteristic have been focused on the role of market characteristic affects firms' efficiency. There only a few study explore the impact of market characteristic's role on spillover FDI. The exceptions are on the study from Sugiharti et al. (2022) and Suyanto et al. (2009). Sugiharti et al. (2022) concludes that higher market competition boosts industrial productivity within the industry which receives FDI. Study from Suyanto et al. (2009) has also confirmed that greater concentrations are linked to greater spillovers of foreign presence. Nevertheless, no study has ever examined how spillovers affect efficiency and productivity in light of domestic firms' distinct market concentration as foreign firms' customers or sellers.

Besides contributing to economic activity and productivity, MNC firms find advantages from sourcing inputs and producing abroad, fragmenting their production process and creating a new trade pattern that is vertical trade of integration (VTI). VTI presents locational advantages and productivity benefits through specialization in different stages of the production process. This vertical specialization exploits efficiency at each stage of the production by linking sequential products and facilities at several regions or countries (Miroudot & Ragoussis, 2009). MNC firms gain benefit from VTI since they serve foreign markets through foreign affiliates. However, another issue arises from VTI, which is additional cost such as distance-related cost.

This study contributes to extending recent empirical literature on the possibility of spillovers in the Indonesian automotive industry not only from foreign firms within the industry, but also from potential externalities arising from downstream and upstream markets using stochastic froentier analysis (SFA). Generally, studies on FDI spillovers examine the role of FDI in explaining the efficiency differences measured by the distance to the frontier; however, few studies consider the impact of efficiency improvement and technological progress on productivity gains from FDI (see, Kneller and Pisu, 2007; Ayyagari & Kosová, 2010; Sari, 2019; and Nguyen et al., 2021). This study attempts to capture the sources of productivity gains through both channels. The other studies have never discussed, based on author knowledge, the impact of spillovers regarding domestic firms' specific market concentration as competitors, buyers, or sellers to foreign firms on efficiency and productivity (see, Sari et al., 2016; Schoors & Van Der Tol, 2002; Suyanto & Salim, 2013). This study aims to fill this gap and analyze the importance of market characteristics in determining spillovers, VTI, trade openness, and foreign ownership. Previous studies on market concentration employ the Herfindahl-Hirschman Index (HHI), while this study utilizes the relative entropy coefficient (RE) to provide another approach to measure market concentration. It is noteworthy that RE shares characteristics with HHI and is an easy index to comprehend (Yi et al., 2018). In this study, the industry-specific characteristic is controlled using the inclusion of firm size and industrial dummy variables. The SFA estimation results are calculated to measure output elasticity with respect to each input and total factor productivity (TFP) growth. The discussion provides TFP decompositions, which are technical efficiency change (TEC), technological progress (TC), and scale efficiency change (SEC).

2. Literature review

Compared to local firms, multinational corporations (MNC) receive FDI using sophisticated technology and invest more in research and development (R&D). By exerting technological superiority, better managerial practice, and the ability to exploit economies of scale, MNC firms can establish subsidiary firms even in unexplored countries and compete against domestic firms (Blomström, & Sjöholm, 1999; Belderbos et al., 2021). Possessing knowledge-based intangible assets such as technological superiority, which may not be available in the host country, could create spillovers to domestic firms (Suyanto & Sugiarti, 2019).

Spillovers occurred in three channels. The first is the demonstration effect, defined as the process of domestic firms upgrading technology by imitating foreign firms' production processes, products, managerial skills, and organizational innovations. The second factor is labor turnover. Foreign firm workers are mostly trained or given access to intangible assets. As a result, productivity spillovers occur when trained labor eventually resigns and works in domestic firms or establishes their own business (De Mello, 1997; Fosfuri et al., 2001; Keller, 2021). The third factor was competition. Domestic firms are willing to protect their market share; therefore, they are forced to operate more efficiently, leading to productivity gains (Glass & Saggi, 2002; Li & Tanna, 2019). On contrary, because FDI-invested companies typically offer high

pay and incentives to draw and keep highly trained individuals, the wage disparity between foreign and domestic businesses also affects labor mobility (Huang & Zhang, 2017). Thus, labor churn and the transfer of labor from FDI firms to domestic firms are avoided (Demena, 2015; Gorodnichenko et al., 2014). Additionally, the presence of foreign companies may have a greater competition effect than the demonstration effect and vertical linking effect, which would be detrimental to domestic companies in the host market (Ascani & Gagliardi, 2020; Le & Pomfret, 2011). Furthermore, MNCs frequently boost competitiveness but "steal" market shares from domestic firms, which eventually results in productivity and efficiency losses. Domestic firms may suffer from the heightened level of competition in the short term by seeing a decline in output and market share (Lin et al., 2009). Domestic enterprises may experience crowding-out effect through decreasing productivity when these local firms distribute their fixed expenses over a lower sales volume, as demonstrated by Aitken & Harrison (1999). The entry of MNCs may result in higher labor costs for native companies. This is due to foreign-invested businesses frequently providing higher wages. This statement is strengthened by Aitken et al. (1996) who argue that in labor markets where there is competition, foreign firms may improve wages for all businesses. Bournakis et al. (2022) also explain that the domestic firms charge lower markups due to the greater presence of MNEs in the domestic market indicating that the presence of foreign firms push the domestic ones to compete. Therefore, the net horizontal effect of FDI on domestic enterprises is theoretically uncertain and depends on the relative strengths of the positive technical spillovers and the negative crowding-out effect.

Spillovers might not only take place intra-industry but also across the industry, which is revealed as vertical spillovers that occur through the supply chain channel and are divided into backward and forward spillovers. Backward spillovers exhibit a negative impact when foreign firms import intermediate inputs instead of buying intensively from the local upstream markets. Barrios et al. (2011) defines backward spillover as how the actions of foreign firms affect local suppliers' or providers' proactive adaptation to guarantee the standardization and quality of the local inputs supplied. This might be due to quality considerations, as the quality of intermediate inputs produced locally is lower than those purchased from abroad. Higher international requirements for product quality and consistent delivery motivate local suppliers to enhance their offerings and workflows in order to draw consistent business from FDI firms (Huynh et al., 2021). In contrast, positive backward spillovers arise when foreign firms transfer technology to domestic suppliers to increase the quality of intermediate inputs bought locally. Foreign firms demand high-quality intermediate inputs, forcing domestic suppliers to lessen inefficiency and improve productivity. Foreign firms are eager to transfer technology and provide technical assistance to several suppliers to avoid monopolies when they transfer only to one supplier (Abegaz & Lahiri, 2021; Blalock & Gertler, 2008). However, the inability to absorb some sorts of spillover effects is caused by poor production levels and a lack of worker training (Sarker & Serieux 2022). This is supported by the argument of Krasniqi et al. (2022) who state that domestic firms are unable to take advantage of the opportunity to integrate into global value chains where MNCs operate because they lack the quality standards, scale of production, and connective networks. In addition, one potential obstacle to backward spillovers is the weak absorptive ability of domestic businesses (Gorodnichenko et al., 2014). Newman et al. (2015) and Behera (2017) argued that forward spillovers can create two opposite effects. Negative forward spillovers occur when foreign firms in the (upstream market steal domestic firms' market share in the same industry, resulting in domestic competitors not competing. Foreign firms have the power to increase prices, while domestic firms in the downstream market suffer higher costs because of the increasing prices of intermediate inputs. In contrast, positive forward spillovers occur through foreign products usually accompanied by services or assistance to use the product efficiently, improving the productivity of domestic buyers (Javorcik, 2004; Yuliani et al., 2019). Another possibility is that domestic firms as buyers gain benefit from purchasing less-costly and high-quality intermediate inputs supplied by foreign firms in the upstream market. In contrast, research from Sarker & Serieux (2022) have found that forward spillovers are only experienced by the high-tech domestic firms possessing low-importing and low-exporting foreign investment firms.

Unlike previous researches, this study utilizes another measurement as a proxy of degree of concentration, which is the relative entropy coefficient (RE). It is noteworthy that RE is an easy index to be interpreted and having the same traits as HHI (Yi et al., 2018). Theoretically, there are two opposing hypotheses regarding degree concentration and efficiency, which are the quiet-life (QL) and efficient-

structure (ES) hypothesis. Hicks (1935) promotes QL and argues that the high market concentration reduces the competition and less likely to provide incentives firms to be efficient. On the contrary, the ES hypothesis suggests efficient firms might create the high concentration. Basically, efficient firms could produce at lower cost leading to higher profits and larger market share, thus resulting in efficient firms growing rapidly compared to inefficient firms (Demsetz, 1973). Another explanation is that MNC presence might intensify competitiveness in the market, pushing domestic companies to better leverage their resources to hold onto market share (Esquivias & Harianto, 2020). A higher output share from MNCs suggests a more concentrated market and reduced competition.

A few among many that have acknowledged the importance of market size in drawing in foreign direct investment (FDI) are Wheeler & Mody (1992), Schmitz & Bieri (1972), and Pistoresi (2000). Recent studies by Asiedu (2006), Mlambo (2006), and Zhang (2008) examined the critical role that market size plays in drawing in foreign direct investment. According to these authors, one thing that attracts foreign investors is a larger market. Market share is a crucial factor in determining foreign direct investment inflows, according to study by Mughal & Akram (2011). The impact of market concentration on efficiency has been thoroughly studied (see, Esquivias & Harianto, 2020; Sari et al., 2016; Setiawan et al., 2012; Sugiarti, 2019), but little study has been done on how market concentration interacts with the spillovers variable. The two studies by Suyanto et al. (2009). and Sugiharti et al. (2022) that examined the effects of market concentration on efficiency, and both efficiency and productivity respectively, stand out as noteworthy exceptions. However, these researches have never discussed, based on authors knowledge, the impact of spillovers based on domestic firms' specific market concentration as buyers or sellers to foreign firms on efficiency and productivity.

3. Methodological approach

3.1. Data and construction of variables

The data employed were annual medium and large manufacturing establishments, which were taken from the Indonesian Central Board of Statistics. The medium establishment survey includes the manufacturing firms employing from 20 to 99 workers while the large establishments employ more than 99 workers at a given year. The complementary data are the wholesale price index (WPI) at a constant price in 2010 and an input-output (I-O) table. The former is implemented to deflate the variables in the production function consisting of monetary data. The latter is utilized to generate vertical spillovers variables that measure the externalities in the upstream and downstream market. The I-O table captures the transaction of goods and services between 175 economic sectors.

The unbalanced panel data consists of 3,105 firms in the automotive industry from 2010 to 2014. The production and inefficiency function are estimated using these data. To calculate the Total Factor Productivity (TFP) growth, firm data should be available for all periods of observation to measure growth. For the purpose of computing TFP, this study employs balanced panel data with 469 observations per year, or 2,345 observations altogether.

This study will estimate through stochastic production function (SPF) consisting of output and input variables. Output is defined as the total output produced by a firm in a given year, measured in Rupiah, while capital is the monetary value of fixed assets: lands, buildings, machinery, vehicles, and other capital goods. Labor is measured through the number of employees worked in each firm, and material is a proxy for total expenditure on raw materials. Energy is the total cost of energy used in production processes, such as gasoline, diesel fuel, kerosene, public gas, lubricants, and electricity.

The cleaning data procedure follows Sari et al. (2016) who control the ratio of material input and output is controlled. The ratio less than 5% and more than 95% will be excluded since using small or huge amounts of materials to produce a certain quantity of outputs seems implausible. However, the data passes the criteria. Therefore, there is no observation excluded following these criteria. The data are cleaned from misreporting and key-punch errors, such as in foreign shares. For instance, the foreign share for a whole selected period is 100% except for one period typed as 0% then this will be corrected to 100%. During the observation period, firms corrected from domestic to foreign were 0.10% while the firms changed to domestic were 0.16%.

Table 1. Summary statistics.

Variables	Unit		Year				
			2010	2011	2012	2013	2014
Output and Input variables							
Output (Q)	Billion Rupiah	Mean	416.65	484.20	495.96	398.27	391.45
		Std. Dev.	2613.74	2462.17	2524.58	2043.21	1975.56
Capital (K)	Billion Rupiah	Mean	9.98	11.67	9.09	6.96	72.23
		Std. Dev.	72.08	64.29	61.87	40.98	564.91
Labor (L)	Person	Mean	312.68	342.95	349.86	333.74	323.63
		Std. Dev.	905.97	952.49	982.06	904.84	859.91
Material (M)	Billion Rupiah	Mean	145.55	211.29	200.82	148.09	132.53
		Std. Dev.	1152.94	1280.18	1215.35	718.03	598.58
Energy (E)	Billion Rupiah	Mean	15.39	26.13	21.50	17.19	15.73
		Std. Dev.	98.92	172.03	149.55	97.21	88.64
Exogenous variables							
Hspill	Ratio	Mean	0.05	0.39	0.38	0.55	0.39
		Std. Dev.	0.04	0.22	0.22	0.00	0.22
Bspill	Ratio	Mean	1.12	1.12	1.06	0.11	0.10
		Std. Dev.	0.26	0.27	0.24	0.08	0.07
Fspill	Ratio	Mean	1.17	1.17	1.01	0.94	0.10
		Std. Dev.	0.32	0.32	0.34	0.46	0.07
VTI	Interval [o,2)	Mean	0.05	0.05	0.05	0.04	0.05
		Std. Dev.	0.18	0.19	0.17	0.15	0.17
For	Binary dummy	Mean	0.09	0.23	0.23	0.21	0.23
		Std. Dev.	0.28	0.42	0.42	0.41	0.42
RE	Ratio	Mean	0.66	0.72	0.72	0.69	0.73
		Std. Dev.	0.11	0.08	0.08	0.07	0.08
XI	Ratio	Mean	0.09	0.09	0.09	0.08	0.09
		Std. Dev.	0.25	0.24	0.24	0.22	0.24
MI	Ratio	Mean	0.18	0.19	0.17	0.19	0.19
		Std. Dev.	0.29	0.30	0.29	0.28	0.28
Fsize	Ratio	Mean	0.02	0.02	0.02	0.02	0.02
		Std. Dev.	0.08	0.08	0.08	0.08	0.08
Number of observation			558	567	583	686	711

Note. Output and input variables are transformed into natural logarithms. The mean is calculated using the arithmetic mean. The Std. Dev. where represents the standard deviation.
Source: Authors.

The exogenous variables consist of the key and supporting variables. The key variables are horizontal, forward, and backward spillovers; relative entropy (RE); and the interaction between each spillover variable and RE. The supporting variables are vertical trade integration, import and export intensity, firm ownership, firm size, and an industrial dummy. The summary statistics are presented in Table 1.

Horizontal spillover captures the impact of foreign firms' existence on domestic firms in the same industry, and is calculated as follows:

$$Hspill_{jt} = \frac{\sum_{i\in j} FSh_{it} * Q_{it}}{\sum_{i\in j} Q_{it}} \tag{1}$$

Where j denotes industry, $\sum_{i\in j} FSh_{it}$ is total foreign share in the same industry. Q_{it} measures the output produced by firm i in t given year, whereas $\sum_{i\in j} Q_{it}$ captures the total output of all firms in the same industry.

The construction of vertical spillover variables requires data across industry linkages obtained from the input-output framework based on the Leontief inverse matrix, following Kohpaiboon (2009) and Sari et al. (2016). This study captures both direct and indirect (inter-sectoral) linkages. Indirect linkage is constructed based on the Leontief inter-industry accounting framework, considering the input-output framework excluding import transactions:

$$X = A^d X + Y^d + E, \quad A^d = [a_{kl}], \quad a_{kl} = X_{kl}/X_t \tag{2}$$

Where X is the column vector of the total gross output, A^d denotes the domestic input coefficient matrix. Y^d defines the column vector of domestic demand for domestically produced goods, whereas E represents the column vector of international demand for domestically produced goods. The element of domestic input-output coefficients matrix is $[a_{kl}]$. By solving Equation (2), the X becomes.

$$X = [I - A^d]^{-1}[Y^d + E], [I - A^d]^{-1} = [b_{kl}] \tag{3}$$

The $[b_{kl}]$ represents the total linkages (direct and indirect) captured in the Leontief domestic inverse matrix. This also elucidates the total output required for inter-sectoral linkages from all other sectors, for instance, industry k's outputs to be used as an intermediate input for industry l when one product of industry l's demand increases.

Forward spillovers are measured by calculating the outputs produced by foreign firms in the upstream market and used by domestic firms as intermediate inputs in the downstream market. Foreign firms' exported outputs were excluded from the measurement. The inputs supplied by firms within the industry are excluded from the calculation, because they are already captured by horizontal spillovers. The measurement is defined as

$$Fspill_{jt} = \sum_{n} b_{kl} \ * \ \frac{\sum_{i \epsilon j} FSh_{it} \ * \ (Y_{it} - X_{it})}{\sum_{i \in j} (Y_{it} - X_{it})} \tag{4}$$

where b_{kl} measures industry k's output demanded by industry l as an intermediate input to produce one unit of industry l's output, Y_{it} is the output produced by a foreign firm in the upstream market. X_{it} indicates the output of the foreign firm to be exported.

Backward spillover captures the impact of foreign firms in the downstream market on the industry that supplies the input. Inputs supplied by firms within the industry were excluded from the calculations. The calculation is as follows:

$$Bspill_{jt} = \sum_{m} b_{kl} \ * \ Hspill_{jt} \tag{5}$$

where b_{kl} is the number of industry k's output demanded by an additional unit of industry l's output.

Vertical trade integration (VTI) values range between 0 and 2. The lower bound implies that the firm uses domestic inputs or supplies only to the domestic market. The upper bound indicates that the firm purchases imported inputs, whereas all outputs produced are exported. The formula for VTI is as follows:

$$VTI_{it} = \frac{2\min (X_{it}, Minp_{it})}{Q_{it}} \tag{6}$$

where $\min (X_{it,} Minp_{it})$ denote the lowest value between X_{it} and $Minp_{it}$, $X_{it,}$ describes exported outputs, respectively. $Minp_{it}$ is the intermediate input imported by firm i in period t;

The foreign firm is a dummy variable valued at one when at least 10% of the capital is owned by foreign firms. The value 0 is when foreign invests capital with a value less than 10% or no foreign capital at all. This baseline is based on the International Monetary Fund. The foreign ownership variable is formulated as follows:

$$\text{For}_{it} = \begin{cases} 1 \ \textit{if the share of foreign capital i at time t is greater than or equal to } 10\% \\ 0 \ \textit{if otherwise} \end{cases} \tag{7}$$

The relative entropy coefficient, measures the degree of market competition. When the value is zero, only a few firms operate in the market. Therefore, the degree of monopoly is high, whereas the degree of competition is low. The closer the value is to 1, the more competitive the market is, and comprises N equally sized firms. RE is measured as follows:

$$RE_{jt} = \frac{\sum_{i=1}^{N} s_{it} \log_e (1/s_{it})}{\log_e (N)} \tag{8}$$

where s_i is the market share of firm i in period t and e is the natural number. where N is the number of firms in the industry. The RE variable interacting with each spillover variable is included in the model. $RE_{jt}.Hspill_{jt}$ measures how market characteristics affect the spillovers of foreign firms within an industry. $RE_{jt}.Bspill_{jt}$, and $RE_{jt}.Fspill_{jt}$ measures how the upstream and downstream market characteristics affect the spillovers of foreign firms.

The trade openness variables were export intensity (XI) and import intensity (MI). Each of these is formulated as follows.

$$XI_{it} = \frac{X_{it}}{Q_{it}} \tag{9}$$

$$MI_{it} = \frac{Minp_{it}}{M_{it}} \tag{10}$$

Where X_{it} is the output exported by firm i and Q_{it} is the quantity produced by firm i. $Minp_{it}$ imported input used in the production process of firm i. M_{it} defines the total material input used for the production of firm.

To control for firm-specific factors and industry effects, we used firm size and an industrial dummy variable (Dd_{it}). These dummy variables were formed based on five-digit ISIC. The dummy variables are from D1 to D13 which are: Motor vehicle with four or more wheels; trailer and semi-trailer industry and car body for four or more wheels; motor vehicle four or more wheels' parts and accessories; ship and boat; Hovercraft; Equipment and components of ship; locomotive and railroad-car; aircraft and its equipment; motorcycle with two and three wheels; the components and equipment of two- and three-wheeled motorcycles; bicycles, wheelchairs, and rickshaws; equipment for bicycles, wheelchairs, and rickshaws; and the automotive industries not yet included. The last variable is firm size, calculated as

$$Fsize_{it} = \frac{Q_{it}}{\sum_{i\in j} Q_{it}} \tag{11}$$

3.2. Methodology

Efficiency measurement was estimated using stochastic frontier analysis (SFA). In SFA, the best-practice deviations are treated as composed residuals: inefficiency (u_{it}) and random error (v_{it}). The former implies a firm's managerial competence, while the latter defines omitted variables, measurement errors, and stochastic elements beyond managerial control (Mortimer, 2017). The stochastic frontier with exogenous variables (z_{it}) and the composed error model are as follows:

$$y_{it} = \beta_0 + x_{it}\beta + z_{it}\tau + v_{it} - u_{it} \tag{12a}$$

$$u_{it} = \delta_0 + z_{it}\delta + w_{it} \tag{12b}$$

where y_{it} is the natural logarithm of firm i 's output in year t, β_0 and δ_0 reflect the intercept. x_{it} denotes the vector logarithm of the input firm. β, τ, and δ are the estimated vectors of the parameters. z_{it} indicates the vector logarithm of the exogenous variables affecting a firm's productivity and efficiency. v_{it} is the error term assumed to be iid $N(0, \sigma_v^2)$ and independently distributed to u_{it}, which is non-negative technical inefficiency. This is assumed to be independently distributed as a truncation at zero of the $N(z_{it}\delta, \sigma_u^2)$. w_{it} indicates a random variable in the inefficiency function.

The technical efficiency (TE) is the ratio of actual output, y_{it}, to its potential output, $\hat{y}_{it}$. The ratio is between 0 and 1. The closer the value is to 1, the more efficient the firm is, whereas the closer the value is to 0, the more inefficient the firm is.

$$TE = \frac{y_{it}}{\hat{y}_{it}} = \frac{f(x_{it}, z_{it}; \beta, \tau).\exp(v_{it} - u_{it})}{f(x_{it}, z_{it}; \beta, \tau).\exp(v_{it})} = \exp(-u_{it}) = \exp(-z_{it}\delta - w_{it}) \tag{13}$$

SFA requires an assumption of specific parametric functional forms of the stochastic production frontier (SPF). Therefore, various null hypotheses were tested to select the best SPF to reflect the data. Each hypothesis examines the translog (H_1) against the sub-translog (H_0) production functions. The first is to test the translog (H_1) and Hicks-neutral (H_0) production functions. Equation 5a captures Hicks-neutral technological progress when the parameter interaction between input and time is dismissed $(\beta_{nt} = 0)$. In the second test, the null hypothesis was that there is no technological progress in which the time coefficients are excluded $(\beta_t = \beta_{tt} = \beta_{nt} = 0)$. The last null hypothesis is Cobb-Douglas, which only includes the parameter of input $(\beta_{nm} = \beta_{nt} = \beta_t = \beta_{tt} = 0)$. The translog frontier production function with an inefficiency effect is specified by the following equation:

$$y_{it} = \beta_0 + \sum_{n=1}^{N} \beta_n xn_{it} + \frac{1}{2}\sum_{n=1}^{N}\sum_{m=1}^{N} \beta_{nm} xn_{it} xm_{it} + \sum_{n=1}^{N} \beta_{nt} xn_{it} t + \beta_t t + \frac{1}{2}\beta_{tt} t^2 + \sum_{k=1}^{K} \beta_k Zk_{it} + \sum_{d=2}^{D} \beta_d Dd_{it} + v_{it} - u_{it} \tag{14a}$$

$$u_{it} = \delta_0 + \sum_{k=1}^{K} \delta_k Zk_{it} + \sum_{d=2}^{D} \delta_d Dd_{it} + w_{it} \tag{14b}$$

where y_{it} is the natural logarithm of gross output of firm i in year t, β_0 is the intercept of the production function. β *and* δ are the estimated parameters, while xn_{it} and xm_{it} are natural logarithms of inputs, such as capital, labor, material, and energy. T indicates the time trend and Zk_{it} denotes a vector of exogenous variables, such as spillovers and other variables. Dd_{it} is an industrial dummy variable. v_{it} is the error term in the production function and u_{it} is inefficiency function of uitis. δ_0 and w_{it} reflect the intercept and error terms in the inefficiency function, respectively.

When the SPF is selected, the next procedure is to test the inefficiency effect. The null hypothesis is that there is no inefficiency effect ($\gamma = \delta_0 = \delta_k = 0$). This implies that it is better to reduce the model to a traditional mean response function. This means that the z_{it} can be directly included in the conventional production function, and the estimation of the data is better fitted using ordinary least squares (OLS). In contrast, the γ=1 indicates that the frontier model is more suitable for application to the data.

Hypotheses testing for both choosing the SPF and checking the inefficiency effect were performed using the generalized likelihood ratio statistic by measuring the formula $\lambda = -2[l(H_0) - l(H_1)]$. The $l(H_0)$ is the log-likelihood estimated value of the restricted frontier model (sub-translog), whereas $l(H_1)$ is the log-likelihood estimated value of the translog model. The stipulation is that when the λ calculation is less than the critical value using the χ^2 distribution, the null hypothesis is accepted. To determine whether to accept or reject the no-inefficiency effect, the calculation is the same using λ, but the distribution used is a mixed χ^2 distribution from Kodde & Palm (1986).

The estimation results of the inputs in the production function (Equation 14a) have no economic meaning. Therefore, these are calculated as the elasticity output with respect to each input, as reflected in the following equation:

$$\varepsilon_{nit} = \frac{\partial y_{it}}{\partial xn_{it}} = \beta_n + \frac{1}{2}\sum_{n=1}^{4}\sum_{m=1}^{4} \beta_{nm} xm_{it} + \beta_{nt} t \tag{15}$$

The estimation results of the inputs to the production function can be calculated to measure total factor productivity (TFP) growth components. Baier et al. (2006) describe TFP growth as a deviation from the actual growth rate of output implied by physical and human capital growth. These deviations might be due to changes in technology, institutional, and production scales. The following equation elaborates on TFP growth into its components:

$$TFPg_{it,t-1} = TEC_{it,t-1} + SEC_{it,t-1} + TC_{it,t-1} \tag{16}$$

TEC represents the technical efficiency changes. A positive TEC indicates that the firm performs better than in the previous period in terms of productivity gain sourced from the diffusion of new technological knowledge, improving managerial expertise, and adjusting to an external shock (Nishimizu & Page, 1982). TEC's calculation requires the estimation of TE firm i in period t from Equation (13) divided by each firm's TE in period t-1 and transformed into the natural logarithm. The TE was calculated as follows:

$$TEC_{it,t-1} = \ln\left(\frac{TE_{it}}{TE_{it,t-1}}\right) x\,100 \tag{17}$$

The calculation of scale efficiency change (SEC) indicates the measurement scale factor (SF). The SF calculation should begin by accounting for the elasticity in Equation (15). The formula for SF is as follows:

$$SF_{it} = (\varepsilon_{Tit} - 1)/\varepsilon_{Tit} \tag{18}$$

Scale efficiency implies that firms may not be equally productive even though they are technically efficient or operating in the production frontier. These firms can gain productivity by changing the scale of their operations (Coelli et al., 2005, p. 58–59). The SEC is defined as follows:

$$SEC_{it,t-1} = \frac{1}{2}\sum_{n=1}^{N}[(SF_{it}\varepsilon n_{it} + SF_{it-1}\varepsilon n_{it-1})(xn_{it} - xn_{it-1})]\,x\,100 \tag{19}$$

The last component is technological change (TC). The calculation of TC includes the partial derivation of Equation (14a) with respect to time. The average of these partial derivations in the two periods was defined as $TC_{it,t-1}$. A positive TC value denotes technological progress, while a negative value implies technological regression in the production process.

$$\frac{\partial y_{it}}{\partial t} = \beta_t + \beta_{tt} t + \beta_{nt}\, x\, n_{it} \tag{20}$$

$$T_{it,t-1} = 0.5\left[\left(\frac{\partial y_{it-1}}{\partial t}\right) + \left(\frac{\partial y_{it}}{\partial t}\right)\right] x\, 100 \tag{21}$$

4. Results and discussion

The correct selection of the functional form of the production function produces accurate estimations. Table 2 provides the results indicating that all sub-translog production function models are inadequate specifications for the Indonesian automotive industry. Therefore, the best model was the translog production function. The rejection of the null hypothesis of the no-inefficiency effect indicates that there are inefficiency effects.

The estimation of the stochastic production function with the inefficiency effect yields three analytical results: estimation of inputs on the production function, estimation of exogenous variables on the production function, and inefficiency function. This study also analyzes output elasticities and TFP, which are constructed from the estimation of inputs in the production function in Table 3. The estimation of exogenous variables on the production and inefficiency functions is presented in Table 4. The values of σ^2 and γ in Table 4 are significant at the 1 percent level. Both justify that the use of SPF is better fitted than OLS because of the presence of inefficiencies (Khalifah et al., 2008).

Table 2. Hypotheses testing of various sub-translog models.

Test	H_0	λ	$\chi^2 1\%$	Conclusion
Hicks neutral	$\beta_{nt} = 0$	66.662	13.277	H_0 is rejected
No-technological progress	$\beta_t = \beta_{tt} = \beta_{nt} = 0$	96.025	16.812	H_0 is rejected
Cobb-Douglas	$\beta_{nm} = \beta_{nt} = \beta_t = \beta_{tt} = 0$	389.874	32.000	H_0 is rejected
No-inefficiency	$\gamma = \delta_0 = \delta_k = 0$	294.122	42.360	H_0 is rejected

Source: Authors.

Table 3. Estimation inputs on the production function.

Variabel	Parameter	Translog	Hicks-Neutral	No Technological Progress	Cobb-Douglas
K	β_k	0.190* (0.023)	0.138* (0.021)	0.136* (0.021)	0.143* (0.006)
L	β_l	0.285* (0.046)	0.290* (0.046)	0.288* (0.046)	0.095* (0.008)
M	β_m	0.135* (0.045)	0.160* (0.045)	0.147* (0.045)	0.566* (0.008)
E	β_e	0.538* (0.041)	0.565* (0.041)	0.567* (0.042)	0.209* (0.007)
k^2	β_{kk}	−0.031* (0.007)	−0.026* (0.006)	−0.032* (0.006)	
l^2	β_{ll}	0.037* (0.010)	0.040* (0.010)	0.041* (0.010)	
m^2	β_{mm}	0.188* (0.014)	0.175* (0.014)	0.180* (0.014)	
e^2	β_{ee}	0.083* (0.015)	0.109* (0.015)	0.109* (0.015)	
Kl	β_{kl}	−0.009*** (0.005)	−0.015* (0.005)	−0.010** (0.004)	
Km	β_{km}	−0.013*** (0.007)	0.009 (0.006)	0.009 (0.006)	
Ke	β_{ke}	0.049* (0.006)	0.025* (0.006)	0.027* (0.006)	
Lm	β_{lm}	−0.052* (0.008)	−0.054* (0.008)	−0.058* (0.008)	
Le	β_{le}	0.030* (0.008)	0.034* (0.008)	0.035* (0.008)	
Me	β_{me}	−0.147* (0.012)	−0.153* (0.012)	−0.155* (0.013)	
T	β_t	−0.087* (0.020)	−0.008 (0.010)		
t^2	β_{tt}	−0.047* (0.009)	−0.038* (0.008)		
Kt	β_{kt}	0.005 (0.004)			
Lt	β_{lt}	−0.007*** (0.004)			
Mt	β_{mt}	0.029* (0.004)			
Et	β_{et}	−0.030* (0.004)			

Note. Values in parentheses are standard errors. *denotes significance at 1%, ** denotes significance at 5% and *** denotes significance at 10%.
Source: Authors.

Table 4. Estimation coefficients on the production function and inefficiency function.

	Production Function		Inefficiency Function	
Variable	Parameter	Translog	Parameter	Translog
Constant	β_0	3.112*	δ_0	−0.799*
		(−0.196)		(−0.221)
Hspill	β_{Hspill}	0.535**	δ_{Hspill}	−0.221**
		(−0.231)		(−0.175)
Bspill	β_{Bspill}	0.866*	δ_{Bspill}	−0.798*
		(−0.187)		(−0.157)
Fspill	β_{Fspill}	−0.687*	δ_{Fspill}	0.755*
		(−0.142)		(−0.164)
VTI	β_{VTI}	−0.370*	δ_{VTI}	0.308*
		(−0.051)		(−0.242)
For	β_{For}	0.004	δ_{For}	−0.016
		(−0.017)		(−0.177)
RE	β_{RE}	−0.131	δ_{RE}	0.528***
		(−0.216)		(−0.339)
RE*Hspill	$\beta_{RE*Hspill}$	−1.067*	$\delta_{RE*Hspill}$	0.483**
		(−0.319)		(−0.178)
RE*Bspill	$\beta_{RE*Bspill}$	−1.356*	$\delta_{RE*Bspill}$	1.397*
		(−0.252)		(−0.183)
RE*Fspill	$\beta_{RE*Fspill}$	1.195*	$\delta_{RE*Fspill}$	−1.352*
		(−0.200)		(−0.162)
XI	β_{XI}	0.146*	δ_{XI}	−0.082*
		(−0.036)		(−0.178)
MI	β_{MI}	0.073*	δ_{MI}	−0.087**
		(−0.027)		(−0.159)
Fsize	β_{Fsize}	0.254***	δ_{Fsize}	−0.090**
		(−0.133)		(−0.241)
Dummy ISIC		YES		YES
Sigma-squared			σ^2	0.086*
				(−0.002)
Gamma			γ	0.055*
				(−0.008)
log likelihood function				−619.2
LR test of the one-sided error				294.122

Note. Values in parentheses are standard errors. *denotes significance at 1%, ** denotes significance at 5% and *** denotes significance at 10.
Source: Authors.

4.1. The FDI spillover impact on firms' productivity and inefficiency

The Hspill estimation coefficients were significantly positive for productivity and significantly negative for inefficiency. The former implies that a firm's output rises with the increasing share of foreign firms' output in the same industry. The latter clarifies that the presence of foreign firms reduces the inefficiency of domestic firms within the industry. This evidence of positive horizontal spillovers might come from the competition effect, which makes domestic firms improve their efficiency to protect their market shares because of foreign firms' presence as competitors. Positive horizontal spillovers may arise from domestic firms observing and imitating foreign firms, resulting in reduced R&D costs and lower inefficiency (Lin et al., 2009).

The backward spillover coefficients differ significantly from zero. A positive sign of productivity refers to the existence of foreign firms that improve the productivity of domestic firms in the upstream market. MNC firms may provide technical assistance and facilitate training for their suppliers. Thus, improving suppliers' product quality fulfills foreign firms' quality requirements. Therefore, domestic firms in the upstream market can gain benefits, especially in terms of better management and reduced inefficiency. This finding of positive FDI spillovers through backward linkage is consistent with Blalock (2002) and Sari et al. (2016) in the Indonesian industry.

The results of forward spillovers on productivity spillovers are negative, whereas the coefficient estimation of inefficiency is positive. These results indicate that foreign firms have no incentive to improve domestic firms' productivity in the downstream market, and foreign firms' presence cannot support downstream firms to lower their technical inefficiency. The negative spillovers from MNC firms, as suppliers in the upstream market, to domestic firms, as buyers, could be due to asymmetric bargaining power when negotiating input supply contracts. Foreign firms have a dominant position or market power in

the upstream market (Newman et al., 2015). Therefore, foreign firms, as suppliers, could increase their prices, while buyers have no choice and purchase at a higher price. This finding is consistent with Merlevede & Schoors (2009) finding that forward spillovers might not be beneficial in the manufacturing sector, but the benefits of forward spillovers could be found in the non-tradable and service sectors. This is also consistent with the argument of Rodriguez-Clare (1996) that the host economy could be hurt when multinationals do not intensively demand intermediate goods and when host countries are too different in terms of the variety of intermediate goods produced.

VTI emanates from negatively affecting productivity, but the impact on inefficiency is positive. VTI can decrease productivity and efficiency, consistent with the empirical study conducted by Barrera-Rey (1995). The source of inefficiency might be the high transportation costs. Affiliate firms are usually located in different countries and incur transportation costs; however, in this case, the cost is higher than the benefits of VTI. Another explanation is that highly integrated firms cannot take advantage of low prices and high-quality inputs in the international market because they supply their own inputs rather than buying from the competitive market (Goldar et al., 2004).

The dummy variable of firm ownership in both the inefficiency and production functions is insignificant. This implies that there is no evidence that firm ownership affects productivity or technical efficiency in the Indonesian automotive industry. The estimation result of ownership on inefficiency is the same as that in Sterner (1990) and Söderbom & Teal (2001).

Based on these results, the estimated coefficient of RE is not different from zero for productivity. A significant positive effect on inefficiency indicates that a lower concentration is associated with greater firm inefficiency. High-concentration firms have an incentive to improve their efficiencies by using better technology and allocating better inputs. This reduces input costs while simultaneously increasing output quality, resulting in firms gaining benefits (Sari, 2019). This result follows the efficient-structure (ES) hypothesis, which suggests that efficient firms might create a high concentration. Efficient firms can produce at lower costs, leading to higher profits and a larger market share, thus resulting in efficient firms growing rapidly compared with inefficient firms (Demsetz, 1973).

The coefficient of the RE*Hspill variable on the production function is statistically negative and positive on the inefficiency function. These findings imply that FDI spillovers within the industry are smaller in a less-concentrated market. The coefficient of RE*Bspill on the production function is negative, showing that suppliers' less concentrated markets have a negative impact on a firm's productivity. The significantly positive coefficient of RE*Bspill in the inefficiency function reveals that a lower degree of concentration in the supplier market has less of an impact on reducing inefficiency. The interaction variable between market concentration and forward spillover (RE*Fspill) in the production function is significantly different from zero and positive, respectively. This means that the less concentrated buyers' market has a positive impact on a firm's productivity. The high significance of the RE*Fspill variable in the inefficiency function implies that domestic firms using the intermediate input from MNC firms may lower the degree of inefficiency if the market is less concentrated.

The remaining regressors measure trade openness, namely export intensity (XI) and import intensity (MI). The positive coefficients of XI and MI on the production function indicate that the degree of export and import intensity increases productivity. Higher export and import activities may become a significant channel for receiving technology spillovers, improving a firm's productivity. Exporting firms tend to develop technology to increase their competitiveness, thereby positively affecting their productivity (Rakhmawan et al., 2015). Higher export and import intensities also reduce firm inefficiency. This is shown by the negative and significant estimation results of both variables in the inefficiency function. By using imported goods as intermediate inputs, firms can improve productivity because imported goods are related to high quality and lower prices, allowing firms to use goods to produce efficiently (Naudé & Serumaga-Zake, 2003). Exporting firms tend to compete in a competitive market, pushing them to produce more efficiently.

Firm size has a significant effect on both productivity and inefficiency. A positive coefficient of the production function indicates that the degree of firm size positively affects a firm's productivity. The finding of the efficiency function reveals that a larger firm has greater efficiency. This is not surprising, because the greater the firm size, the more likely it is to use sophisticated technology, leading to better productivity and efficiency (Lundvall & Battese, 2000).

Table 5. Elasticity of output with respect to each input.

	Domestic Firms	Foreign firms	All firms
Elasticity of capital (ε_k)	0.171	0.174	0.171
Elasticity of labor (ε_l)	0.086	0.056	0.080
Elasticity of Energy (ε_e)	0.095	0.084	0.093
Elasticity of Material (ε_m)	0.669	0.687	0.673
Total elasticity (ε)	1.021	1.001	1.017

Note. The calculation of total elasticity is $\varepsilon = \varepsilon_k + \varepsilon_l + \varepsilon_m + \varepsilon_e$
Source: Authors.

Table 6. TFP growth and its components.

	2010–2011				2011–2012				2012–2013				2013–2014			
Industry classification	TC	TEC	SEC	TFP	TC	TEC	SEC	TFP	TC	TEC	SEC	TFP	TC	TEC	SEC	TFP
Domestic																
D1	−10.37	−0.38	−0.92	−11.67	−15.60	0.24	1.10	−14.26	−20.61	0.32	−0.15	−20.44	−25.52	−0.38	0.07	−25.83
D2	−9.08	−1.32	−0.19	−10.59	−13.49	−3.97	1.57	−15.89	−17.69	15.28	−0.22	−2.64	−22.04	−8.74	0.52	−30.26
D3	−8.92	−12.98	1.10	−20.80	−12.66	−1.75	0.00	−14.40	−17.76	12.26	−0.04	−5.54	−22.09	−8.98	0.53	−30.54
D4	−8.94	−2.19	0.15	−10.98	−13.46	−1.65	−0.38	−15.48	−17.77	14.80	−1.08	−4.05	−22.11	−22.43	2.10	−42.45
D6	−9.19	5.30	0.55	−3.33	−14.36	−3.23	−1.18	−18.76	−16.63	1.93	1.66	−13.05	−21.26	−16.86	−1.25	−39.37
D7	−8.84	2.35	0.15	−6.34	−13.05	1.38	−0.32	−11.99	−13.58	−42.53	−16.63	−72.75	−17.02	48.96	15.14	47.08
D8	−12.65	3.91	2.88	−5.86	−16.94	−1.96	1.70	−17.19	−21.88	4.18	−1.12	−18.82	−24.30	8.82	0.18	−15.30
D9	−9.56	−4.44	6.24	−7.76	−13.43	3.76	−0.80	−10.48	−17.32	0.14	0.79	−16.39	−21.18	3.39	−0.67	−18.45
D10	−7.89	−8.10	0.45	−15.54	−13.04	−0.01	0.44	−12.61	−17.59	15.59	−0.04	−2.04	−21.81	−21.30	0.82	−42.29
D11	−9.48	−0.21	−0.23	−9.92	−14.21	2.21	0.31	−11.69	−18.66	23.19	−0.17	4.35	−23.12	−36.08	0.63	−58.57
D12	−8.02	−5.87	1.86	−12.02	−12.59	−1.60	−2.33	−16.53	−17.93	20.37	1.66	4.10	−21.82	−29.70	1.43	−50.10
All domestic firms	−8.74	−6.86	0.61	−15.00	−13.16	−1.50	0.34	−14.32	−17.76	13.96	−0.16	−3.96	−22.05	−14.46	0.78	−35.73
Foreign																
D1	−9.09	−0.01	−1.33	−10.43	−14.38	−1.09	1.80	−13.67	−20.24	1.54	0.35	−18.35	−24.35	−0.24	0.90	−23.68
D2	−7.88	−0.18	−0.51	−8.57	−13.79	−3.80	0.04	−17.55	−17.79	12.18	−0.58	−6.20	−21.97	−6.09	0.28	−27.78
D3	−8.88	−13.33	0.55	−21.66	−12.34	−0.24	0.19	−12.40	−17.30	11.51	−0.06	−5.85	−21.77	−8.50	−0.31	−30.58
D4	−7.89	−3.95	−0.02	−11.86	−11.47	−2.48	−0.25	−14.20	−17.08	15.50	0.10	−1.48	−22.48	−20.56	1.60	−41.44
D8	−9.08	9.88	1.12	1.91	−10.88	−6.53	−0.01	−17.42	−17.06	8.88	0.53	−7.65	−21.65	8.65	−0.36	−13.35
D9	−12.07	0.19	6.15	−5.74	−14.87	−0.48	−1.16	−16.52	−17.26	−0.08	1.07	−16.27	−21.84	0.56	−1.85	−23.13
D10	−8.00	−6.52	0.51	−14.01	−13.24	−0.25	−0.15	−13.64	−18.15	14.76	0.06	−3.33	−21.99	−21.43	0.36	−43.06
D12	−8.64	−4.44	−0.03	−13.11	−15.18	−1.78	−0.38	−17.34	−20.44	20.53	−0.44	−0.35	−22.68	−29.70	0.83	−51.55
All foreign firms	−8.67	−9.22	0.43	−17.46	−12.72	−0.49	0.20	−13.00	−17.63	11.71	0.04	−5.88	−21.92	−11.66	0.06	−33.52

Source: Authors.

Table 5 provides information on the average elasticity of output with respect to each input. The average elasticity of output with respect to the capital of local firms is less than that of foreign firms, whereas the opposite occurs in the elasticity of labor. The interpretation is that to produce the same quantity of output, foreign firms employ less labor and more capital than domestic firms. This condition proves that domestic firms in developing countries are commonly labor intensive, while foreign firms are capital intensive. Foreign firms exert less energy but a higher amount of materials than domestic firms do to produce the same quantity of output.

4.2. The total factor productivity (TFP) growth and its components

TFP and its components are classified based on firm ownership and industry classification. Table 6 provides the results from calculation of TFP growth and its components. It shows that most TFP, both domestic and foreign, grew negatively during the observation period. On average, the deteriorating TFP growth of foreign firms is slightly higher than that of domestic firms. By contrast, positive growth occurred on domestic D7 in 2013–2014, domestic D11 and D12 in 2012–2013, and foreign D8 in 2010–2011.

Domestic and foreign industries experienced deterioration in TC. Despite the lack of technological progress in both industries, the deterioration in foreign firms was, on average, lower than that in domestic firms. Foreign industries experienced lower technological regression than domestic industries. The technological regression might be due to the utilization of old machines, since most Indonesian manufacturing firms do not intend to upgrade machinery (Sari et al., 2016). This is supported by the evidence that in several manufacturing industries, such as sugar, food, and beverage, the automotive industry still uses the old technology, which has a higher maintenance and production cost, an unstable domestic

supply, and the potential forcing firms out of business (Afrianto, 2016; Agustinus & Fitriyani, 2020; Krisnamurthi, 2013, p. 201).

The next component is TEC, which, on average, makes the greatest contribution to TFP. The TEC growth of the majority of domestic and foreign firms' TEC growth were negative, indicating that the production processes were inefficient. The lack of adequate managerial skills could affect the negative growth of TEC. Another reason is that firms may not be efficient in using inputs or technology. The last TFP component is SEC, which does not seem to have high volatility. Although the growth was relatively small, with an average of 0.18% and 0.39% for foreign and domestic industries, respectively, these positive SEC values imply that most firms operate on an optimal scale.

5. Conclusion

The existence of foreign firms within industries spills over both productivity and efficiency of domestic firms. The same is true when domestic companies are suppliers in the upstream market. On the other hand, domestic firms that use multinational corporations' (MNC'_ products as intermediate inputs have a negative effect on productivity and efficiency. Based on these results, policymakers should ensure that the benefits of foreign direct investment (FDI) spillovers outweigh their disadvantages. The government should attract foreign investment when MNC firms produce outputs used as intermediate inputs for export or final goods that are ready to be used. This is because the empirical results show that selling intermediate inputs to local buyer firms may create negative spillovers.

The empirical results show that vertical trade integration may negatively affect productivity and efficiency. On the contrary, firm size, exports, and import intensity are associated with improved productivity and reduced inefficiency. The higher the degree of market concentration, the more efficient the firm is. The interaction variable between market concentration and horizontal spillover implies that the spillovers of FDI within the industry are smaller in a less concentrated market. A less concentrated market of domestic suppliers has a negative impact on the firm's productivity and less impact on reducing inefficiency. By contrast, the less concentrated local buyers' market has a positive impact on the firm's productivity and contributes to a lower degree of inefficiency.

Despite positive spillovers, total factor productivity (TFP) shows negative growth in both domestic and foreign firms. The main concerns are technological change (TC) and technical efficiency changes (TEC), as the growths are mostly negative and relatively high. The policy recommendation for this circumstance is to encourage firms to improve technological progress, such as upgrading their machines and investing in human resources, by providing training workers aiming at mastering better managerial expertise. The government should support research and development (R&D) by facilitating firms, providing incentives for research conducted by universities or national laboratories, or providing tax incentives.

Authors' contributions

HATI: conception, analysis, interpretation; MF: interpretation, writing draft; DWS: conception, supervision; TH: supervision; SKS: clearing data; FM: writing revision.

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Data availability statement

The data used in this study includes annual medium and large manufacturing establishments, which are taken from the Indonesian Central Board of Statistics. The complementary data are the wholesale price index (WPI) at a constant price in 2010 and an input-output (I-O) table. The datasets used in this paper will be made available upon a reasonable request to the corresponding author.

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