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The impacts of technological innovation and institutional quality on the productivity of Vietnamese manufacturing firms

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ABSTRACT

This research aims to assess the pivotal role of total factor productivity (TFP) in shaping the performance of manufacturing enterprises in Vietnam. It systematically examines the influence of technological innovation and the quality of economic institutions on the TFP of these firms. Employing robust methodologies such as control function (CF) and feasible generalized least squares regression (FGLS) models, a comprehensive panel dataset of Vietnamese manufacturing companies is meticulously scrutinized. The data, meticulously sourced from the General Statistics Office of Vietnam and the Vietnam Chamber of Commerce and Industry, spans the five-year period from 2015 to 2019. The findings of this study elucidate several key insights. First, it reveals that the manufacturing landscape in Vietnam is predominantly characterized by labor-intensive operations, with an apparent trend toward increasing returns to scale. Furthermore, the study underscores that TFP's contribution to manufacturing output remains relatively modest, averaging at 1.933 over the period from 2015 to 2019. Additionally, it identifies a concerning decline in the average TFP score, along with a widening gap between firms, which tends to exacerbate during the study period. Finally, the research establishes a positive correlation between investments in production technology and the quality of economic governance within provincial governments in Vietnam, both of which significantly bolster the TFP of manufacturing firms.

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1. Introduction

The manufacturing industry plays a strategic role in the economic development of a country. It has been at the forefront of modernization, creating skilled jobs, and having positive spillover effects in other industries (Tybout, 2000). Moreover, it is also the key to innovation and technology diffusion (Mijiyawa, 2017). In general, the manufacturing industry has good growth in developed countries. However, there is evidence that it has not experienced steady growth in developing and emerging countries, which is mainly due to the impact of technological innovation and institutional quality (Ngo et al., 2019).

In recent years, Vietnam has been one of the countries with the fastest economic growth in the world. In particular, the manufacturing industry plays a key role and has always been shown to be an important driving force in economic growth. Although certain achievements have been achieved, the Vietnamese manufacturing industry has not yet developed commensurate with its potential and still has plenty of room for development. Most firms are small and medium-sized, so they still face many difficulties in capital and production technology, most of these firms are using technology that lags behind the world average by 2 to 3 times, and the technological improvement of firms is still slow, so the productivity is very low. Competence, qualifications, and technology of domestic firms are not high, growth still depends heavily on foreign direct invested (FDI) firms. The attraction of FDI capital has made strong progress, but the spillover and transfer of technology from FDI firms to

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domestic firms is still limited (Xuan, 2020). Productivity growth of the Vietnamese manufacturing industry is concentrated mainly in a few areas based on low and medium technology (textiles, footwear, food processing), while high-tech fields are often in the FDI sector, they are mainly taking advantage of cheap labor and preferential policies, so there has not been much spillover of technology effect to create breakthroughs in productivity. Therefore, the level of added value in the Vietnamese manufacturing industry is not high, and total factor productivity (TFP) is still low (Nguyen, 2017).

The allocation of the manufacturing sector within the framework of the Gross Domestic Product (GDP) was articulated in the Resolution of the 13th Party Congress and subsequently formalized by the National Assembly, which has set the ambitious objective of this sector contributing more than 25% to the GDP by the year 2025. As a consequence, there has been a pronounced evolution in policy orientation in recent years, aimed at catalyzing the advancement of the manufacturing sector, enabling it to seamlessly integrate into the global production chain, and thereby establishing a solid foundation for the country's industrialization and modernization. Concurrently, there has been a marked enhancement in the quality of economic governance, the ease and receptiveness of the business environment, and administrative reform initiatives undertaken by provincial authorities in Vietnam. Evidently, this is manifest in the consistent ascent of scores on the Provincial Competitiveness Index (PCI) across various provinces in recent years. This transformation has engendered a propitious environment for business operations, administrative services, and financial facilitation, thereby empowering firms to optimize their production processes and subsequently augmenting their overall performance (Quoc Trung, 2021).

Furthermore, the presence of a conducive institutional framework fosters confidence among enterprises to invest in and develop technology, thereby enhancing production efficiency and amplifying the contribution of TFP to overall output.

Derived from the aforementioned rationale, the primary objective of this study is twofold: firstly, to estimate the production function and discern the influence of TFP on the output of Vietnamese manufacturing entities. Secondly, to construct and analyze a model examining the impact of technological advancements and the quality of economic institutions on the TFP of said entities.

The ensuing sections of this paper are structured as follows: Part 2 provides a comprehensive theoretical foundation pertaining to TFP estimation and the determinants thereof. Section 3 expounds on the functional control method employed in TFP estimation and elucidates the empirical analysis model applied to Vietnamese manufacturing firms. Section 4 delves into the data, TFP estimation outcomes, and the ramifications of technological innovation and institutional quality on the TFP of Vietnamese manufacturing enterprises. Finally, Section 5 proffers conclusions and recommendations derived from the study's findings.

2. Literature reviews and theoretical basis

2.1. Estimated total factor productivity

The concept of TFP was first proposed by Tinbergen (1942), but it is only widely known through the definition of Solow (1957). It can be said that TFP is the improvement of efficiency in the use of tangible factors such as capital and labor by the impact of intangible factors such as technological innovation, production rationalization, management improvement, and raising the level of labor. Improving TFP means improving production output with the same amount of input. Therefore, estimating the contribution of TFP to output is an important issue that has been interested, researched, and developed by many economists over the years.

There are many approaches to estimating the contribution of TFP to output. Nowadays, estimation of aggregate production function and control function (CF) methods are widely used. The estimation of the aggregate production function method usually assumes that firms achieve maximum technical efficiency, so all output combinations lie on the production frontier, only technological change increases TFP (Solow, 1957). There are two commonly used ways to estimate technological change in the estimation of aggregate production function method: adding the time trend variable into the aggregate production function (Beckmann et al., 1972) or growth accounting (Solow, 1957). However, Leibenstein (1966) pointed out limitations on the assumption of maximum technical efficiency of firms in the estimation of aggregate production function method. Furthermore, the estimation results of these methods encounter some econometric problems such as endogenous problems; the problem of choice; and shortage of prices of inputs and outputs; and are quite sensitive to the choice of functional form, so the TFP estimation results can be biased. To overcome the endogeneity, Olley and Pakes (1996) were the first to propose the method of control function by two-stage estimation procedure. The investment level of the firm in the year was chosen by Olley and Pakes (1996) as a proxy for productivity shock. However, investment by firms can be accumulated over several years rather than just one year, so there are many observations of zero investment at times. This violates the assumption of monotony in the investment function of Olley and Pakes (1996), so the application scope of the model is limited. Levishon and Petrin (2003) overcome this by choosing intermediate input levels that represent productivity shocks. However, both Olley and Pakes (1996) and Levishon and Petrin (2003) assume that firms can adjust input levels immediately without incurring cost losses when affected by productivity shocks. Bond and Soderbom (2005) pointed out the

limitations of this and suggested that the coefficient of labor can be consistently estimated in the first stage if the free variables vary independently of the proxy variable. Otherwise, the coefficients will be perfectly multicollinear in the first stage and therefore the coefficient of labor cannot be determined. Wooldridge (2009) proposed to solve the problems of Olley and Pakes (1996) and Levishon and Petrin (2003) by the generalized method of moments regression (GMM). In particular, equations with the same dependent variable but characterized by a different set of tools established by Olley and Pakes (1996) and Levishon and Petrin (2003) have been restricted to the relevant moments in terms of Wooldridge (2009).

2.2. The impact of innovation and institutional quality on total factor productivity

Growth in total factor productivity (TFP) is the main driver of economic growth (Comin, 2010). TFP growth stems from technological advancements, improvements in management and organization, and improvements in input quality (Syverson, 2011). Numerous economists have extensively explored the intricate nexus between TFP and innovation. A pivotal aspect of this inquiry pertains to the profound influence of technological innovation in bridging the performance chasm between firms characterized by low productivity and those positioned at the vanguard of productivity, a phenomenon manifesting itself through the contraction of TFP disparities. This process of narrowing the gap assumes paramount significance in the context of developing nations such as Vietnam, where instances of high productivity, nestled deeply within the frontier, are sporadic. Within this framework, it is imperative to acknowledge that enterprises invariably strive to make strategic investments in cutting-edge production technologies and equipment, gain access to state-of-the-art information technology infrastructure, and harness the synergistic benefits arising from the dissemination of the most recent technological advancements. Such endeavors are undertaken with the overarching objective of augmenting their operational efficiency. Furthermore, it is noteworthy that technological innovation serves as a catalyst for cultivating sustainable competitiveness among firms. This competitive edge not only facilitates the expansion of market share but also engenders an upswing in profitability, thereby rendering it a pivotal factor in the corporate landscape.

Business innovation is defined by the OECD (2018) as "a new or improved product or business process (or combination thereof) that differs significantly from the firm's previous products or business processes and that has been introduced on the market or brought into use by the firm." The sources of innovation are diverse, but research and development (R&D) is considered one of the important factors influencing innovation decisions. Romer (1990) emphasized the role of R&D for each firm to create new products as well as use more modern technology, which leads to the promotion of consumption and production. R&D intensity leads to increased engagement in process and product innovations (Griffith et al., 2006; Hall et al., 2009). At the same time, firms conduct more optimal production, leading to increased TFP and reduced costs. In addition, R&D activities also have a spillover effect through the absorption capacity of firms. Competition in the market will drive R&D to be stronger, thus leading to larger-scale TFP improvement. Most researchers confirm that innovation has a positive impact on firm performance (Griffith et al., 2006; Friesenbichler and Peneder, 2016; Wadho and Chaudhry, 2018). However, there are also some opposing views, Griffith et al. (2006) and Raffo et al. (2008) found a negative effect of innovation on firm productivity in Germany and Argentina. Roper et al. (2008) also found similar results for firms in Ireland. This is explained by the disruptive effects of innovation and its impact on the product life cycle. A new product can disrupt production and thus reduce the firm productivity. As a result, the product may take time to be efficiently manufactured before improving the firm productivity (Roper et al, 2008). In addition, there are many studies conducted at the firm and industry levels that have demonstrated a positive correlation between investment in digital technologies and productivity (Dewan and Min, 1997; Doms et al., 2004; Hollenstein, 2004; Syverson, 2011; Arendt and Grabowski, 2017). Dewan and Min (1997) have found that investment in information technology is an alternative to traditional capital and has the potential to improve labor efficiency. Hollenstein (2004) showed that the timing and extent of Information and Communication Technology (ICT) adoption is of significant importance to the firm productivity. Doms et al. (2004) examined the correlation between information technology (IT) investments and retail industry performance. Research has found that most of the IT investment in the retail sector is done by large firms. Furthermore, the authors establish a significant correlation between IT investment intensity and productivity growth. Arendt and Grabowski (2017) have established a correlation between innovation outputs with ICT and productivity growth, thereby verifying the intermediate function of innovations and ICT in enhancing productivity.

Recent empirical studies have also focused more intensively on the importance of institutions in explaining productivity differences. If a country has good governance, intellectual property rights are guaranteed and policies are strictly enforced, it will motivate economic actors to invest more in human capital, improve efficiency, and achieve higher productivity levels (Acemoglu et al., 2005). Good governance supports reducing transaction costs and investment risk, thus encouraging investment and innovation in the private sector, and ultimately productivity growth and economic efficiency (North,

1990, Boerner and Hainz, 2009; Driffield et al., 2013). The concept of "institutions" is complicated, and established by multiple measures of social, political, and administrative indicators (Lasagni et al., 2015). A common measure of institutional quality is the world governance indicator developed by Kaufmann et al. (2011). In addition, Nifo and Vecchione (2014) developed an institutional quality index (IQI) that measures governance quality at both the national and local levels. Institutions that prescribe rules to make markets work more efficiently and promote fair competition, positively impact firm operations. It can be recognized by the quality of the business environment of the localities where the firm is located (Lasagni et al, 2015). Higher institutional quality improves geographic attractiveness, development opportunities, and ultimately productivity (North, 1991). Conversely, poor institutional quality makes it difficult to enforce contracts and pay bribes, leading to increased operating costs for firms. It gives firms an incentive to absorb inefficient technologies for the production process rather than absorb modern technology (Fredriksson and Svensson, 2003). Syverson (2011) argued that institutions and political contexts influence firm productivity through a number of channels. First, incentive mechanisms encourage firms to invest more in R&D, leading to enabling technology innovation, shortening the technology gap, and converging productivity with that of top local firms (Griffith et al., 2006). Second, the intensity of competition follows the 'Darwin' selection, which means that more efficient firms will take market share from less efficient ones to increase their returns to scale and productivity (Foster et al., 2001). Third, the quality of market regulations can create an unfriendly business environment and reduce the productivity of firms operating in such a setting (Lasagni et al., 2015).

In recent years, there have been a number of studies investigating the relationship between technological innovation, institutions, and firm productivity in the Vietnamese context. Specifically, Nguyen (2017) assessed the impact of business reform on the TFP of Vietnamese manufacturing firms. The author shows that business reform can encourage firms to invest in more advanced technologies, thereby promoting productivity convergence towards the frontier. Dinh et al. (2023) investigated the impact of digital technology on the TFP of SMEs in Vietnam. The authors have found that digital technology positively affects firm productivity. However, digital technology productivity rewards vary from firm to firm. Studies by Nguyen and Freeman (2009) and Bach (2019) showed that the state-owned firm sector inhibits the development of the private firm sector and leads to the misallocation of capital. Ngo and Nguyen (2020) showed that tax incentives and government subsidies for exports have a positive impact on firm TFP. Le et al. (2020) examined the impact of factors such as state ownership and local institutional quality (represented by transparency and control of corruption in the provincial competitiveness index, PCI) on productivity differences between firms. Besides, a number of other studies estimate the role of institutions in the performance of firms, in which TFP is one of the measures of firm performance (Nguyen and Van Dijk, 2012; Tran et al., 2016; Van Vu et al., 2018). These studies also used some or all of the different components of PCI as a proxy for institutional quality.

The literature review shows that studies in the context of the Vietnamese manufacturing industry often use the approach of Levishon and Petrin (2003) in TFP estimation and analysis. Moreover, studies have not analyzed simultaneously the impact of investment in machinery and equipment and the provincial competitiveness index on the TFP of manufacturing firms. In addition, the update of the manufacturing industry data for the period 2015-2019 has not been carried out. Therefore, the study will bring new results in estimating the TFP of the Vietnamese manufacturing industry, as well as exploring the impact of technological innovation and institutional quality on the TFP of the Vietnamese manufacturing industry.

3. Methodology

We analyze the impact of technological innovation and institutional quality on the TFP of Vietnamese manufacturing firms using a two-stage approach. In the first stage, we apply the method of Wooldridge (2009) to estimate the production function and predict the TFP of firms. In the second stage, we investigate the relationship between TFP and investment in machinery and equipment, local institutional quality, international trade, and firm characteristics.

We select the Cobb-Douglas production technology to estimate TFP for Vietnamese manufacturing firms. The production function of firm i at time t with one output y and two inputs k and l is as follows:

$$y_{it} = \beta_0 + \beta_k k_{it} + \beta_l l_{it} + \varepsilon_{it} \quad (1)$$

where, k_{it} is the state variable and l_{it} is the free variable, all variables y_{it}, k_{it}, and l_{it} are taken as natural logarithms before being included in the model (Olley and Pakes, 1996).

We can decompose ε_{it} into the productivity shock v_{it} observed by the business owner but not by the economist and the unobserved error η_{it}, and then Eq. 1 rewritten as:

$$y_{it} = (\beta_0 + v_{it}) + \beta_k k_{it} + \beta_l l_{it} + \eta_{it}. \quad (2)$$

The quantity $\omega_{it} = \beta_0 + v_{it}$ is the productivity of firm i at time t (Van Beveren, 2012). We proceed to estimate the coefficients of Eq. 2, from which we get the estimate $\hat{\omega}_{it}$ of ω_{it} as:

$$\hat{\omega}_{it} = \hat{\beta}_0 + \hat{v}_{it} = y_{it} - \hat{\beta}_k k_{it} - \hat{\beta}_l l_{it} \quad (3)$$

where, $\hat{\beta}_k$, $\hat{\beta}_l$ estimates and TFP calculation are based on the GMM method by Wooldridge (2009) and performed by the estimation procedure of Rovigatti and Mollisi (2018).

To determine the factors affecting TFP, the research is based on the theoretical basis analyzed in section 3 and inherits the studies of Botric et al. (2017), Saleem et al. (2019), and Binh and Tung (2020). The empirical model of the impact of technological innovation and institutional quality on the TFP of Vietnamese manufacturing firms is established as follows:

$$\text{TFP} = \text{f (Techs, Institutions, Procoms, Trades, Controls)} \quad (4)$$

where, Techs are variables that represent technological improvement and technological innovation; Institutions are variables of quality economic institutions; Procoms are variables representing departmental productivity; Trades are variables representing international trade; Controls are some control variables to be considered for inclusion in the model.

4. Estimated results

4.1. Data and variables

We have utilized enterprise census data, meticulously gathered by the General Statistics Office of Vietnam (GSO), alongside provincial competitiveness index data acquired from the Vietnam Chamber of Commerce and Industry (VCCI). This dataset spans the period spanning from 2015 to 2019. Initially, we computed the variable values for each year under consideration. Subsequently, we applied stringent criteria to cull outlier observations, excluding instances characterized by negative revenue figures or a negative count of employees. The focus of our analysis remained on manufacturing firms that exhibited continuous operational activity throughout the entire five-year duration, commencing from 2015 and concluding in 2019. To augment our dataset, we seamlessly integrated the provincial competitiveness index data recorded within the same temporal window, extending from 2015 to 2019. This meticulous process culminated in the acquisition of a balanced dataset, comprising a total of 3,312 manufacturing firms, encompassing a collective total of 16,560 individual observations, over the aforementioned five-year period. Comprehensive elucidation of the variables, encompassing their definitions, measurement methodologies, and pertinent descriptive statistics, is presented in Table 1 for reference and clarity.

4.2. TFP estimation results

To estimate the TFP of Vietnamese manufacturing firms, we apply the model of Wooldridge (2009). Specifically, the production function of firms is as follows:

$$lnVA_{it} = \beta_0 + \beta_k lnK_{it} + \beta_l lnL_{it} + \eta_{it} + \nu_{it} \quad (5)$$

where, L plays the role of a free variable, K plays the role of a state variable, and the intermediate input variable M is a proxy variable to control the production function and predict TFP. The *prodest* package on Stata16 by Rovigatti and Mollisi (2018) was used to estimate the production function and predict TFP, the estimated results are described in Table 2.

The estimated coefficients in our analysis exhibit congruence with established economic theory and are characterized by statistical significance. Notably, the elasticity of output per labor surpasses that of capital, underscoring the enduring labor-intensive nature of Vietnamese manufacturing firms. Furthermore, the cumulative elasticity of output concerning both capital and labor exceeds unity, signifying a regime of increasing returns to scale within these firms. Our findings regarding TFP prognostication reveal that, on average, firms registered a TFP score of 1.933 during the five-year period from 2015 to 2019. This implies that factors beyond the traditional inputs of capital and labor, collectively referred to as "all other factors," contributed to a remarkable increase in firm output, precisely by a factor of 1.933.

The distribution of TFP over the years presented in Table 3 shows that the TFP of Vietnamese manufacturing firms tends to decrease significantly in the period from 2015 to 2019. In which, the highest TFP score was 2.082 in 2016, and the lowest was 1.762 in 2019. In general, the average level of TFP achieved by Vietnamese manufacturing firms is still very low (1,933) and there is still plenty of room for TFP in the period 2015-2019. This is supported when compared with the research results of Ngo and Nguyen (2020) when estimating TFP for the Vietnamese manufacturing industry in the period 2010-2015. However, Ngo and Nguyen (2020) used the method of Ackerberg et al. (2015) in estimating TFP. In addition, the standard deviation of TFP is still large, averaging around 0.680, implying that there exists a large productivity gap between Vietnamese manufacturing firms. Furthermore, the value of the standard deviation tends to increase, indicating that the gap is widening.

Next, we analyze TFP by firm ownership and firm size, the results are presented in Table 4. In terms of ownership, the TFP of private manufacturing firms is the lowest, averaging 1.746 over the whole study period. Next is the state-owned firm sector with an average TFP of 2.101. And finally, FDI firms have the best TFP, reaching an average of 2.141. As for firm size, the results show that small manufacturing firms have the lowest average TFP, reaching an average of 1.854 in the period from 2015 to 2019. Medium-sized firms ranked second with an average TFP of 1.935. And large firms have the highest TFP, at 1.969. The Kernel density of TFP according to firm ownership and firm size in Fig. 1 shows that the biggest TFP bottleneck of the Vietnamese manufacturing industry is currently in the private

firm sector and small firm sector. The current situation of the Vietnamese manufacturing industry in recent years shows that these sectors are facing difficulties in accessing capital and innovating production technology. And those are the main causes of low TFP scores in the sectors.

Table 1: Definition and descriptive statistics of variables

Variables in TFP estimation model						
Variables			Definition	Observation	Mean	SD
Output variable		$VA_{(million\ VND)}$	The added value of the firm, calculated as the sum of profits, income, depreciation, and indirect taxes at constant prices in 2010	16560	209462.5	1772778.0
Input variables		$K_{(million\ VND)}$	The total real assets of the firm at the end of the year, calculated at constant prices in 2010	16560	670593.6	5944369.0
		$M_{(million\ VND)}$	The value of the firm's intermediate inputs, calculated by the difference of revenue and added value at constant prices in 2010	16560	909615.9	11700000.0
		$L_{(person)}$	The number of full-time employees of the firm in the year	16560	919.1	43067.0
Dependent		*TFP*	Total factor productivity was estimated using the Wooldridge (2009) method	16560	1.9	0.7
Independent	Techs	*lnMa*	Calculated by the natural logarithm of the firm's investment in machinery and equipment in the year	16560	4.6	2.3
	Institutions	*lnPci*	Calculated by the natural logarithm of the provincial competitiveness index in Vietnam	16560	4.1	0.1
	Procoms	*lnLp*	Calculated by the natural logarithm of the ratio between added value and labor	16560	5.3	0.9
		Cp	Calculated by the ratio between added value and total assets	16560	0.4	2.0
	Trades	*Ex*	A dummy variable that takes the value 1 if the firm has export activities, otherwise it takes the value of 0	16560	0.7	0.4
		lnAge	Calculated by the natural logarithm of the firm age	16560	2.4	0.6
		Ownership	A multi-category dummy variable includes the state sector (*Ownership1*), the private sector (*Ownership2*), and the FDI sector (*Ownership3*). In which the basic category is the FDI sector	16560	3.4	0.7
	Controls	*Size*	A multi-category dummy variable includes small firms (*Size1*), medium firms (*Size2*), and large firms (*Size3*). In which the basic category is small firms	16560	1.2	0.7
		Region	A multi-category dummy variable including North Midlands, (*Region1*), Red River Delta (*Region2*), Central Coast (*Region3*), Central Highland (*Region4*), South East (*Region5*), Mekong River Delta (*Region6*) In which the basic category is South East (*Region5*)	16560	2.9	1.9

The variables *VA*, *K*, *L*, and *M* are taken from the natural logarithm before being put into the model

Table 2: Production function estimation and TFP prediction

lnVA	Coef.	Std. err.	z	P>|z|
lnL	0.638***	0.007	95.93	0.000
lnK	0.425***	0.008	50.44	0.000
Wald test on constant returns to scale: Chi2 = 76.27. p = (0.00)				
Hansen's J statistic for overidentification = 157.49. p = (0.00)				
TFP		1.933		

*** is statistically significant at 1%; Coef.: Coefficient; Std. err.: Standard error

Table 3: Distribution of TFP in the period 2015-2019

TFP	Obs.	Mean	Std. dev.	Min	Max
2015	3312	2.016	0.658	-0.478	5.852
2016	3312	2.082	0.593	-0.363	5.417
2017	3312	1.910	0.654	-0.838	4.924
2018	3312	1.895	0.653	-1.222	5.523
2019	3312	1.762	0.784	-4.773	5.285

Obs.: Observation; Coef.: Coefficient; Std. err.: Standard error

4.3. The impact of technological innovation and institutional quality on TFP

Research to determine the contribution of TFP to output is an important issue. However, it is more important to identify the factors that affect TFP. Based on the theoretical basis and methodology presented in sections 2 and 3, we built an empirical model to analyze the impact of technological innovation and the quality of economic institutions on the TFP of Vietnamese manufacturing firms. The specific model is as follows:

$$TFP_{it} = \beta_0 + \beta_1 lnMa_{it} + \beta_2 lnPci_{it} + \beta_3 lnLp_{it} + \beta_4 Cp_{it} + \beta_5 Ex_{it} + \beta_6 lnAge_{it} + \beta_7 Ownership1 + \beta_8 Ownership2 + \beta_9 Size2 + \beta_{10} Size3 + \beta_{11} Region1 + \beta_{12} Region2 + \beta_{13} Region3 + \beta_{14} Region4 + \beta_{15} Region6 + \varepsilon_{it} \quad (6)$$

Correlation analysis of the variables was performed before model estimation (6). The Pearson correlation matrix of the variables presented in Table 5 shows that no correlation coefficient between the two independent variables is greater than 0.5 and is statistically significant. That is, there is no evidence that the model has multicollinearity, so the selected model is suitable. Estimating model (6) by the pooled ordinary least square method (POLS) does not reflect the unique and specific impacts of each firm. The study estimates the model (6) according to the fixed effect method (FEM) and the random effect method (REM). Then, we conduct the Hausman test to choose the appropriate model. The test results show that the FEM is selected. Finally, the tests on heteroskedasticity and series autocorrelation of the model are carried out. These defects are overcome by the feasible generalized least-squared regression method (FGLS). The

estimated coefficients of the model are presented in Table 6.

The estimated results from the model show that the coefficient of the variable *ln Ma* is positive and statistically significant at 1%, reflecting technological innovation through spending on machinery and equipment of Vietnamese manufacturing firms during this period had a positive impact on TFP. Nowadays, the competition among manufacturing firms is getting stronger and stronger. This requires firms to regularly improve and innovate technology because it is the decisive factor in increasing the contribution of TFP to output.

Moreover, in the context of the achievements of the Industrial Revolution 4.0, the improvement and innovation of production technology and the application of Information and Communication Technology (ICT) is an inevitable trend. It helps businesses optimize production and management and ultimately improve productivity. This result has also been confirmed by Hollenstein (2004) and Arendt and Grabowski (2017). In general, the hardware infrastructure in manufacturing firms is currently low in Vietnam, not meeting the need for modernization in production. The investment in equipment, machinery, and technology mainly takes place in a small number of firms. The adoption of digital technology is increasingly focused on businesses, so productivity has increased in some industries. However, this effect is not common across all manufacturing sectors in Vietnam (Dinh et al., 2023). Therefore, firms need to identify investment in equipment, technology, and digital transformation as a key strategy to improve TFP.

The estimated coefficient of variable *lnPci* is statistically significant at 1%, showing that there is a positive impact of the quality of economic institutions and business environment on the TFP of the firms. This shows that the convenience in accessing land for production investment of firms, the saving in time and cost in administrative procedures of firms, have contributed to improving the TFP of the Vietnamese manufacturing industry. Along with that, planning documents and legal documents are easily accessible and transparent, budget documents are published in a timely manner. These make the firms have appropriate plans to invest in production technology as well as effectively combine resources to promote TFP growth. More transparency will help the private sector be treated more equally. It makes the business environment predictable and allows for more efficient business operations. This has been supported by the findings of Nguyen et al. (2016), Tran et al. (2016), Van Vu et al. (2018), and Le et al. (2020). Moreover, business support services in the provinces of Vietnam such as: Searching for market information, trade promotion, legal advice, technology support, and labor training, have made the firms improve labor quality, and more stable production, thereby leading to the TFP achieving better. In fact, the business environment and provincial competitiveness have uneven development in Vietnam. The provinces with high PCI scores are mainly located in the South East and the Red River Delta. Therefore, these areas have attracted a number of large domestic and foreign economic groups to invest in production and business, and are the main driving force in the development of the Vietnamese manufacturing industry.

Table 4: Distribution of TFP by firm ownership and firm size

TFP	Observation	Mean	Standard deviation	Min	Max
State-owned firms	670	2.101	0.670	-0.117	4.845
Private firms	8660	1.746	0.661	-4.339	5.852
FDI firms	7230	2.141	0.638	-4.773	5.826
Small firms	2860	1.854	0.831	-4.177	5.852
Medium firms	8040	1.935	0.672	-4.773	5.523
Large firms	5660	1.969	0.600	-4.302	5.179

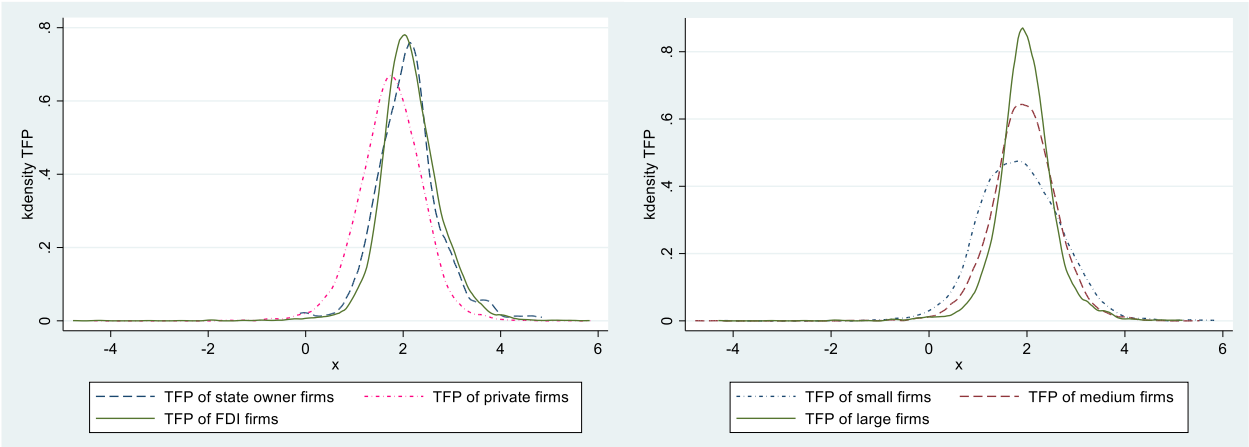

Fig. 1: Kernel density of TFP according to firm ownership and firm size

Table 5: The Pearson correlation matrix for variables in the model of determinants to TFP

	TFP	*lnMa*	*lnPci*	*lnLp*	*Cp*	*Ex*	*lnAge*	*Ownership1*	*Ownership2*	*Size1*	*Size2*	*Region1*	*Region2*	*Region3*	*Region4*	*Region6*
TFP	1															
lnMa	0.094***	1														
lnPci	-0.072***	-0.095***	1													
lnLp	0.835	0.125	0.005***	1												
Cp	0.140***	-0.005	-0.005	0.007	1											
Ex	0.210***	0.095***	-0.056***	0.229***	0.017**	1										
lnAge	-0.022**	-0.047***	0.229***	-0.013	0.000	-0.023**	1									
Ownership1	0.051***	0.054***	0.027***	0.063***	0.000	-0.041	0.185	1								
Ownership2	-0.288***	-0.049***	0.002	-0.278***	-0.036***	-0.391***	0.115***	-0.215***	1							
Size2	-0.053***	-0.045***	-0.042***	0.013	-0.045***	-0.278***	-0.200***	-0.077***	0.129***	1						
Size3	0.003	-0.065***	0.005	0.011	-0.014	-0.033***	-0.001	-0.036***	0.133***	-0.443***	1					
Region1	-0.002	-0.020**	-0.093***	0.025***	0.006	-0.032***	-0.101***	-0.051***	0.009	0.069***	-0.017	1				
Region2	-0.041***	0.028***	-0.125***	-0.055***	-0.001	-0.059***	-0.040***	0.034***	-0.005	0.029***	-0.018**	-0.257***	1			
Region3	-0.091***	0.005	0.073***	-0.121***	-0.007***	-0.119***	0.015	0.041***	0.167***	-0.024***	0.025***	-0.310***	-0.105***	1		
Region4	-0.028***	-0.002	-0.056***	-0.028***	-0.007	-0.030***	0.022**	0.042***	0.030***	0.017**	0.028***	-0.096***	-0.033***	-0.039***	1	
Region6	-0.051***	0.007	0.054***	-0.037***	-0.009	-0.029***	0.001	0.033***	0.116***	-0.015*	-0.019**	-0.224***	-0.076***	-0.092***	-0.028***	1

*, **, and *** are statistically significant at 10%, 5% and 1% respectively

Table 6: Results of model estimation of factors affecting TFP

TFP	Coefficient	Standard error	z	P>|z|
lnMa	0.002***	0.000	4.880	0.000
lnPci	1.085***	0.027	40.410	0.000
lnLp	0.798***	0.002	378.470	0.000
Cp	0.140***	0.003	44.390	0.000
Ex	0.012***	0.003	3.680	0.000
lnAge	0.020***	0.004	5.800	0.000
Ownership1	-0.028***	0.008	-3.290	0.001
Ownership2	-0.019***	0.005	-4.090	0.000
Size2	0.144***	0.006	25.420	0.000
Size3	0.046***	0.004	12.800	0.000
Region1	-0.042***	0.005	-9.030	0.000
Region2	0.014	0.008	1.670	0.095
Region3	-0.079***	0.008	-10.390	0.000
Region4	-0.027	0.021	-1.320	0.188
Region6	-0.043***	0.009	-4.570	0.000
_cons	2.209***	0.110	20.030	0.000

*** is statistically significant at 1%

The coefficients of *lnLp* and *Cp* are both positive and significant at the 1% level. This shows that there is a positive impact of labor productivity and capital productivity on the total factor productivity of the manufacturing firms. In the past years, the income level of workers in manufacturing firms has been improved day by day, the remuneration regimes are also better. These factors have motivated employees to work harder and more actively, leading to a higher TFP level for the firms. Besides, capital productivity shows efficiency in the production management of the firm's executives. It shows that when the firms have a suitable development strategy, optimizing the use of capital will help them achieve better TFP levels.

Furthermore, there is evidence of a positive impact of exports on the TFP of the manufacturing firms during this period. Accordingly, the productivity of firms participating in exporting is 0.012 times higher than that of firms not participating in exporting, corresponding to an increase of 0.6% compared to the average TFP, at a 1% level of statistical significance. This shows that self-selection and learning by exporting have had great impacts on the TFP of Vietnamese manufacturing firms. Therefore, the reality shows that the export activities of the manufacturing sector have been increasingly promoted in recent years, the export index is always in the leading group in Vietnam.

The estimated coefficients of the control variables show that: the number of years of operation of the business has a positive impact on TFP. It reflects the positive impact of experience on TFP in the field of manufacturing. The State-owned firms and the private firms have lower TFP levels than the FDI firms. This is evidence that the technology, management, and labor quality of the FDI firms are better than the domestic ones. Besides, medium and large firms have better TFP than small firms. And finally, manufacturing firms in the South East provinces have better TFP levels than firms in the rest of Vietnam.

5. Conclusions and recommendations

The study conducted an assessment of TFP levels and conducted an analysis of the determinants influencing TFP within Vietnamese manufacturing firms during the five-year period from 2015 to 2019. Based on the outcomes of the estimations and model analyses, the study can draw several key conclusions and offer policy recommendations as follows:

Firstly, it is evident that Vietnamese manufacturing firms continue to exhibit a predominantly labor-intensive character, with TFP contributing modestly to their overall output. Consequently, these firms should prioritize initiatives aimed at enhancing labor skills, reinforcing corporate governance, and optimizing existing factors to elevate TFP. Moreover, given the observed trend of increasing returns to scale, firms could strategically consider expanding their production scale to enhance operational efficiency.

Secondly, technological advancement and innovation emerge as pivotal factors influencing TFP. Hence, firms should focus on investments geared towards upgrading machinery, equipment, and modernizing information technology and communication infrastructure to attain higher TFP scores. Additionally, the government should devise strategies for fostering the development of science, technology, and innovation within the manufacturing sector. This includes providing robust support for production technology, particularly for private and small to medium-sized manufacturing firms. Encouraging high-quality Foreign Direct Investment (FDI) inflow into the manufacturing sector and strengthening linkages between FDI enterprises and domestic firms are essential to catalyze technology spillover.

Thirdly, the quality of economic institutions and the business environment exert a substantial influence on manufacturing firms' TFP. Consequently, there is a pressing need for innovative policy enhancement pertaining to national industrial development, with a particular emphasis on the manufacturing sector. To this end, expeditious finalization and promulgation of the draft Law on Supporting Industry and the Law on Industrial Development, as aligned with Resolution 16/2021/QH15 of the National Assembly, are paramount. The enactment of these laws will serve as the pinnacle legal framework for harmonizing national industrial development policies, effectively allocating resources, and realizing the objectives set forth for the manufacturing industry. This comprehensive approach will fortify the Vietnamese manufacturing sector's TFP, positioning it as a dynamic economic driver prepared to confront emerging challenges and opportunities while achieving its designated objectives.

Compliance with ethical standards

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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