

## Article

# Total Factor Productivity Growth of Vietnamese Enterprises by Sector and Region: Evidence from Panel Data Analysis

Hai Quang Nguyen <sup>1,2</sup> 

<sup>1</sup> Faculty of Business Administration, University of Economics and Law, Ho Chi Minh City 71309, Vietnam; nhquang@uel.edu.vn

<sup>2</sup> Vietnam National University, Ho Chi Minh City 71309, Vietnam

**Abstract:** Total factor productivity growth (TFPG) is an important indicator evaluating the enterprise development model. The aim of this study is to consider the imbalance between TFPG and enterprises growth patterns of sectors and regions in Vietnam. The results of panel data analysis in 2005–2018 show that the growth of Vietnamese enterprises is mainly due to increased capital, especially in the non-state enterprise sector and in the Red River Delta. Total factor productivity (TFP) was found to be present in the non-state and inward foreign investment sectors during the five years 2014–2018. By comparison, the state-owned enterprise sector fell sharply during the same period. Strong upward increases in TFP were notable in the Northern Midlands and Mountain areas, the Mekong River Delta, and the Southeast, while there was a marked downward trend in the Central Highlands and the Red River Delta, especially marked in the Central Highlands. Thus, the results from this study are a basis to suggest an appropriate policy mix that helps to improve the performance of enterprises in different sectors and regions of Vietnam.

**Keywords:** total factor productivity growth; enterprise sectors; enterprises in regions; panel data analysis



**Citation:** Nguyen, Hai Quang. 2021. Total Factor Productivity Growth of Vietnamese Enterprises by Sector and Region: Evidence from Panel Data Analysis. *Economies* 9: 109. <https://doi.org/10.3390/economies9030109>

Academic Editor: Michele Meoli

Received: 31 May 2021

Accepted: 3 August 2021

Published: 10 August 2021

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## 1. Introduction

TFPG reflects the change or development trend of intangible factors such as technology innovation, production rationalization, management improvements, upskilling of the labor force, etc. Moreover, TFPG reflects efficiency in the use of all factors and constitutes an important source of sustained long-term growth (Tan and Virabhak 1998). As a result of its importance, there have been many studies measuring and evaluating TFPG in various countries: for example, in East Asia by Felipe (1999); in the Singapore service industry by Tan and Virabhak (1998), Mahadevan (2002), Kong and Tongzon (2006); the measurement of TFPG in agriculture by Coelli and Rao (2005), Avila and Evenson (2010); technical efficiency, technological change and TFPG in Chinese state-owned enterprises by Kong et al. (1999); the Wu (2011) study of TFPG in China; TFP in manufacturing and the services sector of post transition economies in Eastern Europe by Botrić et al. (2017), etc. These studies have enriched the theory and measurement methods of TFPG and TFP in different industries, fields, and contexts.

Vietnam is located in Southeast Asia and is a developing country. TFP, therefore, plays a key development role in narrowing the economic gap with other countries. Consequently, enterprises have a particularly important role to play in the economy, as the main driver of Gross Domestic Product (GDP) and source of employment. According to the General Statistics Office of Vietnam (2020), as of 31 December 2018, Vietnam had 610,000 active enterprises reporting production and business statistics (accounting for 80.5% of the total number of active enterprises) and employing around 14.82 million people. As a result, enterprises contribute the most to the development of the economy. According to the GSO of Vietnam, they account for more than 60% of the country's GDP. However, the effectiveness of enterprises across sectors and regions is patchy.

There are many reasons behind this, such as advantages specific to individual industries, regions, businesses, and each enterprise's growth model. Hence, the study of TFPG of enterprises across sectors and regions in Vietnam is an issue of practical significance. The study findings provide useful insights into the repercussions of unbalanced development between sectors and regions. Furthermore, the study can serve as the basis for developing an appropriate policy mix geared towards improving the performance of enterprises in the different sectors and regions of Vietnam.

Previous TFP and TFPG studies in Vietnam have addressed various fields and have been diverse in their scope. These include measuring TFP in agriculture (Bao 2014; Giang et al. 2019); TFPG in the coal industry (Phuong 2018); TFP in air transport (Quang 2017); TFPG among modes of transport (Quang 2019); TFP in the food industry (Long 2020), TFP in the manufacturing sectors (Huong 2017; Thanh et al. 2020); TFP for foreign direct investment enterprises (Hien et al. 2019) and state ownership (Le et al. 2021). In addition, there are a number of studies examining factors affecting TFP, such as: the impact of the investment climate on TFP in the agricultural sector (Trung and Cuong 2010); the impact of investment climate on the TFP of manufacturing firms (Giang et al. 2018); the impact of innovation on the TFP of small and medium-sized enterprises (Hue et al. 2019); the determinants of TFP in manufacturing industry (Oanh 2019).

These studies are mainly focused on specific industries or specific ownership sectors. The methods used include both the parametric approach (Trung and Cuong 2010; Quang 2017; Giang et al. 2018, 2019; Quang 2019; Oanh 2019; Le et al. 2021) and the non-parametric approach (Coelli and Rao 2005; Kong and Tongzon 2006; Wu 2011; Bao 2014; Phuong 2018). In addition, some recent studies also utilized a semi-parametric approach (Huong 2017; Thanh and Van 2020). Most of the parametric and non-parametric approaches use the Ordinary Least Square (OLS) regression technique to estimate the parameters for the TFPG calculation or are based on OLS such as robust regression (Bao 2014), Fixed Effect Models (FEM), and the Random Effects Model (REM) for panel data (Giang et al. 2019; Le et al. 2021). The semi-parametric approach uses the estimation technique of Olley and Pakes (1996) (Giang et al. 2018) or the procedure of Akerberg et al. (2006) (Thanh and Van 2020). These approaches are discussed in Section 2.

While some publications have carried valuable coverage of TFP and TFPG in Vietnam, knowledge gaps remain for two main reasons. Firstly, meaningful insights into the repercussions of unbalanced development can only be obtained by comparing TFPG among enterprise sectors and enterprises in different regions. However, the author found no research results relating to this issue; only studies focused on an industry, a specific locality, or a type of ownership as outlined above. These will form the basis of business development policies that align with the need for development orientation and enterprise performance improvement in Vietnam's various sectors and regions.

Secondly, although the parameters were estimated by different methods, such as OLS, FEM, REM, robust regression, semi-parametric estimation procedure of Olley and Pakes or Akerberg et al., there are other appropriate methods for each data type that needs to be considered. For example, if the series is not stationary but cointegrated, the cointegration regression would be appropriate to prevent spurious regression. The above outlines the motivations behind this study of enterprise TFPG among sectors and regions of Vietnam. The objective of this paper is to verify the unbalanced development of TFPG and the growth model of enterprises in the sectors and regions of Vietnam.

The key empirical contribution of this paper will be in detailing the different roles of TFP, capital, and labor on the growth model of enterprises operating across various sectors and regions in Vietnam with an updated sample to 2018. To the best of the author's knowledge, this is the first attempt to provide useful insights into the repercussions of unbalanced TFP developments between sectors and regions in Vietnam based on a consistent data set and methodology.

After the introduction section, the structure of the study includes four further sections: Section 2 presents a literature review; Section 3 presents the research methodology and

data; Section 4 presents the study results and discussion; and finally, conclusions and implications from the study results are presented in Section 5.

## 2. Literature Review

According to Mahadevan (2003), since the early 1940s, the concept of TFPG and what it measures has been hotly debated, leading to various definitions. Fundamentally, though, TFPG is determined by the growth rate of the output minus the growth rate of the input (Mahadevan 2003; Felipe and McCombie 2004). Consequently, researchers have synthesized and proposed two main approaches to measure the TFPG, such as the frontier approach and the non-frontier approach (Mahadevan 2003; Kong and Tongzon 2006). Each approach has a method of parameter estimation and non-parametric estimation. Table 1 below summarizes the differences between these two approaches.

**Table 1.** Different approaches to measuring TFPG.

Frontier Approach: Assumes Technical Inefficiency		Non-Frontier Approach: Assumes Technical Efficiency	
Parametric estimation	Non-parametric estimation	Parametric estimation	Non-parametric estimation
Stochastic frontier Neutral shifting Non-neutral shifting Bayesian approach	Deterministic Data Envelopment Analysis (DEA) Stochastic DEA	Average response function Cobb–Douglas production Cobb–Douglas translog	Translog divisia index

Source: Kong and Tongzon (2006).

According to Mahadevan (2003), most studies have used the non-frontier approach for calculating TFP growth. The frontier approach was initiated by Farrell (1957), but it was not until the late 1970s that the approach was formalized and used for empirical investigation.

The important difference between the frontier and non-frontier approaches lies in the definition of “frontier”. A frontier refers to a bounding function or, more appropriately, a set of best obtainable positions. The frontier approach then determines the role of technical efficiency in a company’s overall performance, while the non-frontier approach assumes that companies are technically efficient.

However, what the frontier and non-frontier approaches have in common is that both can be estimated using the parametric or non-parametric approach. The parametric technique is an econometric estimation of a specific model since it is based on the statistical properties of the error terms, it allows for statistical testing and hence validation of the chosen model. The choice of the functional form is crucial to model the data as different model specifications can give rise to different results.

In the frontier approach, non-parametric techniques by Data Envelopment Analysis (DEA) are often applied by researchers (Coelli and Rao 2005; Kong and Tongzon 2006; Wu 2011; Bao 2014; Phuong 2018; Hien et al. 2019). For the non-frontier approach, the parameter technique, which is estimated by adapting production functions is also commonly applied. There are two common ways to obtain TFP based on firm-level production functions: Cobb–Douglas production functional form, and a translog production function. It is argued that both approaches have good mathematical properties. However, according to Giang et al. (2018), the elasticity of the production to the inputs in the Cobb–Douglas function allows for easier interpretation than the trans logarithmic production. To be more specific, the translog technique generally suffers from a collinearity problem among the regressors (Kinda et al. 2011).

When measuring TFP for firms across broad industries or sectors, a simple production function consisting of two inputs, capital and labor, and an output factor of value-added, is often used because these are factors that most generally reflect inputs and outputs (Tan and Virabhak 1998; Felipe 1999; Giang et al. 2018, 2019; Oanh 2019; Thanh and Van 2020; Oanh 2019). When measured within specific industries or firms, inputs can be

extended beyond capital and labor (Bao 2014; Thanh et al. 2020; Le et al. 2021), or outputs can be measured by the number of products (Quang 2019).

To overcome the problem of endogeneity between inputs and unobserved productivity, Olley and Pakes (1996) proposed a semi-parametric approach which was later extended by Levinsohn and Petrin (2003) and Wooldridge (2009). The robustness to measurement errors is also an advantage of the semi-parametric method (Van Biesebroeck 2007). This approach is often used to estimate unobserved productivity at the firm level and has been applied to the measurement of manufacturing firms in Vietnam (Huong 2017; Thanh and Van 2020).

Although there are many different approaches, they can be summarized into three main methods:

- (1) The non-parametric approach using DEA;
- (2) The parameter approach using the production function (Cobb–Douglas production and the transformed production function);
- (3) The semi-parametric approach estimating Cobb–Douglas production functional form specified by the methodology of Levinsohn and Petrin (2003).

Non-parametric approaches have the benefit of not assuming a specific functional form/shape for the frontier. However, they do not provide a general relationship (equation) regarding the outputs and inputs to enter, as do parametric or semi-parametric approaches. The frequent techniques to estimate the production function include OLS estimation, the Olley and Pakes method, and the Levinsohn and Petrin approach.

### 3. Research Methodology and Data

#### 3.1. Specification Research Model

As it was appropriate to the data source being collected, this study used the parameter approach and Cobb–Douglas production function estimation to determine TFPG because it provides an equational relationship regarding outputs and inputs, as discussed above. The elasticity of the inputs in the Cobb–Douglas function allows for easier interpretation than the production translog function and is still in common use (Giang et al. 2018, 2019; Oanh 2019; Thanh and Van 2020; Thanh et al. 2020; Le et al. 2021). As this study uses estimates for enterprise sectors and enterprise in regions, the enterprises examined do not belong to a specific industry, and the most common factors that reflect inputs are capital and labor. Hence, a Cobb–Douglas production function with two inputs is used in this study, as has been the case with other recent studies (Giang et al. 2018, 2019; Oanh 2019; Thanh and Van 2020). The simple Cobb–Douglas production function follows Equation (1).

$$Q = AK^{\alpha}L^{\beta} \quad (1)$$

where:

Q: Amount of output

A: TFP

K: Amount of capital

L: Labor quantity

$\alpha$  and  $\beta$ : The coefficients of the contribution of capital and labor, respectively.

When calculated, TFPG is shown as the percentage increase of output after subtracting the contribution of the capital increase and increased labor. From Equation (1), the formula for calculating TFP growth rate has been widely applied by many researchers and takes the form of Equation (2) (Felipe 1999; Huong 2017; Oanh 2019; Quang 2019; Thanh and Van 2020).

$$G_{TFP} = G_Q - (\alpha G_K + \beta G_L) \quad (2)$$

where:

$G_{TFP}$ : TFPG

$G_Q$ : Growth rate of output

$G_K$ : Growth rate of capital

$G_L$ : Growth rate of labor

With  $\alpha + \beta = 1$ .  $\alpha G_K$  and  $\beta G_L$  are the contributions of increase in  $G_Q$  due to capital increase and increase in labor, respectively.

Because of  $\alpha + \beta = 1$  ( $\beta = 1 - \alpha$ ), to facilitate the estimation of the parameters, Equation (1) is divided on both sides by  $L$  in the Equation (3).

$$\frac{Q}{L} = AK^\alpha L^\beta = AK^\alpha L^{1-\alpha} = A \left( \frac{K}{L} \right)^\alpha \text{ or } q = Ak^\alpha \quad (3)$$

where:

$q = Q/L$ : Output per labor

$k = K/L$ : Capital per labor

Transforming Equation (3) into a linear expression by taking logarithm on both sides of the Equation, we have:

$$\log(q) = \log(A) + \alpha \log(k) \quad (4)$$

This study measures the TFPG of enterprises among sectors as well as regions, so that the Equation (4) is generalized into Equation (5) below.

$$\text{Model}_{ij}: \log(q_{ij}) = \log(A_{ij}) + \alpha \log(k_{ij}) \quad (5)$$

where:

$i = 1$ : Enterprise sector ( $j = so$ : State-owned enterprise sector;  $j = ns$ : Non-state enterprise sector;  $j = fd$ : Foreign direct investment sector)

$i = 2$ : Regions ( $j = rr$ : Red River Delta;  $j = nm$ : Northern Midlands and Mountain areas;  $j = nc$ : North Central and Central coastal areas;  $j = ch$ : Central Highlands;  $j = se$ : Southeast;  $j = mr$ : Mekong River Delta)

Determining TFPG in this study involves two steps. Step 1: Estimate the contribution coefficients of capital ( $\alpha$ ) and labor ( $\beta$ ) in the Cobb–Douglas production function for each enterprise sector and region by Equation (5). Step 2: Calculate TFPG for each enterprise sector and region in each period by Equation (2). Although the data collected to estimate the parameters in Step 1 are from 2005–2018, when calculating TFPG in Step 2, it was applied only to the last five or ten years for homogeneity of comparison. The specific five-year periods were 2009–2013 and 2014–2018, and for the 10 year period, 2009–2018 was used.

### 3.2. Measurement of Input and Output Variables

#### 3.2.1. Output

Enterprise performance output can be measured by product volume or the value of the product (revenue). However, in different industries and sectors, products will be heterogeneous or revenue will not reflect the true nature of the output. For example, to generate one unit of revenue, the manufacturing industry expends significantly more resources than it takes the service industry to do the same. Therefore, for the measurement of different sectors, the output is often used as value added (Tan and Virabhak 1998; Felipe 1999; Mahadevan 2002; Huong 2017; Giang et al. 2019; Thanh and Van 2020).

Value-added reflects the newly created value of the enterprises. It is the difference between the total output value and the intermediate inputs. Since intermediate inputs are not available in the data set, this study applies value-added calculation according to the income method of the GSO of Vietnam. It is calculated by total gross profit, interest, taxes, labor costs, and depreciation. In other words, it covers labor costs, depreciation, profit before tax, and interest. Since there are no data on depreciation and interest expenses, this study uses profit before tax and employee income as a proxy of the output value as per the study of Dat et al. (2020).

### 3.2.2. Input Variable: The Volume of Capital

The data commonly used to represent capital are the total assets/ capital sources or fixed assets. In addition, depending on the availability of data, stock capital is also used for representation (See and Li 2015; See and Rashid 2016). Based on enterprise survey data from the GSO of Vietnam, this study used the total annual capital of the enterprise to represent the amount of capital. Therefore, it is the average of capital at the beginning and the end of the financial year.

### 3.2.3. Input Variable: The Amount of Labor

The data representing the amount of labor commonly used are the average number of employees in the financial year (See and Li 2015; See and Rashid 2016; Giang et al. 2019; Quang 2019) or labor costs (Tan and Virabhak 1998). Based on enterprise survey data from the GSO of Vietnam, this study used the average number of employees per year to represent the volume of labor. It is the average number of employees at the beginning and the end of the year or the average number of employees at the end of two adjacent financial years as in Equation (6) below. This average method has been implemented in research by Vasigh and Fleming (2005) or Quang (2019).

$$\text{The average labor in year } t = \frac{\text{Labor at the end of year } t - 1 + \text{Labor at the end of year } t}{2} \quad (6)$$

### 3.3. Research Data

Data from the GSO of Vietnam's annual report (namely, the "Enterprise, Cooperative and Non-farm individual business establishment" section) were used by this study to collate annual data on average capital within the year, the number of employees at the end of the year, profit before tax, and the income of employees.

The years collected are 2005 and the years 2008–2018. These years were selected as these are the only years for which the GSO of Vietnam has a full range of official data. The statistical data relates to all active enterprises as of 31 December of each year. Due to a change in the division of the state-owned enterprise sector, the data for central enterprises and local enterprises were collected for 2005 and 2008–2015. Meanwhile, the data for enterprises with 100% state capital and enterprises where the state holds more than 50% of charter capital were collected for the year 2010 and during 2013–2018. The annual number of employees was collected a year ago to calculate the average number of employees. To ensure the study's data stability, enterprises with negative or very modest gross profit before tax and employee income were excluded. A summary of the sample is presented in Table 2 below.

**Table 2.** Sample.

Sector/Regions	Case Study	Object	Enterprise-Year	Note
Enterprise sectors	State-owned enterprise sector	Central enterprises; local enterprises	37,053 (0.84%)	
		Enterprises wholly financed by state capital; enterprises where the state holds more than 50% of the charter capital		
	Non-state enterprise sector	Private enterprises; partnership companies; private limited liability companies; companies with 50% or less of their charter capital shared by the state; joint-stock companies without state capital	4,254,065 (96.41%)	
	Foreign investment enterprise sector	100% foreign invested enterprises; enterprises joint ventures with foreign parties.	121,367 (2.75%)	

Table 2. Cont.

Sector/Regions	Case Study	Object	Enterprise-Year	Note
Regions	Red River Delta	Hanoi; Vinh Phuc; Bac Ninh; Quang Ninh; Hai Duong; Hai Phong; Hung Yen; Thai Binh; Ha Nam; Nam Dinh; Ninh Binh	1,385,785 (31.42%)	
	Northern Midlands and Mountain areas	Ha Giang; Cao Bang; Bac Can; Tuyen Quang; Lao Cai; Yen Bai; Thai Nguyen; Lang Son; Bac Giang; Phu-Tho; Dien Bien; Lai Chau; Son La; Hoa Binh.	186,098 (4.22%)	The data year 2010 for Hoa Binh was not used.
	North Central and Central coastal areas	Thanh Hoa; Nghe An; Ha Tinh; Quang Binh; Quang Tri; Hue; Danang; Quang Nam; Quang Ngai; Binh Dinh; Phu Yen; Khanh Hoa; Ninh Thuan; Binh Thuan	581,360 (13.18%)	The data years 2011 and 2012 for Quang Ngai, and 2018 for Thanh Hoa were not used
	Central Highlands	Kon Tum; Gia Lai; Dak Lak; Dak Nong; Lam Dong	116,164 (2.63%)	The data year 2018 for Gia Lai was not used.
	Southeast	Binh Phuoc; Tay Ninh; Binh Duong; Dong Nai; Ba Ria-Vung Tau; Ho Chi Minh City.	1,787,089 (40.52%)	
	Mekong River Delta	Long An; Tien Giang; Ben Tre; Tra Vinh; Vinh Long; Dong Thap; An Giang; Kien Giang; Can Tho; Hau Giang; Soc Trang; Bac Lieu; Ca Mau	354,319 (8.03%)	The data year 2008 for Dong Thap was not used.

As can be seen from the sample in Table 2, the non-state sector accounted for the majority (more than 96%) of the enterprise sector. The bulk of enterprises are located in two areas, the Southeast and the Red River Delta, which contain the two most extensive economic centers in Vietnam, Ho Chi Minh City and Hanoi. The data collected were processed to calculate the average employee according to Equation (5) and the output value per employee and the amount of capital per employee. Descriptive statistical data in the research models are presented in Table 3 below.

Table 3. Descriptive statistics of the data in the models.

	Variable	Mean	Maximum	Minimum	Std. Dev.	CV	Number of Observations
Model <sub>1,so</sub>	k <sub>1,se</sub>	3.9409	10.1469	0.2752	2.7138	0.6886	32
	q <sub>1,so</sub>	0.2025	0.3373	0.0258	0.0854	0.4219	
Model <sub>1,ns</sub>	k <sub>1,ns</sub>	1.1726	3.7193	0.1070	0.9021	0.7693	60
	q <sub>1,ns</sub>	0.0950	0.2803	0.0146	0.0604	0.6362	
Model <sub>1,fd</sub>	k <sub>1,fd</sub>	1.6328	3.3818	0.3240	0.9765	0.5981	24
	q <sub>1,fd</sub>	0.2492	0.4804	0.0270	0.1554	0.6237	
Model <sub>2,rr</sub>	k <sub>2,rr</sub>	0.8862	3.4817	0.1274	0.5946	0.6709	132
	q <sub>2,rr</sub>	0.0909	0.4109	0.0010	0.0748	0.8233	
Model <sub>2,nm</sub>	k <sub>2,nm</sub>	0.6926	1.9820	0.1097	0.4349	0.6279	166
	q <sub>2,nm</sub>	0.0606	0.4257	0.0090	0.0568	0.9377	
Model <sub>2,nc</sub>	k <sub>2,nc</sub>	0.8259	5.3941	0.1202	0.7908	0.9575	165
	q <sub>2,nc</sub>	0.0594	0.2395	0.0103	0.0347	0.5841	
Model <sub>2,ch</sub>	k <sub>2,ch</sub>	0.8351	2.6364	0.1659	0.4836	0.5791	59
	q <sub>2,ch</sub>	0.0636	0.1218	0.0158	0.0249	0.3921	
Model <sub>2,se</sub>	k <sub>2,se</sub>	1.2012	4.6877	0.1393	1.0611	0.8834	72
	q <sub>2,se</sub>	0.1520	0.9725	0.0274	0.1569	1.0325	
Model <sub>2,mr</sub>	k <sub>2,mr</sub>	0.8403	3.2942	0.1416	0.6184	0.7360	155
	q <sub>2,mr</sub>	0.0808	0.1658	0.0110	0.0345	0.4275	

Source: Analysis results from the GSO of Vietnam.

## 4. Research Results and Discussion

### 4.1. Unit Root Test and Cointegration Test

Panel unit root tests were conducted for all three patterns. These included a trend and an intercept exists, only an intercept exists, or neither exists using the testing methods of Im, Pesaran and Shin (IPS), Fisher type test using Augmented Dickey–Fuller (ADF), and the Philips Perron (PP) test. These unit root tests are appropriate methods for unbalanced panel data. The lag length was automatically chosen by the Schwarz Information Criterion (SIC) with Newey–West automatic bandwidth selection and Bartlett kernel. The panel unit root test results are represented in the Appendix A. According to the results of the unit root test, the series are stationary at different level for each test of each pattern, but there is at least one series that is not stationary at level, so that OLS estimation might be a spurious regression (Granger and Newbold 1974). Under these circumstances, a cointegration test was conducted to evaluate the long-term relationship among variables. According to Pedroni (1999), there are seven test statistics to analyze the cointegration relation among the variables in a panel data model where the null hypothesis of no cointegration has been formulated. Additionally, the Kao test (developed by Kao 1999), which has the null hypothesis of no cointegration, was utilized to assess the cointegration relation. The results of the panel cointegration test for each model are presented in the Appendix A. The first test performed was the Pedroni test. The results for at least 4/7 tests were statistically significant at either 0.05 or 0.01 level in both “Individual Intercept” and “Individual Intercept and Individual trend” for most models, except for model<sub>1,ns</sub>, model<sub>1,fd</sub>, and model<sub>2,se</sub>. In other words, most of the tests achieve statistical significance at the 0.01 or 0.05 level for these models. Model<sub>1,ns</sub> and model<sub>1,fd</sub> produced the most test results (at least 4/7), which were statistically significant at 0.01 or 0.05 level for “Individual Intercept” but for “Individual Intercept and Individual trend”, they do not meet this requirement. By contrast, in model<sub>2,se</sub>, although 5/7 tests that are statistically significant at 0.01 or 0.05 level for the case of “Individual Intercept and Individual trend”, there are only 2/7 tests statistically significant at the 0.01 or 0.05 level for “Individual Intercept”. Therefore, the Pedroni test cannot reject the null hypothesis for models<sub>1,ns</sub>, models<sub>1,fd</sub>, and models<sub>2,se</sub> where the Kao test was conducted.

The Kao test results for these models in the Appendix A all produce relatively large *t*-Statistic values with significance at the 0.01 or 0.05 level. Thus, with the Pedroni test, as supplemented by the Kao test, it is possible to accept alternative hypotheses for all models. This means that the variables in all models are long-run associated.

### 4.2. The Results of the Parameter Estimation

Due to the cointegration relationship between the variables in the models, parameters can be estimated by cointegrating regression for panel data, such as by fully modified ordinary least squares (FMOLS) or dynamic ordinary least squares (DOLS). This study chose the FMOLS method because there is a large variation in the long-term coefficients of variance among the objects of the panel data (type of enterprise in sectors or enterprise in provinces within regions). The estimated results of the parameters in the models where the FMOLS method was applied are presented in Table 4 below.

Table 4 above shows a greater than 50% adjusted R<sup>2</sup> for all models. As the standard errors are quite small, the regression models are appropriate and accepted. The estimated parameters ( $\alpha$ ) in all models have quite large T-statistic values with statistical significance at the 1% level, except for model<sub>2,mr</sub> at 5% level, so the parameters are accepted. Thus, the estimated values of the parameters are in the range of 0 to 1. According to the estimation results, the role of capital is higher than that of labor in all enterprise sectors. The greatest leverage is the foreign investment enterprise sector, followed by the non-state enterprise sector and finally, the state-owned enterprise sector. For regions, the role of capital is substantially greater than that of labor, except for region 3 (North Central and Central Coastal areas). The most prominent is region 1 (Red River Delta), the next is region 5



(Southeast), followed by region 2 (Northern Midlands and Mountain areas), region 6 (Mekong River Delta), and region 4 (Central Highlands).

**Table 4.** Results of the estimated coefficients of capital per labor.

	Enterprise Sectors				Enterprises by Region				
	Model <sub>1,se</sub>	Model <sub>1,ns</sub>	Model <sub>1,fd</sub>	Model <sub>2,rr</sub>	Model <sub>2,nm</sub>	Model <sub>2,nc</sub>	Model <sub>2,ch</sub>	Model <sub>2,se</sub>	Model <sub>2,mr</sub>
Coefficient	0.6649	0.8817	0.9386	0.9749	0.6200	0.4738	0.6076	0.7946	0.6130
Std. Error	0.0816	0.0811	0.2575	0.1129	0.0670	0.0743	0.1010	0.1718	0.0574
t-Statistic	8.15 ***	10.87 ***	3.64 ***	8.64 ***	9.26 ***	6.38 ***	6.02 ***	4.63 ***	10.67 ***
R-squared	0.9060	0.8395	0.8892	0.6826	0.6380	0.5798	0.5480	0.7888	0.6903
Adj R-squared	0.8921	0.8231	0.8775	0.6505	0.6010	0.5365	0.5009	0.7673	0.6591

Note: \*\*\* for statistically significant at the 0.05 and 0.01 levels, respectively. Coefficients are the estimates of capital contribution ( $\alpha$ ) in Equation (5). Source: Cointegration regression results from Eview.

The robustness check is performed by comparing the estimated results of the FMOLS and OLS methods. Accordingly, the OLS method is applied to the FE and RE models, with the appropriate model being selected by the Hausman Test (Correlated Random Effects). The estimated results produced by the OLS method are detailed in the Appendix A. Table 5 below shows the estimated coefficient of capital per labor in the models where the FMOLS and OLS methods were applied. According to Table 5, the two methods produce similar estimated results, especially in the non-state enterprise sector, the foreign investment enterprise sector, the Red River Delta region, and the Southeast region (all lower than 3%). Only the Central Highlands region has a relatively significant difference (nearly 25%). Despite certain differences, it is believed that the results from the FMOLS method are more appropriate because the series are cointegrated in each model.

**Table 5.** Differences in coefficients estimated by FMOLS and OLS methods.

	Enterprise Sectors				Enterprise by Region				
	Model <sub>1,se</sub>	Model <sub>1,ns</sub>	Model <sub>1,fd</sub>	Model <sub>2,rr</sub>	Model <sub>2,nm</sub>	Model <sub>2,nc</sub>	Model <sub>2,ch</sub>	Model <sub>2,se</sub>	Model <sub>2,mr</sub>
FMOLS	0.6649	0.8817	0.9386	0.9749	0.6200	0.4738	0.6076	0.7946	0.6130
OLS	0.7756	0.8689	0.9191	0.9949	0.6910	0.5905	0.7098	0.7824	0.6794
	(FEM)	(REM)	(FEM)	(REM)	(REM)	(FEM)	(FEM)	(REM)	(FEM)
Difference	−0.1107	0.0128	0.0195	−0.0200	−0.0710	−0.1167	−0.1022	0.0122	−0.0664
%	−16.65	1.45	2.08	−2.05	−11.45	−24.63	−16.82	1.54	−10.83

Source: Estimation results from FMOLS and OLS.

#### 4.3. TFPG Comparison between Enterprises

By measuring the output growth of enterprise in sectors as well as in regions and the results of estimating the parameters in the models, this study has identified the increase in output due to increased capital and labor. The study then determines TFPG using Equation (2). TFPG calculation results for enterprises in sectors and regions are shown in Table 6 below.

According to Table 6, for the whole period of 2009–2018, the non-state enterprise sector had the highest output growth, with an average growth rate of 22.18% per year. This was followed by the foreign investment enterprise sector, which increased by 18.53%. The worst performing were state-owned enterprises which increased by only 8%. Output growth is mainly due to capital increase, in the above order 21.39%, 19.53%, and 9.35%. As a result, the TPF of the enterprise sectors in the period 2009–2018 showed negative growth. Over each five-year period, the TFPG of the state-owned enterprise sector tends to decrease rapidly from an average of 5.44% per year in 2009–2013 to −4.93% per year from 2014 to 2018. Meanwhile, the non-state enterprise sector and the foreign investment enterprise sector have the opposite trend. To be more specific, TFPG increased by 2.62% per year and 1.49% per year in the period of 2014–2018, respectively, instead of decreasing by

−3.11% per year and −4.98% per year during 2009–2013, as shown in Table 6. These figures signify that the state-owned enterprise sector is adopting innovative technology, improved management, and the upskilling of the labor force more slowly than their counterparts in the non-state enterprise and foreign investment enterprise sectors. On the other hand, it also shows the strong growth of the non-state enterprise sector and the foreign direct investment sector, as well as the declining size of the state-owned enterprise sector.

**Table 6.** The contribution of factors to the growth of enterprise. Unit: %.

	2009–2013				2014–2018				2009–2018			
	Output Growth	Input Growth		TFPG	Output Growth	Input Growth		TFPG	Output Growth	Input Growth		TFPG
	Capital	Labor			Capital	Labor			Capital	Labor		
SO	17.19	11.93	−0.18	5.44	−0.46	6.86	−2.39	−4.93	8.00	9.35	−1.30	−0.04
NS	24.29	26.14	1.26	−3.11	20.10	16.83	0.65	2.62	22.18	21.39	0.95	−0.16
FD	21.43	25.77	0.64	−4.98	15.70	13.61	0.60	1.49	18.53	19.53	0.62	−1.61
RR	29.23	27.66	0.26	1.30	13.14	14.45	0.15	−1.46	20.92	20.87	0.21	−0.16
NM	23.67	19.45	3.58	0.64	31.41	15.34	2.77	13.30	27.48	17.37	3.17	6.94
NC	22.42	14.50	4.36	3.56	12.50	10.02	2.69	−0.22	17.36	12.22	3.52	1.62
CH	18.86	14.75	1.81	2.30	−1.46	8.76	−0.17	−10.04	8.22	11.69	0.80	−4.27
SE	16.13	18.90	1.46	−4.23	12.59	8.40	1.01	3.18	14.35	13.50	1.24	−0.39
MR	21.71	19.55	3.36	−1.20	18.07	8.72	2.72	6.64	19.88	13.94	3.04	2.90

Note: SO is state-owned enterprise sector; NS is non-state enterprise sector; FD is foreign direct investment sector; RR is Red River delta; NM is Northern Midlands and Mountain areas; NC is North Central and Central coastal areas; CH is Central Highlands; SE is Southeast; MR is Mekong River delta. Source: Calculation results of TFPG.

By region, during 2009–2018, the highest output growth was in the Northern Midlands and Mountain areas (an average annual growth rate of 27.48%); followed by the Red River Delta, Mekong River Delta, North Central, and Central Coastal areas, Southeast, with average annual growth rates of 20.92%, 19.88%, 17.36%, and 14.35%, respectively; the least successful by this measure was the Central Highlands with an average annual growth rate of only 8.22%. Like the enterprise sectors, the output growth of enterprises in the regions is mainly based on the capital increase. To be more specific, the most significant growth in output due to capital increase is in the Red River Delta (20.87% per year), followed by the Northern Midlands and Mountain areas (17.37% per year), and the Mekong River Delta (13.94% per year), Southeast (13.5% per year), North Central and Central Coastal areas (12.22% per year) and the Central Highlands (11.69% per year). The leading TFPG figure belongs to the Northern Midlands and Mountain areas (6.94% per year), followed by the Mekong River Delta (2.90% per year), North Central and Central Coastal areas (1.60% per year). The remaining three regions have negative average growth TFP. Specifically, the largest decrease is the Central Highlands (average decrease of 4.27% per year), followed by the Southeast and Red River Delta with slight decreases of 0.39% per year and 0.16% per year, respectively. There are three regions with an increasing TFPG trend at each five-year period, namely Northern Midlands and Mountain areas, Mekong River Delta, and the Southeast. The remaining three regions with a decreasing trend are the Central Highlands, Red River Delta, North Central, and Central Coastal areas. Although the TFPG of the North Central, and Central Coastal areas tended to decrease, they still maintained growth during 2014–2018. The business performance of Central Highlands enterprise is showing signs of a sharp decline. Businesses in this region only increased their capital size while the number of employees tended to fall. This indicates that workers are taking up employment with enterprises in the Central Highlands and other regions.

#### 4.4. Discussion

The above study results prove that the non-state enterprise sector and the foreign investment enterprise sector strongly innovate technology to improve labor productivity

more than the state-owned enterprise sector. These results are consistent with some recent studies demonstrating that foreign direct investment enterprises in Vietnam have an expanding role in TFP (Hien et al. 2019); and negative TFP growth of state-owned enterprises in China (Ozyurt 2009). The results also support the outcome of the study by Le et al. (2021), which argues that state ownership is negatively associated with TFP. The decline in TFPG is because enterprises in the state-owned sector remain inefficient, have fewer incentives to change and change management. In addition, the study by Le et al. (2021) also shows that corruption control hinders TFP. It should be noted that during the last three decades of reforms, state-owned enterprises have been reformed, many privileges of the state-owned enterprises have been removed and the least efficient were merged or equitized. However, the results of this study cast doubt about the effectiveness of state-owned enterprise reform measures in Vietnam.

The relatively stable TFPG of the non-state enterprise sector during 2009–2018 found in this study is evidence that lends support to the view that the private sector is increasingly effective and plays an important role in the economic development of Vietnam. One of these reasons was studied by Le et al. (2021). They indicated that transparency promotes the TFP of private enterprises more than that of state-owned enterprises. In addition, in Vietnam, small and medium-sized enterprises are mainly in the non-state sector (between 2005 and 2018, the non-state enterprise sector accounted for 96.41% of the number of enterprises but only 59.13% of the labor and 50.83% of the capital). Hence, the TFPG of the non-state sector partly reflects the efficiency of small and medium-sized enterprises. The TFPG of the non-state sector found in this study is also consistent with the research results of Hue et al. (2019), which indicated that innovation has a positive impact on the TFP of small and medium-sized enterprises in Vietnam.

TFPG differences between regions of any country are apparent, but this study has shown specific differences between six regions in Vietnam by analyzing data up to 2018. It is believed that no previous studies have conducted this type of analysis. To be more specific, the Northern Midlands and Mountain areas and the Mekong River Delta are developing well as these regions increased their TFPG during 2009–2018 as well as in 2014–2018 and 2009–2013. This could be a sign of their emerging status as economic zones. North Central and Central Coastal areas, and the Southeast, although still maintaining TFPG growth, are experiencing slower growth rates. Meanwhile, the TFPG of the Red River Delta and the Central Highlands has ceased growth and is now dipping downwards. This trend is especially marked in the Central Highlands, where workers move away to find employment in other regions. Despite efforts to combat the outward labor migration and increase agricultural employment, negative growth persists. The reason for this phenomenon is because most provinces in this region are slow to develop, have poor transportation infrastructure, have few industrial zones, and the pace of industrialization and urbanization is relative slow. These findings, therefore, illustrate the unbalanced development of TFP among the regions of Vietnam.

The growth models indicate the vital role of capital in the foreign direct investment enterprise, non-state enterprise sectors as well as enterprises in the region of the Red River Delta and the Southeast. Vietnamese enterprises have seen output value growth in recent years, mainly thanks to capital increase. This is especially the case in the non-state sector, the foreign investment sector as well as the Red River Delta, and Northern Midlands and Mountain areas. Two main factors can explain this. First, it is derived from the roles of capital and labor as in the model estimates above. Second, increasing labor will be limited at the macro level because human social resources are limited and hampered by slow growth, while raising capital will face fewer obstacles.

## 5. Conclusions and Implications

This study has identified and compared TFPG among enterprise sectors and enterprises in different regions in Vietnam by using the parametric approach with two input variables, capital and labor. Based on cointegrating regression analysis techniques for panel

data, the study has found evidence of the different roles of capital and labor in the output of the enterprise sectors as well as individual enterprises within different regions. The role of capital to output growth in the foreign investment sector is the most prominent, followed by the non-state enterprise sector and finally, the state-owned enterprise sector. The foremost capital beneficiary is the Red River Delta, then the Southeast, the Northern Midlands and Mountain areas, followed by the Mekong River Delta, Central Highlands, and the North Central and Central Coastal areas. On the other hand, the contribution of labor toward the output growth rate of enterprise sectors and enterprises in regions is the opposite of capital contribution. In the period 2009–2018, the growth of output value (profit before tax and income of employees) of Vietnamese enterprises was mainly attributed to the capital increase, especially in the non-state enterprise sector and the Red River Delta. Indeed, the growth of the state-owned enterprise sector was entirely funded by capital during 2009–2018, and this is also found to hold in the Central Highlands during the period 2014–2018.

Besides the role of capital and labor, which indicate an enterprise's efficiency and productivity, this study also shows that TFP plays a key role in increasing the output volume of Vietnamese enterprises. From 2009 to 2018, there was a stark contrast in TFPG in terms of value and changing trends between enterprise sectors and individual enterprises within regions. In the five years 2014–2018, only the non-state enterprise sector and the foreign direct investment sector had TFP growth, but the state-owned enterprise sector fell sharply. The TFP of the Northern Midlands and Mountain areas, the Mekong River Delta, and the Southeast also trended toward growth. Meanwhile, the TFP of the Central Highlands and the Red River Delta tended to decrease and grow negatively in the period 2009–2018, especially in the Central Highlands. Although tending to decrease slightly, the TFP of the North Central and Central Coastal areas still maintained a positive growth rate during 2009–2018. These findings demonstrate the weakness of the state-owned enterprise sector and the increasing efficiency of the non-state enterprise sector and the foreign direct investment enterprise sector. The unbalanced development of TFPG among regions found in this study is indicative of the growing economic gap among regions. This is a scenario not usually expected internationally but for Vietnam is a case in point.

The results of this study imply that the government should continue to push ahead with reforms to improve the efficiency of state-owned enterprises. Although the state-owned sector accounts for only 0.84% of enterprises, they provide 14.01% of labor and 31.33% of capital in active enterprises. Therefore, they still play an important role in maintaining the state-owned sector and remain necessary. However, the state only needs to hold key areas to ensure social cohesion that other sectors do not want to participate in, such as reducing state ownership and loosening administrative controls. In addition, the state continues to create mechanisms to promote the non-state enterprise sector and foreign direct investment enterprise sector, creating a level playing field for all types of enterprises. In order to reduce the economic gap between regions, the state also needs to have policies to support underdeveloped enterprise areas, declining TFPG, especially in the Central Highlands, such as infrastructure development, policies to support capital and training, and so on. Addressing these issues would help the regions create advantageous conditions for production and business, innovation management, and technology to improve TFP. On their side, enterprises need to focus on increasing capital for growth and development, especially innovating and improving technology and management methods to promote TFPG. Capital increases will be more favorable than labor growth because, from a social perspective, the ability to increase labor will be limited. However, innovation in technology and management to increase TFP is the central issue to improve the efficiency of enterprises. The contribution of this study can be considered in two ways. First, academically, this study enriches the method of estimating capital and labor contribution coefficients by cointegration regression analysis for panel data. Second, in practical terms, this study shows the different roles of capital, labor, and TFPG in increasing the output of the enterprise sectors and enterprises in different regions of Vietnam. Furthermore, the study's findings on

unbalanced development within sectors and regions form the basis to build an appropriate policy mix.

Although this study has obtained some valuable results, some limitations should be noted. Firstly, due to data limitations, this study only explores TFPG from a macro perspective, such as among sectors and regions, without analyzing the internal performance of each specific industry. Secondly, due to the macro perspective, this study only considers two inputs when studying each specific industry, so the input factors need to be supplemented accordingly. Nevertheless, these issues may still provide opportunities for further study.

**Funding:** This research was funded by University of Economics and Law, Vietnam National University, Ho Chi Minh, Vietnam, under grant number 2-2021.

**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** Data are available in the GSO statistical yearbooks, accessible from: <http://thongke.gov.vn/default.aspx?tabid=512&idmid=5&ItemID=11973>; <http://thongke.gov.vn/default.aspx?tabid=512&idmid=5&ItemID=12574>; <http://thongke.gov.vn/default.aspx?tabid=512&idmid=5&ItemID=13760>; <http://thongke.gov.vn/default.aspx?tabid=512&idmid=5&ItemID=14080>; <http://thongke.gov.vn/default.aspx?tabid=512&idmid=5&ItemID=15161>; <http://thongke.gov.vn/default.aspx?tabid=512&idmid=5&ItemID=16051>; <http://thongke.gov.vn/default.aspx?tabid=512&idmid=5&ItemID=18531>; <http://thongke.gov.vn/default.aspx?tabid=512&idmid=5&ItemID=18940>; <http://thongke.gov.vn/default.aspx?tabid=512&idmid=5&ItemID=19298>.

**Acknowledgments:** The author is grateful to the four anonymous reviewers and Academic Editor whose comments have contributed to improving the quality of this paper.

**Conflicts of Interest:** The authors declare no conflict of interest.

## Appendix A

### Appendix A.1. Unit Root Test

Table A1. Results of unit root test.

Model	Variable	Intercept			Intercept and Trend			None	
		IPS	ADF	PP	IPS	ADF	PP	ADF	PP
Model <sub>1,se</sub>	Lnk <sub>1,se</sub>			I(1) **			I(0) **		I(1) **
	Lnq <sub>1,se</sub>			I(0) **			I(0) **	I(1) **	I(0) **
Model <sub>1,ns</sub>	Lnk <sub>1,ns</sub>	I(1) **	I(1) **	I(0) **			I(0) **	I(0) *	I(0) **
	Lnq <sub>1,ns</sub>	I(1) **	I(1) **	I(0) **			I(0) **	I(0) *	I(0) **
Model <sub>1,fd</sub>	Lnk <sub>1,fd</sub>			I(0) **			I(1) **	I(1) *	I(0) **
	Lnq <sub>1,fd</sub>	I(0) *	I(0) *	I(0) **			I(1) **	I(1) *	I(0) **
Model <sub>2,rr</sub>	Lnk <sub>2,rr</sub>	I(1) **	I(1) **	I(0) **		I(0) *	I(0) **	I(0) *	I(0) **
	Lnq <sub>2,rr</sub>			I(0) **	I(0) **	I(0) **	I(0) **	I(0) **	I(0) **
Model <sub>2,nm</sub>	Lnk <sub>2,nm</sub>	I(1) *	I(1) *	I(0) **			I(0) **	I(0) **	I(0) **
	Lnq <sub>2,nm</sub>	I(1) **	I(1) **	I(0) **		I(0) *	I(0) **	I(0) **	I(0) **
Model <sub>2,nc</sub>	Lnk <sub>2,nc</sub>	I(0) *	I(0) *	I(0) **		I(1) *	I(0) **	I(0) **	I(0) **
	Lnq <sub>2,nc</sub>	I(1) **	I(1) **	I(0) **		I(1) *	I(0) **	I(0) **	I(0) **
Model <sub>2,ch</sub>	Lnk <sub>2,ch</sub>	I(1) **	I(1) **	I(0) **	I(1) *	I(1) **	I(0) **	I(0) **	I(0) **
	Lnq <sub>2,ch</sub>	I(0) **	I(0) **	I(0) **		I(0) *	I(0) **	I(0) *	I(0) **
Model <sub>2,se</sub>	Lnk <sub>2,se</sub>			I(0) **			I(0) **	I(1) **	I(0) **
	Lnq <sub>2,se</sub>	I(0) **	I(0) **	I(0) **	I(0) **	I(0) **	I(0) **	I(0) **	I(0) **
Model <sub>2,mr</sub>	Lnk <sub>2,mr</sub>	I(0) *	I(0) *	I(0) **			I(0) **	I(0) **	I(0) **
	Lnq <sub>2,mr</sub>	I(1) **	I(1) **	I(0) **	I(1) *	I(1) **	I(0) **	I(0) **	I(0) **

Note: IPS is Im, Pesaran, and Shin W-stat; ADF is ADF-Fisher Chi-square; PP is PP-Fisher Chi-square; \* and \*\* for statistically significant at the 0.05 and 0.01 levels, respectively. IPS is not applied to cases where both trend and intercept do not exist. Source: Panel root test in Eview.

## Appendix A.2. Panel Cointegration Analysis

Table A2. Results of panel cointegration analysis.

Method	Statistic	Model <sub>1,so</sub>		Model <sub>1,ns</sub>		Model <sub>1,fd</sub>	
		Intercept	Intercept and Trend	Intercept	Intercept and Trend	Intercept	Intercept and Trend
Pedroni	Panel v-Statistic	−0.0455	−1.6070	−0.4622	−2.3110	1.4164 *	−0.9897
	Panel rho-Statistic	−0.2552	1.3435	−4.3196 ***	−2.3311 ***	−1.1022	0.6289
	Panel PP-Statistic	−2.5230 ***	−3.1500 ***	−8.1478 ***	−8.4721 ***	−1.6727 **	−1.3183 *
	Panel ADF-Statistic	−4.9161 ***	−9.0783 ***	−2.2795 **	−1.7380 **	−1.9117 **	−4.2644 ***
	Group rho-Statistic	0.6993	2.1171	−0.9465	0.9110	0.1715	1.0395
	Group PP-Statistic	−2.4435 ***	−2.8963 ***	−4.5103 ***	−2.5874 ***	−1.9581 **	−1.2123
	Group ADF-Statistic	−6.0571 ***	−7.1538 ***	−1.2953 *	−0.8409	−3.9348 ***	−3.5794 ***
Kao	<i>t</i> -Statistic	−2.8673 ***		−3.8813 ***		−2.5375 ***	
Method	Statistic	Model <sub>2,rr</sub>		Model <sub>2,nm</sub>		Model <sub>2,nc</sub>	
		Intercept	Intercept and Trend	Intercept	Intercept and Trend	Intercept	Intercept
Pedroni	Panel v-Statistic	−0.4622	−2.3110	−2.1192	−2.1073	0.2031	−1.9078
	Panel rho-Statistic	−4.3196 ***	−2.3311 ***	1.0091	0.9985	−1.232	0.8919
	Panel PP-Statistic	−8.1478 ***	−8.4721 ***	−3.1830 ***	−3.2656 ***	−3.0504 ***	−2.8992 ***
	Panel ADF-Statistic	−2.2795 **	−1.7380 **	−1.8907 **	−1.9782 **	−2.6199 ***	−2.8952 ***
	Group rho-Statistic	−0.9465	0.9110	2.1039	2.0900	−0.4770	1.7097
	Group PP-Statistic	−4.5103 ***	−2.5874 ***	−5.2581 ***	−6.0345 ***	−5.2654 ***	−5.4597 ***
	Group ADF-Statistic	−1.2953 *	−0.8409	−3.1778 ***	−3.5341 ***	−2.7551 ***	−3.3649 ***
Kao	<i>t</i> -Statistic	−3.1907 ***		−2.1387 **		−1.875 **	
Method	Statistic	Model <sub>2,ch</sub>		Model <sub>2,se</sub>		Model <sub>2,mr</sub>	
		Intercept	Intercept and Trend	Intercept	Intercept and Trend	Intercept	Intercept and Trend
Pedroni	Panel v-Statistic	1.4956 *	−0.6836	0.3038	2.2866 **	3.2626 ***	1.9791 **
	Panel rho-Statistic	−2.0196 **	−0.2082	−0.6547	1.1971	−2.9179 ***	−0.9262
	Panel PP-Statistic	−3.5270 ***	−3.4684 ***	−1.8858 **	−2.0502 **	−4.6645 ***	−5.7623 ***
	Panel ADF-Statistic	−3.7776 ***	−4.0809 ***	−1.5604 *	−4.0503 ***	−4.8606 ***	−6.4263 ***
	Group rho-Statistic	−1.0403	0.6765	0.3378	1.8987	−0.8830	0.8593
	Group PP-Statistic	−3.7789 ***	−3.5445 ***	−2.4016 ***	−3.5458 ***	−3.8367 ***	−7.3680 ***
	Group ADF-Statistic	−4.1037 ***	−4.1548 ***	−1.3130 *	−4.1671 ***	−4.0760 ***	−5.8579 ***
Kao	<i>t</i> -Statistic	−3.2950 ***		−2.1346 **		−4.6312 ***	

Note: \*, \*\* and \*\*\* for statistically significant at the 0.10, 0.05 and 0.01 levels, respectively. Source: Panel cointegration analysis in Eview.

## Appendix A.3. Estimation by OLS Method

Table A3. Results of the estimated coefficients of capital by OLS.

Variables		Model <sub>1,se</sub>		Model <sub>1,ns</sub>		Model <sub>1,fd</sub>	
		FEM	REM	FEM	REM	FEM	REM
lnq	Coefficient	0.7756	0.6589	0.8845	0.8689	0.9191	
	<i>t</i> -Statistic	10.92 ***	12.88 ***	14.14 ***	14.09 ***	5.67 ***	
	Std. Error	0.0710	0.0512	0.0626	0.0617	0.1620	
Constant	Coefficient	−2.5504	−2.4267	−2.4418	−2.4438	−1.9244	
	<i>t</i> -Statistic	−30.65 ***	−31.71 ***	−73.84 ***	−11.12 ***	−25.42 ***	
	Std. Error	0.0832	0.0765	0.0331	0.2197	0.0757	
R-squared		0.8878	0.8112	0.8746	0.7702	0.8896	
Adj R-squared		0.8733	0.8056	0.8630	0.7662	0.8790	
F-statistic		61.33 ***	146.04 ***	75.34 ***	194.37 ***	84.58 ***	
Hausman test		5.61 **		2.23			
Observations		36		60		24	
N (object)		4		5		2	
Variables		Model <sub>2,rr</sub>		Model <sub>2,nm</sub>		Model <sub>2,nc</sub>	
		FEM	REM	FEM	REM	FEM	REM
lnq	Coefficient	0.9999	0.9949	0.6955	0.6910	0.5905	0.5724
	<i>t</i> -Statistic	12.80 ***	13.07 ***	17.02 ***	17.02 ***	13.75 **	13.56 ***
	Std. Error	0.0781	0.0761	0.0409	0.0406	0.0429	0.0422
Constant	Coefficient	−2.3880	−2.3896	−2.6176	−2.6221	−2.6994	−2.7068
	<i>t</i> -Statistic	−51.23 ***	−18.11 ***	−73.00 ***	−35.46 ***	−79.96 ***	−35.91
	Std. Error	0.0466	0.1319	0.0359	0.0739	0.0338	0.0754
R-squared		0.7376	0.5694	0.7137	0.6385	0.6474	0.5230
Adj R-squared		0.7135	0.5661	0.6871	0.6363	0.6145	0.5200
F-statistic		30.66 ***	171.93 ***	26.89 ***	289.66 ***	19.68 ***	178.70 ***
Hausman test		0.08		1.00		5.31 **	
Observations		132		166		165	
N (object)		11		14		14	
Variables		Model <sub>2,ch</sub>		Model <sub>2,se</sub>		Model <sub>2,mr</sub>	
		FEM	REM	FEM	REM	FEM	REM
lnq	Coefficient	0.7098	0.6492	0.7992	0.7824	0.6794	0.6413
	<i>t</i> -Statistic	11.14 ***	11.22 ***	8.74 ***	9.70 ***	17.93 ***	17.68 ***
	Std. Error	0.0637	0.0578	0.0914	0.0807	0.0379	0.0363
Constant	Coefficient	−2.6026	−2.6240	−2.0636	−2.0661	−2.3417	−2.3579
	<i>t</i> -Statistic	−62.05 ***	−64.21 ***	−50.66 ***	−17.44 ***	−89.13 ***	−42.34 ***
	Std. Error	0.0419	0.0409	0.0407	0.1185	0.0263	0.0557
R-squared		0.7165	0.6739	0.8126	0.5762	0.7458	0.6559
Adj R-squared		0.6898	0.6682	0.7953	0.5701	0.7224	0.6536
F-statistic		26.79 ***	117.79 ***	46.96 ***	95.16 ***	31.82 ***	291.62 ***
Hausman test		5.15 **		0.15		12.05 ***	
Observations		59		72		155	
N (object)		5		6		13	

Note: \*\* and \*\*\* for statistically significant at the 0.05 and 0.01 levels, respectively. Cross-sections in model<sub>1,fd</sub> = 2 (N = 2) so REM does not apply. Source: Results from OLS regression for panel data.

The tables on the results of the estimated coefficients of capital per labor above give the adjusted R-squared and the significance in the F-statistics of both FEM and REM in the models which are greater than 50% and at a 0.01 level. Hence, both methods in all models are appropriate. The Hausman test indicates that the Chi-square statistic in the Cross-section random is significant at 0.01 or 0.05 levels in the State-owned Enterprise Sector, North Central and Central coastal areas, Central Highlands, and Mekong River Delta, so FEM is selected (except foreign direct investment enterprises sector, because REM

does not apply in this case). In the remaining cases, the Chi-square statistic is not significant at a 0.05 level, so REM is more appropriate and selected.

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