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Enhancing Urban Development Quality Based on the Results of Appraising Efficient Performance of Investors—A Case Study in Vietnam

Chia-Nan Wang [1,2] and Han-Khanh Nguyen [1,*]

1 Department of Industrial Engineering and Management, National Kaohsiung University of Applied Sciences, No. 415 Chien Kung Road, Sanmin District, Kaohsiung City 80778, Taiwan; cn.wang@fotech.edu.tw

2 Department of Industrial Engineering and Management, Fortune Institute of Technology, Kaohsiung 83160, Taiwan

* Correspondence: khanhnh@lhu.edu.vn; Tel.: +886-979-089-119

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Abstract: Economic development and the overpopulation in Vietnam have led to rapid urbanization, which has posed countless difficulties and challenges to its government. In particular, creating adequate accommodation, life activities, and entertainment are extremely urgent issues. The planning and investment in industry zones, urban areas, residential districts, and amusement parks at the right time and right place contribute to social stability and economic development, and are important issues for every government—especially in Vietnam which remains a developing country with regard to rapid industrialization and modernization speed. The population density in many localities is too dense, while in others it is too thin, resulting in a state where inhabitants have no shelter, whereas many of the buildings have been abandoned. To deal with these matters, the authors used this study to assess the investment effectiveness of leading corporations in the field of investment in urban development and infrastructure investment in Vietnam. The study focused on addressing the following issues: assessing the effectiveness of corporations in urban development and infrastructure investment in Vietnam and predicting the business state of the groups. Through business data of corporations from 2013–2016, the authors used a Grey system theory to forecast business situations for the period from 2017–2020. The authors also used data envelopment analysis (DEA) to evaluate the effectiveness of investments of the group from 2013–2020. The results will help corporations in creating suitable investment and business strategies with the changes of the domestic and world economy, and can be considered as a foundation for management units, for local government to create planning projects with feasible content, for long-term vision, and practical efficiency to quickly meet the needs of urban development plans.

Keywords: urban development; data envelopment analysis; infrastructure investment; grey forecasting

1. Introduction

1.1. Urban Planning and Development

Investment in urban development and infrastructure has been recognized by Vietnam's government as one of the most important missions to boost economic development and sustainable growth.

With regard to today's practical requirements, urban development has demonstrated a number of comprehensive renovation requirements, particularly the integration of specialized planning with urban planning (see Figure 1). Toward sustainable development, urban planning products need to show a strategy, enhance the macro-regulations of the state, have community responsibilities, and to be able to put into place a comprehensive coordination system (integrated planning of technical infrastructure: transport, electricity, water, etc.) [1]. Integration of projects is demonstrated through the interconnection of planning layers, planning sectors, and sector planning systems. Urban development must ensure that waste is minimized in all sectors. Urban development projects should be easily coordinated between sectors and socio-economic infrastructure should be modernized and synchronized to meet the requirements of urban development integration.

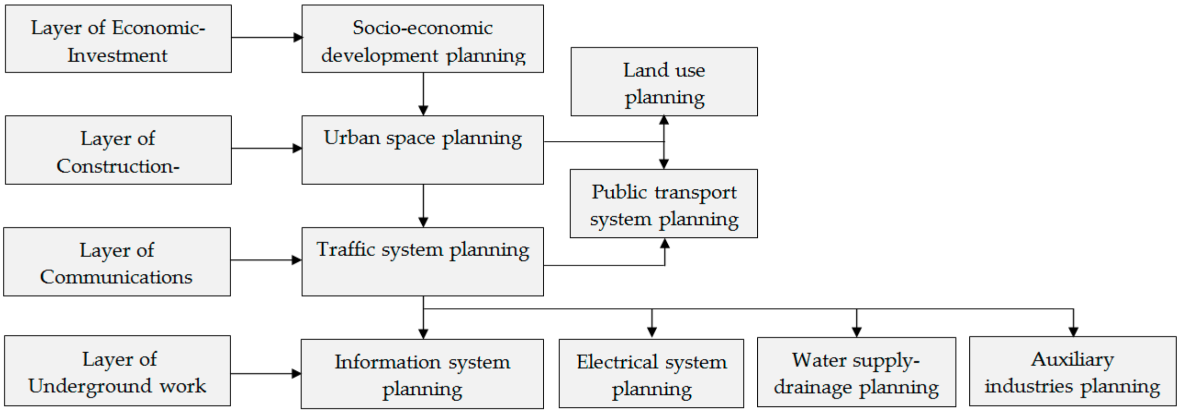

Figure 1. Urban planning process [2].

1.2. Orientation and Urban Development in Vietnam

Vietnam is located in the heart of Southeast Asia, an area of land of 331,698 km^2, and is divided into 63 provinces and cities [3]. Pursuant to Resolution No. 134/2016/QH13 of the national assembly of the socialist republic of Vietnam on the adjustment of land use planning in the national phase from 2017 to 2020, as shown in Table 1 [4].

Table 1. The use planning of Vietnam land from 2017 to 2020.

Targets	Acreage (1000 ha)			
	2017	**2018**	**2019**	**2020**
1. Agricultural land	26,898.14	26,960.77	27,009.46	27,038.09
2. Non-agricultural land group	4363.59	4503.75	4645.04	4780.24
• Defence land	290.08	308.85	325.16	340.96
• Security land	62.58	65.54	68.51	71.14
• Industrial zone land	141.61	157.69	174.84	191.42
• Infrastructure development land	1434.45	1477.48	1519.94	1561.39
• Historic land	30.23	31.84	33.57	35.19
• Landfill land	16.45	18.31	20.17	21.91
• Urban areas inhabited land	184.52	189.67	194.74	199.13
3. Unused land	1866.97	1664.15	1474.19	1310.36
4. High-tech zone land	3.63	3.63	3.63	3.63
5. Economic zone land	1582.96	1582.96	1582.96	1582.96
6. Urban land	1766.50	1828.94	1890.96	1941.74

Sources: Resolution [4].

Vietnam's current population is about 94,444,200 people, ranks the 14th in the world, eighth in Asia, and third in Southeast Asia [5]. The population density is currently 305 people/km^2, 5.2 times more than the population density in the world, and ranks third in Southeast Asia [5]. The average Vietnam population by area is shown in Table 2.

Table 2. Average population of Vietnam by areas in 2015 (Currency unit: 1000 Persons).

Areas	Population
Red River Delta	20,925.5
Northern Midlands and mountain areas	11,803.7
North Central and Central coastal areas	19,658.0
Central Highlands	5607.9
South East	16,127.8
Mekong River Delta	17,590.4

Sources: Population and employment [6].

In recent years, along with innovation and integration policies as well as rapid socioeconomic development, Vietnam's urban system has grown rapidly both in quantity and quality. By October 2015, there were about 788 metropolitan areas in Vietnam, including two special municipalities (Hanoi, Ho Chi Minh City), 15 first-class (I) cities, 25 second-class (II) cities, 42 third-class (III) cities, 74 fourth-class (IV) cities, and approximately 630 fifth (V) class cities. The rate of urbanization is approximately 35.2% [7]. The role of the system of urban planning projects has contributed greatly to the general development. However, based on the requirements of practical progression, it is obvious that some of the problems have to be fixed in the near future.

Besides, investment activities in general and investment in urban development and infrastructure investment in particular also get positive results: investments, disbursements, and budgets have grown increasingly, which created more jobs and contributed to improving the balance of payments and completing objectives and tasks of the social economic development plan in the period of 2010–2016. However, the state investment certificate does not match the planning, and it also takes place at the local area, particularly in creating luxury apartments, new urban areas, industrial parks, etc. Many projects were neither verified nor carefully reviewed for technical criteria, technology, working environment, etc. which leads to low-quality projects. Although the government and local authorities have a higher incentive, investors are not interested. That situation has led to the paradox that the local areas with a high economic development rate attract many projects with the economic growth rate exceeding the average growth rate for the whole country, while regions that are less developed, attract fewer projects, the economic growth rate is low, and without adjusting capital investment planning and orientation of the state, the disparity in development levels between economic regions will increase social imbalance and entail unpredictable consequences.

Further, the inspection and supervision of the implementation of the obligations of the investors on capital contribution schedules, capital raises, and construction activities, the environment, technology transfer, implementation of obligations to laborers and financial obligations toward the state are not good, which includes lack of coordination between ministries, branches, and localities. In addition, weakness of the infrastructure, the related infrastructure works, and the critical shortage of trained workers, engineers, and managers continue to be a barrier to urban development and infrastructure investment in Vietnam. In this research, through business data of decision-making units (DMUs), the authors use data envelopment analysis (DEA) to evaluate the effectiveness of investment of DMUs in the past and use the Grey system theory to forecast business situations for the next period.

2. Literature Review

In the past, some researchers combined DEA models and Grey system theory to their studies: Saranga [8] used DEA to identify the inefficiencies of DMUs in the Indian auto component industry. Leachman et al. [9] used DEA to assess the performances of DMUs in the automobile industry. Zhao et al. [10] employed DEA to evaluate the performances of DMUs in the Chinese coal mining industry. In the manufacturing and service industries, DEA has been applied to assess business performances and strategies. For example, Chandraprakaikul and Suebpongsakorn [11] used DEA to explore the operational performances of 55 Thailand logistics companies. Lo and Lu [12] argued the reasons for using DEA models, the super-slack-based measure (SBM), and Malmquist models. Charles et al. [13] used DEA to assess the efficiency of a Printed Circuit Boards assemble line. Chang et al. [14] proposed a nonradial DEA model with the slack-based measure (SBM) to analyze the environmental efficiency of China's transportation section. Chia-Nan Wang and Nhu-Ty-Nguyen [15] combined DEA models and Grey system theory to evaluate the effectiveness and to predict the manpower of undergraduate educational systems.

Thus, the use of DEA to evaluate the efficiency of corporations in urban development and infrastructure investment sector in Vietnam from 2013 to 2016 and to use the Grey model (1,1) ((GM) (1,1)) to forecast business situations for the period from 2017 to 2020 help corporations make the right decisions for the future, thereby saving state budgets and avoiding wasting the country's land resources [16]. These matters have importance and urgency for corporations and countries; the authors address these issues in the next section.

3. Materials and Methodology

3.1. Research Development

In this research, the authors combine DEA models and Grey system theory to evaluate the effectiveness of 16 leading corporations in urban development and infrastructure investment sector in Vietnam from 2013 to 2020, which includes four parts, as follows and as shown in Figure 2.

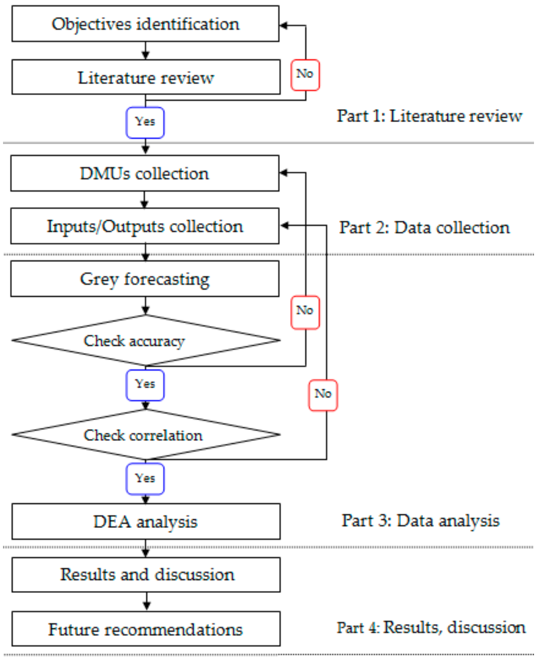

Figure 2. Research process.

Part 1. The authors chose the research topic, then learned about the history of research in this field.

Part 2. Next, the authors continued to choose the appropriate group and input/output factors for the field of research, which included a suitable size and time in order to do the research data.

Part 3. After collecting data, the analysis stage, applying the models in this research, was conducted. GM (1,1) was used for developing a forecast through the time series data with four input factors and two output factors for all corporations. In fact, there were many prediction methods, and the authors used GM (1,1) to predict the data from the DMUs from 2017 to 2020 because this was a highly reliable prediction method and would be suitable with the data of DMUs [16]. Mean absolute percentage error (MAPE) was applied to measure the accuracy prediction and to check if the forecasting error was reliable.

- If the variables had MAPE, which were too large, they would be removed and returned to the step collecting data to rebuild a new DMU-DMU, which had variables that met our requirements. Besides, Malmquist radial models were used to evaluate a corporation's performance in this period. Next, the results of GM (1,1), were utilized to see future trends.
- The business results from year 2013 to year 2016 of DMUs were put in the DEA model to measure the efficiency and distinguish the ranking of corporations. The DEA model was used to establish a best practice group from among a set of observed units and to identify the units that were inefficient when compared with the best practice group [17]. In this case, if the input factors and output factors had a correlation coefficient at zero and negative, they would be removed and returned to the step collecting data to rebuild a new DMU-DMU, which had variables that could meet our requirements.
- Next, the prediction results were put into the DEA model to measure efficiency and to distinguish the ranking of corporations in the period from 2017–2020.

Part 4. After that, based on the Malmquist productivity index (MPI) of corporations the efficiency change, technical change, and productivity index were analyzed, evaluated, and utilized to see future trends.

3.2. Data Collection

In this study, the authors combined DEA models and Grey system theory to evaluate the effectiveness of 16 leading corporations in urban development and infrastructure investment sectors in Vietnam from 2013 to 2016, as shown in Table 3.

Table 3. List of corporations in urban development and infrastructure investment in Vietnam.

Order	Code	Corporations Name
1	DMU1	Industrial Urban Development Joint Stock Company (J.S.C) No. 2-D2D
2	DMU2	Hanoi Southern City Development J.S.C-NHN
3	DMU3	Tu Liem Urban Development J.S.C-NTL
4	DMU4	Song Da Urban & Industrial Zone Investment & Development J.S.C-SJC
5	DMU5	Idico Urban And House Development J.S.C-UIC
6	DMU6	C.E.O. Investment J.S.C-CEO
7	DMU7	Real Estate 11 J.S.C-D11
8	DMU8	Development Investment Construction J.S.C-DIG
9	DMU9	Dat Xanh Real Estate Service & Construction Corporation-DXG
10	DMU10	FLC Group J.S.C-FLC
11	DMU11	Ba Ria-Vung Tau House Development JSC-HDC
12	DMU12	Ha Do Group J.S.C-HDG
13	DMU13	International Development and Investment Corporation-IDI
14	DMU14	Becamex Infrastructure Development J.S.C-IJC
15	DMU15	Kinh Bac City Development Share Holding Corporation-KBC
16	DMU16	Danang Housing Investment Development J.S.C-NDN

Source: Synthetic by researcher [18–33].

Data used in this study (Appendix A) were collected from realistic financial reports on websites of corporations in the period from 2013–2016. After studying, the authors decided to use data with four input factors and two output factors as follows:

Input Factors:

(1) **Owner's equity (OE):** Total amount of capital contributed by owners that the business is not required to pay. The capital is invested by business owners and investors or formed from business results.

(2) **Total assets (TA):** Total value of all assets of an enterprise, both tangible and intangible.
(3) **Cost of goods sold (CS):** Total cost of the input of the business to create the product.
(4) **Total operating expenses (TE):** Includes items of financial costs, selling expenses, and business management costs.

Output Factors:

(1) **Net sales (NS):** Reflects an enterprise's sales revenue and providing a service.
(2) **Profit after tax (PT):** Reflects the result of a business (profit and loss) after income tax.

Therefore, these factors play an important role in assessing the effectiveness of investment and decision-making in the business of managers.

3.3. Methodology

3.3.1. Grey Forecasting Generation Theory

The initial data on the use of the GM (1,1) model for prediction should be tested according to formula [16]:
$\delta_i = \frac{x^{(0)}(i-1)}{x^{(0)}(i)}; (i = 2; 3; \ldots; n)$. All values must be within:

$$\delta^{(0)}(i) = (e^{-\frac{2}{n+1}}; e^{\frac{2}{n+1}}) \tag{1}$$

The GM (1,1) model is calculated by the following differential equation:

$$\frac{dx^{(1)}(k)}{dk} + ax^{(1)}(k) = b \tag{2}$$

In detail, a and b are coefficients. The source data are considered as a string [16]:

$$X^{(0)} = \left(X^{(0)}_{(1)},\ X^{(0)}_{(2)}, \ldots,\ X^{(0)}_{(n)}\right), X^{(0)} > 0, n \geq 4 \tag{3}$$

In this study, the original data are the actual business data of enterprises in the period from 2013–2016.

The initial data completed verification, which we calculated according to the following steps [16]: The authors use the cumulative method to compute the $X^{(1)}$ values [16]:

$$X^{(1)} = \left(X^{(1)}_{(1)}, X^{(1)}_{(2)}, \ldots, X^{(1)}_{(n)}\right), n \geq 4, \text{where} : X^{(1)}_{(1)} = X^{(0)}_{(1)}, X^{(1)}_{(k)} = \sum_{i=1}^{k} X^{(0)}_{(i)}, k = 1, 2, \ldots, n. \tag{4}$$

The generated mean sequence $Z^{(1)}$ of $X^{(1)}$ is defined as [16]:

$$Z^{(1)} = \left(Z^{(1)}_{(1)},\ Z^{(1)}_{(2)}, \ldots,\ Z^{(1)}_{(n)}\right), n \geq 4, \text{where} : Z^{(1)}(k) = 0.5 \times \left(X^{(1)}_{(k)} + X^{(1)}_{(k-1)}\right),\ k = 2, 3, \ldots, n. \tag{5}$$

The equations of the GM (1,1) model were built and the $Z^{(1)}$ values calculated [16]:

$$\frac{dX^{(1)}(k)}{dk} + aX^{(1)}(k) = b, \text{where} : Z^{(1)}(k) = 0.5 \times \left(X^{(1)}_{(k)} + X^{(1)}_{(k-1)}\right),\ k = 2, 3, \ldots, n. \tag{6}$$

The formula for calculating parameters a and b by the least-squares method is as follows [16]:

$$\hat{\theta} = \begin{bmatrix} a \\ b \end{bmatrix}^T = \left(B^T B\right)^{-1} B^T \overline{Y}_N, (\text{where} : B = \begin{bmatrix} -\alpha Z^{(1)}_{(2)} 001 \\ \ldots\ldots 0000\ldots \\ -\alpha Z^{(1)}_{(n)} 001 \end{bmatrix}, Y = \begin{bmatrix} X^{(0)}_{(2)} \\ \ldots\ldots \\ X^{(0)}_{(n)} \end{bmatrix}) \tag{7}$$

The formula was built to calculate the predictive value of the model [16]:

$$\hat{X}^{(1)}_{(k+1)} = (X^{(0)}_{(1)} - \frac{b}{a})\, e^{-ak} + \frac{b}{a};\ (k = 1, 2, 3, \ldots, n) \tag{8}$$

The predicted value of the GM (1,1) model is calculated based on the following formula [16]:

$$\hat{X}^{(0)}_{(k+1)} = \hat{x}^{(1)}_{(k+1)} - \hat{x}^{(1)}_{(k)}; (\text{where}: \hat{x}^{(0)}_{(1)} = x^{(0)}_{(1)}; \text{k} = 1, 2, 3, \ldots, n) \tag{9}$$

Evaluation of Volatility Forecasts

The authors use the MAPE method to determine the reliability of the predicted values, calculated according to the following formula [34]:

$$MAPE = \frac{1}{n}\sum_{k=2}^{n}\left|\frac{X^{(0)}_{(k)} - \hat{X}^{(0)}_{(k)}}{X^{(0)}}\right| \times 100\% \tag{10}$$

The grades of mean absolute percentage error are divided into four levels as Table 4.

Table 4. The grades of mean absolute percentage error (MAPE) [34].

MAPE Valuation (%)	≤10	10 ÷ 20	20 ÷ 50	≥50
Accuracy	Excellent	Good	Qualified	Unqualified

3.3.2. Data Envelopment Analysis Model

To evaluate the performance of the infrastructure investment and urban development groups in Vietnam, the authors used the following two models:

Super Efficiency SBM Model

This model, introduced by Tone (2001) [35], develops on SBM. We used n DMUs with input and output matrices $X = (x_{ij}) \in R^{m\times n}$ and $Y = (\mathrm{y}_{ij}) \in R^{s\times n}$, respectively. λ is a non-negative vector in R^n [35]. The vectors $S^- \in R^m$ and $S^+ \in R^s$ indicate the input excess and output shortfall, respectively. The SBM model in fractional form is as follows [35]:

$$\text{Min } \rho = \frac{1 - \frac{1}{m}\sum_{i=1}^{m} s_i^- / x_{i0}}{1 + \frac{1}{s}\sum_{i=1}^{s} s_i^- / y_{i0}} \textit{Subject to}:\ x_0 = X\lambda + s^-, y_0 = Y\lambda - s^+, \lambda \geq 0,\ \text{s}^- \geq 0,\ \text{s}^+ \geq 0. \tag{11}$$

The authors optimized solution for SBM is $(p^*, \lambda^*, s^{-*}, s^{+*})$. A DMU (x_0, y_0) is super-SBM if $p^* = 1$. This condition is equivalent to $S^{-*} = 0, \textit{and } S^{+*} = 0$, in the optimal solution, the inputs are guaranteed and output is stable. SBM is non-radial and deals with input and output slack. The SBM returns an efficiency measure between 0 and 1 [35].

The best performer has an efficient status and is expressed by unity. Tone (2002) discriminates these efficient DMU and ranks the efficient DMUs by a super-SBM model [35]. The DMU (x_0, y_0) is SBM-efficient, $p^* = 1$, and the super-SBM model will be followed [35]:

$$Min\delta = \frac{\frac{1}{m}\sum\limits_{i=1}^{m} \overline{x}_i / x_{i0}}{\frac{1}{s}\sum\limits_{r=1}^{s} \overline{y}_i / y_{r0}} \textit{subject to}: \overline{x} \geq \sum_{j=1, j\neq 0}^{n} \lambda_j x_j, \overline{y} \geq \sum_{j=1, j\neq 0}^{n} \lambda_j y_j, \overline{x} \geq x_{i0};\ \overline{y} \leq y_{r0}, \overline{y} \geq y_0, \lambda \geq 0. \tag{12}$$

However, DEA's previous models still have some limitations in assessing the business performance. Thus far, the DEA-Solver Pro 8.0 Manuel model has overcome these limitations [36]:

When $y_{ro} \leq 0$. $\overline{y}_r^+$ and y_{-r}^+ will be defined: $\overline{y}_r^+ = \max_{j=1,\ldots,n}\{y_{rj}|y_{rj} > 0\}$; $\overline{y}_r^+ = \min_{j=1,\ldots,n}\{y_{rj}|y_{rj} > 0\}$. If the output r has no positive elements, then it is defined as $\overline{y}_r^+ = y_{-r}^+ = 1$. The term is replaced by s_r^+/y_{r0} in the objective function in the following way (value y_{r0} never changes in constraint conditions) [36].

If $\overline{y}_r^+ > \overline{y}_{-r}^+$, the term is replaced by [36]:

$$s_r^+ \bigg/ \frac{y_{-r}^+(\overline{y}_r^+ - y_{-r}^+)}{\overline{y}_r^+ - y_{r0}}. \tag{13}$$

If $\overline{y}_r^+ = \overline{y}_{-r}^+$, the term is replaced by:

$$s_r^+ \bigg/ \frac{(\overline{y}_{-r}^+)^2}{\mathrm{B}(\overline{y}_r^+ - y_{r0})}. \tag{14}$$

The B value in the DEA-Solver is 100. In all cases, the proposition is positive and tighter than y_{-r}^+. Furthermore, it is inversely proportional to the distance $\overline{y}_r^+ - y_{r0}$ and it is related to the magnitude of the unsupportive output [36].

Malmquist Productivity Index (MPI)

To evaluate the performance of a business between two periods of time, the authors used three indicators:

Malmquist (MI); catch-up (C); and frontier shift (F).

(MI) evaluates the performance change in the second period compared with the first period.

(C) assesses the level of effort to improve the performance of the second period compared with the first period.

(F) evaluates the change in performance boundaries around the second period compared with the first period.

The authors denote DMU_0 in period 1 as (x_0^1, y_0^1), period 2 as (x_0^2, y_0^2), and use the following notations for efficiency of DMU $(x_0,y_0)^{t_1}$ measured by the frontier technology t_2 [37]:

$$\delta^{t_2}\left((x_0,y_0)^{t_1}\right)(t_1 = 1,\ 2 \text{ and } t_2 = 1,\ 2). \tag{15}$$

The formula for calculating the (C), (F), and (MI) index is as follows [37]:

$$\left.\begin{array}{r} C = \frac{\delta^2[(x_0,y_0)^2]}{\delta^1[(x_0,y_0)^1]} \\ F = \left[\frac{\delta^1[(x_0,y_0)^1]}{\delta^2[(x_0,y_0)^1]} \times \frac{\delta^1[(x_0,y_0)^2]}{\delta^2[(x_0,y_0)^2]}\right]^{\frac{1}{2}} \end{array}\right\} \Rightarrow MI = C \times F = \left[\frac{\delta^1[(x_0,y_0)^2]}{\delta^1[(x_0,y_0)^1]} \times \frac{\delta^2[(x_0,y_0)^2]}{\delta^2[(x_0,y_0)^1]}\right]^{\frac{1}{2}} \tag{16}$$

If:

$(C) > 1; (F) > 1; (MI) > 1 \Rightarrow$ The performance of period 2 is better than period 1.
$(C) = 1; (F) = 1; (MI) = 1 \Rightarrow$ The performance of period 2 is equivalent to period 1.
$(C) < 1; (F) < 1; (MI) < 1 \Rightarrow$ The performance of period 2 is less than period 1.

The authors developed output-oriented (MI) with output-oriented radial DEA models. The output-oriented models take all output slacks into account but no input slacks. This is explained below in output-orientation (O-V) [37]:

$$\delta^s\left((x_0,y_0)^s\right) = \min_{\theta,\lambda}\theta \tag{17}$$

Subject to:

$$x_0^s \geq X^s\lambda; (\frac{1}{\theta})y_0^s \leq Y^s\lambda; L \leq e\lambda \leq U; \lambda \geq 0 \tag{18}$$

Intertemporal score in output-orientation (O-V):

$$\delta^s\left((x_0,y_0)^t\right) = \min_{\theta,\lambda}\theta \tag{19}$$

Subject to:

$$x_0^t \geq X^s\lambda; (\frac{1}{\theta})y_0^t \leq Y^s\lambda; L \leq e\lambda \leq U; \lambda \geq 0 \tag{20}$$

The radial approaches suffer from one general problem in the neglect of slacks. Tone developed the non-radial measures of efficiency and super-efficiency: slacks-based measure (SBM) and super-SBM. Using these measures, the authors developed the non-radial and slacks-based MI. In the output-oriented case, the authors solved as follows [37].

SBM-O:

$$\delta^t\left[(x_0,y_0)^s\right] = \underset{\lambda,s^+}{\mathrm{Min}}\frac{1}{\left[1 + ((\frac{1}{q})\sum\limits_{i=1}^{q}\frac{s_i^+}{y_{i0}^s})\right]} \tag{21}$$

Subject to:

$$x_0^s \geq X^t\lambda; y_0^s = Y^t\lambda - s^+; L \leq e\lambda \leq U; \lambda \geq 0, s^+ \geq 0 \tag{22}$$

where the vector $s^+ \in R^q$ denotes the output-slacks [37].

Super-SBM-O:

$$\delta^t\left[(x_0,y_0)^s\right] = \underset{\lambda,s^+}{\mathrm{Min}}\frac{1}{\left[1 - ((\frac{1}{q})\sum\limits_{i=1}^{q}\frac{s_i^+}{y_{i0}^t})\right]} \tag{23}$$

Subject to:

$$x_0^s \geq X^t\lambda; y_0^s = Y^t\lambda - s^+; L \leq e\lambda \leq U; \lambda \geq 0, s^+ \geq 0 \tag{24}$$

4. Results and Discussion

4.1. Results and Analysis of the Grey Forecasting

The authors used the GM (1,1) model to predict the realistic input and output factors of top urban development and infrastructure investment in Vietnam corporations from 2017 to 2020. The authors used the factor of owner's equity (OE)—Input 1 of DMU1 (at Table 5)—to explain calculation procedure in this part.

Table 5. Data of DMU1 from 2013 to 2016 (Currency unit: Million Viet Nam Dong (VND)).

Year	Inputs				Outputs	
	(I)OE	(I)TA	(I)CS	(I)TE	(O)NS	(O)PT
2013	364,972	1,112,361	140,222	41,366	238,066	44,749
2014	390,115	1,114,028	195,573	43,110	295,588	57,299
2015	382,949	1,105,783	186,792	51,776	277,039	54,700
2016	400,377	1,375,058	320,147	41,542	412,151	55,192

Sources: Synthetic by researcher [18].

The sequence of raw data:

$$X^{(0)} = (364{,}972, 390{,}115, 382{,}949, 400{,}377)$$
$$X^{(1)}(1) = X^{(0)}(1) = 364{,}972$$
$$X^{(1)}(2) = X^{(0)}(1) + X^{(0)}(2) = 755{,}087$$
$$X^{(1)}(3) = X^{(1)}(2) + X^{(0)}(3) = 1{,}138{,}036$$
$$X^{(1)}(4) = X^{(1)}(3) + X^{(0)}(4) = 1{,}538{,}413$$

Then, the authors created the different equations of GM (1,1) to find $X^{(1)}$ series, the mean obtained by the mean equation as follows:

$$Z^{(1)}(2) = 0.5 \times (364972 + 755087) = 560029.5$$
$$Z^{(1)}(3) = 0.5 \times (755087 + 1138036) = 946561.5$$
$$Z^{(1)}(4) = 0.5 \times (1138036 + 1538413) = 1338224.5$$

To find *a* and *b* in order to solve the equations, the primitive values are substituted into the Grey differential equation to obtain:

$$\begin{cases} 390115 + a \times 560029.5 = b \\ 382949 + a \times 946561.5 = b \\ 400377 + a \times 1338224.5 = b \end{cases}$$

and converted into the form of a matrix as follows:

$$B = \begin{bmatrix} -560029.5001 \\ -946561.5001 \\ -1338224.501 \end{bmatrix}; Y_N = \begin{bmatrix} 390115 \\ 382949 \\ 400377 \end{bmatrix}.$$

The authors used formula (7) to find *a*, *b*: $\begin{bmatrix} a \\ b \end{bmatrix} = \begin{bmatrix} 0 - 0.0133 \\ 378576.52 \end{bmatrix}$.

Then, we used the two coefficients *a* and *b* into equation: $\frac{dx^{(1)}}{dt} - 0.0133 \times X^{(1)} = 378576.52$.

The authors used formula (8) to find the prediction model:

$$\hat{X}^{(1)}(k+1) = 28829372 \times e^{0.0133 \times \kappa} - 28464400$$

Instead of values of k, we have the results:

$k = 1$	$X^{(1)}(1) = 364{,}972.00$;	$k = 5$	$X^{(1)}(5) = 1{,}940{,}019.92$
$k = 2$	$X^{(1)}(2) = 750{,}939.24$;	$k = 6$	$X^{(1)}(6) = 2{,}347{,}005.30$
$k = 3$	$X^{(1)}(3) = 1{,}142{,}057.00$;	$k = 7$	$X^{(1)}(7) = 2{,}759{,}421.68$
$k = 4$	$X^{(1)}(4) = 1{,}538{,}394.01$;	$k = 8$	$X^{(1)}(8) = 3{,}177{,}341.53$

The authors computed the simulated values of $X^{(0)}$ in the original series by Formula (9):

$X^{(0)}(1) = X^{(1)}(1) = 364{,}972.00$—for year 2012
$X^{(0)}(2) = X^{(1)}(2) - X^{(1)}(1) = 385{,}967.24$
$X^{(0)}(3) = X^{(1)}(3) - X^{(1)}(2) = 391{,}117.76$
$X^{(0)}(4) = X^{(1)}(4) - X^{(1)}(3) = 396{,}337.01$
$X^{(0)}(5) = X^{(1)}(5) - X^{(1)}(4) = 401{,}625.91$—result forecast for year 2017
$X^{(0)}(6) = X^{(1)}(6) - X^{(1)}(5) = 406{,}985.38$—result forecast for year 2018
$X^{(0)}(7) = X^{(1)}(7) - X^{(1)}(6) = 412{,}416.38$—result forecast for year 2019
$X^{(0)}(8) = X^{(1)}(8) - X^{(1)}(7) = 417{,}919.85$—result forecast for year 2020

Thereby, the authors could obtain the forecasting results of all DMUs from 2017–2020 (Appendix B).

For checking the forecasting accuracy, the results of MAPE are listed in Table 6.

Table 6. Average MAPE of DMUs.

DMUs	Average MAPE (%)	DMUs	Average MAPE (%)
DMU1	5.11	DMU9	7.40
DMU2	14.43	DMU10	18.84
DMU3	8.44	DMU11	3.31
DMU4	12.65	DMU12	13.95
DMU5	7.59	DMU13	5.12
DMU6	11.33	DMU14	12.15
DMU7	5.21	DMU15	8.15
DMU8	16.49	DMU16	5.30
Average all MAPE		9.72%	

Source: Calculated by researcher.

By convention is shown in the Table 4; the results of MAPE are shown in Table 6: Nine DMUs have MAPE (%) smaller than 10% (excellent), and seven DMUs have MAPE from 10%–20% (good), confirming that the GM (1,1) model in this research provides a highly accurate prediction.

4.2. Pearson Correlation

To apply the DEA model, we have to ensure the relationship between input and output factors is isotonic, which means that, if the input quantity increases the output quantity could not decrease under the same condition [34]. Higher correlation coefficient means closer relation between two variables, while lower correlation coefficient means that they are less correlated [34].

The interpretation of the correlation coefficient is explained in more detail as follows. The correlation coefficient is always between (−1) and (+1). The closer the correlation is to (±1), the closer it is to a perfect linear relationship [34]. Its general meaning is shown in Table 7.

Table 7. The Pearson correlation coefficient.

Correlation Coefficient	<0.2	0.2 ÷ 0.4	0.4 ÷ 0.6	0.6 ÷ 0.8	>0.8
Degree of Correlation	Very low	Low	Medium	High	Very high

By convention is shown in Table 7, the results shown in Table 8 indicate that the correlation complies well with the prerequisite condition of the DEA model (correlation coefficients between input factors and output factors show strong correlation). This shows that these positive correlations of input and output variables are appropriate, which explains why the authors use these indicators for DEA methodologies. The correlation is important and affects the performance.

Table 8. Correlation of inputs and outputs.

	2013						2014					
	OE	**TA**	**CS**	**TE**	**NS**	**PT**	**OE**	**TA**	**CS**	**TE**	**NS**	**PT**
OE	1.0000	0.8956	0.3377	0.8618	0.4085	0.4343	1.0000	0.8169	0.2255	0.4591	0.2958	0.7434
TA	0.8956	1.0000	0.6323	0.9515	0.7039	0.7256	0.8169	1.0000	0.6200	0.8739	0.7068	0.8842
CS	0.3377	0.6323	1.0000	0.5650	0.9923	0.9007	0.2255	0.6200	1.0000	0.8277	0.9895	0.6999
TE	0.8618	0.9515	0.5650	1.0000	0.6322	0.6125	0.4591	0.8739	0.8277	1.0000	0.8966	0.8088
NS	0.4085	0.7039	0.9923	0.6322	1.0000	0.9409	0.2958	0.7068	0.9895	0.8966	1.0000	0.7635
PT	0.4343	0.7256	0.9007	0.6125	0.9409	1.0000	0.7434	0.8842	0.6999	0.8088	0.7635	1.0000
	2015						2016					
OE	1.0000	0.8945	0.5852	0.6072	0.6733	0.8947	1.0000	0.8081	0.5866	0.5522	0.6486	0.7838
TA	0.8945	1.0000	0.5739	0.8659	0.7043	0.8182	0.8081	1.0000	0.8244	0.9188	0.9093	0.9544
CS	0.5852	0.5739	1.0000	0.5656	0.9805	0.7666	0.5866	0.8244	1.0000	0.8571	0.9776	0.8304
TE	0.6072	0.8659	0.5656	1.0000	0.7001	0.6236	0.5522	0.9188	0.8571	1.0000	0.9389	0.9260
NS	0.6733	0.7043	0.9805	0.7001	1.0000	0.8384	0.6486	0.9093	0.9776	0.9389	1.0000	0.9201
PT	0.8947	0.8182	0.7666	0.6236	0.8384	1.0000	0.7838	0.9544	0.8304	0.9260	0.9201	1.0000

Source: Calculated by researcher.

4.3. Performance Rankings

The results in Table 9 indicate that the number of efficient DMUs from the 2013–2016 sequence is 9, 11, 11, 12, and the number of inefficient DMUs sequence is 7, 5, 5, 4. Average scores are 1.1851, 1.4334, 1.4159, 1.6396, respectively, which explains that super-SBM can distinguish DMUs with differences in their scoring.

Table 9. Summary of super–SBM results.

	2013	2014	2015	2016
No. of DMUs in Data	16	16	16	16
No. of DMUs with inappropriate Data	0	0	0	0
No. of evaluated DMUs	16	16	16	16
Average of scores	1.1851	1.4334	1.4159	1.6396
No. of efficient DMUs	9	11	11	12
No. of inefficient DMUs	7	5	5	4
No. of over iteration DMUs	0	0	0	0

Source: Calculated by researcher.

The results in Table 10 show scores and rankings of DMUs in the period from 2013–2016, which indicates that the ranking of corporations in urban development and infrastructure investment in Vietnam tends to change strongly year by year (for example, ranking of DMU10 changed from No.13 in 2013 increase to No.3 in 2014, reduced to No.11 of 2015 and increased to No.8 in 2016).

Table 10. Scores and rankings of all DMUs period 2013–2016.

DMUs	2013		2014		2015		2016	
	Score	Rank	Score	Rank	Score	Rank	Score	Rank
DMU1	1.0194	8	0.7131	13	0.7838	12	1.0624	9
DMU2	1.0000	9	1.0000	11	1.0739	8	1.0000	12
DMU3	1.6226	3	0.5665	14	1.0806	7	1.1992	7
DMU4	0.6281	15	0.7183	12	1.6596	3	1.4672	4
DMU5	3.9616	1	5.0496	1	5.0439	1	6.7785	1
DMU6	0.7708	10	1.0435	9	1.0644	9	1.0070	11
DMU7	2.0837	2	2.4658	2	3.1740	2	4.3096	2
DMU8	0.4246	16	0.4283	16	0.4249	16	0.5909	16
DMU9	1.3485	4	1.8046	4	1.3862	5	1.4677	3
DMU10	0.6559	13	2.3425	3	1.0000	11	1.1962	8
DMU11	0.6299	14	0.5364	15	0.7269	14	0.9121	13
DMU12	0.6982	12	1.0852	7	0.7687	13	0.8644	14
DMU13	0.7281	11	1.0205	10	1.0311	10	1.3319	6
DMU14	1.1724	5	1.0651	8	0.5085	15	0.6002	15
DMU15	1.0488	7	1.5420	6	1.5632	4	1.4197	5
DMU16	1.1694	6	1.5532	5	1.3651	6	1.0271	10

Source: Calculated by researcher.

The authors used the forecasted results as input factors for the GM (1,1) model to evaluate the ranking of DMUs in the period of 2017–2020, as shown in Table 11. The results indicate that the ranking of corporations in urban development and infrastructure investment in Vietnam will change in the future. DMUs are divided into four groups:

Group 1: DMUs get effective business; they are always at the top position and include DMU4 (ranking is, respectively, 3, 1, 1, 1); DMU5 (ranking is, respectively, 1, 2, 2, 2); DMU7 (ranking is, respectively, 2, 3, 3, 3); DMU15 (ranking is, respectively, 5, 4, 4, 4).

Group 2: DMUs make strong progress in the future: DMU8 (ranking is, respectively, 13, 13, 9, 3); DMU9 (ranking is, respectively, 16, 13, 12, 10); DMU11 (ranking is, respectively, 9, 9, 6, 6); DMU14 (ranking is, respectively, 15, 16, 8, 7).

Group 3: DMUs have inefficient business in the future: DMU10 (ranking is, respectively, 4, 5, 10, 13); DMU12 (ranking is, respectively, 12, 12, 14, 15); DMU16 (ranking is, respectively, 11, 15, 16, 16).

Group 4: For other DMUs, there are small changes in this period.

This reflects the intense competition of corporations in urban development and infrastructure investment in Vietnam.

Table 11. Forecasted scores and rankings of 16 DMUs period 2017–2020.

DMUs	2017		2018		2019		2020	
	Score	Rank	Score	Rank	Score	Rank	Score	Rank
DMU1	1.0064	13	0.6811	14	0.5632	15	0.4814	14
DMU2	1.0000	14	1.0000	10	1.0000	11	1.0000	11
DMU3	1.2837	6	1.3321	7	1.2843	7	1.2471	8
DMU4	4.2784	3	9.4478	1	22.1119	1	54.7273	1
DMU5	6.6878	1	7.6942	2	7.8405	2	6.5804	2
DMU6	1.0204	10	0.9058	11	0.7502	13	0.8902	12
DMU7	5.2242	2	5.5088	3	5.8675	3	6.3164	3
DMU8	0.6351	16	0.7750	13	0.8752	12	1.0129	10
DMU9	1.2783	7	1.3705	6	1.7778	5	3.0782	5
DMU10	1.7949	4	1.4234	5	1.1025	10	0.8158	13
DMU11	1.0318	9	1.1620	9	1.3741	6	1.7206	6
DMU12	1.0119	12	0.7924	12	0.5928	14	0.4704	15
DMU13	1.2003	8	1.2671	8	1.1409	9	1.0888	9
DMU14	0.6496	15	0.6059	16	1.2029	8	1.6515	7
DMU15	1.6205	5	2.7488	4	3.9337	4	5.9245	4
DMU16	1.0176	11	0.6534	15	0.5180	16	0.4300	16

Source: Calculated by researcher.

4.4. Components of the Malmquist Productivity Index (MPI)

4.4.1. Catch-Up Efficiency Change

The results of the changes in the catch-up of corporations in urban development and infrastructure investment are shown in Table 12. The results show the efficiency change in technology of the activity management as well as the attribute to investment planning, technical experience, management, and organization of corporations in urban development and infrastructure investment in Vietnam.

According to results in Table 12, the average Malmquist index catch-up for all DMUs in 2013–2014 is 0.9577 and 2014–2015 is 1.0050 (increased 4.94%). The index of next period, 2015–2016, is 1.0121 (increased 0.71%). Among 16 corporations, DMU6 (C.E.O. Investment J.S.C-CEO) and DMU10 (FLC Group J.S.C-FLC) have reduced the average Malmquist index catch-up in this period. However, DMU8 (Development Investment Construction J.S.C.-DIG) has the highest increased average Malmquist index catch-up (the year 2013 was 0.8159 increased to 1.2358 in 2016, equaled an increase of 51.46%), and DMU4 (Song Da Urban & Industrial Zone Investment & Development J.S.C-SJC) has the high increased average Malmquist index catch-up, with efficiency scores of 0.9043, 1.0113, and 1.1720, respectively, leading to the growth in the Malmquist index of corporations of the catch-up criteria in this period. This clearly indicates that, in this period, corporations in the urban development and infrastructure investment sector in Vietnam focused on technical efficiency in terms of technical experience, management, and organization making big changes in their catch-up scores during this period.

Table 12. The Malmquist Productivity Index (MPI) catch-up efficiency change.

Catch-Up	2013–2014	2014–2015	2015–2016	Average
DMU1	0.8786	1.0944	0.9441	0.9724
DMU2	1.0000	1.0000	1.0000	1.0000
DMU3	0.7399	1.1463	0.9206	0.9356
DMU4	0.9043	1.0113	1.1720	1.0292
DMU5	1.0000	1.0000	1.0000	1.0000
DMU6	1.0403	1.0000	0.9432	0.9945
DMU7	1.0000	1.0000	1.0000	1.0000
DMU8	0.8159	1.0124	1.2358	1.0214
DMU9	1.0000	1.0000	1.0000	1.0000
DMU10	1.0574	1.0000	0.9929	1.0168
DMU11	0.8670	1.0655	1.0374	0.9899
DMU12	1.1063	0.8562	1.0333	0.9986
DMU13	1.0240	1.0000	1.0000	1.0080
DMU14	0.8888	0.8944	0.9145	0.8992
DMU15	1.0000	1.0000	1.0000	1.0000
DMU16	1.0000	1.0000	1.0000	1.0000
Average	0.9577	1.0050	1.0121	0.9916
Max	1.1063	1.1463	1.2358	1.0292
Min	0.7399	0.8562	0.9145	0.8992
SD	0.0978	0.0665	0.0838	0.0324

Source: Calculated by researcher.

4.4.2. Frontier Shift

Table 13 shows results of the change in frontier shift of corporations in urban development and infrastructure investment sectors in Vietnam in the period of 2013–2016. Table 13 shows that corporations tended to strongly change their levels of technical changes or their innovation effect in this period. DMU5, especially, has the highest change in Malmquist index frontier shift (in the year 2013 it was 0.4103, in 2016 the Malmquist index was 1.7506 (increased 327%). Average Malmquist index frontier shift of all DMUs in 2013–2014 is 0.5910 and period 2015–2016 is 1.0182 (increased 72.28%).

Table 13. The MPI frontier shift.

Frontier	2013–2014	2014–2015	2015–2016	Average
DMU1	0.4547	0.8993	0.8898	0.7479
DMU2	1.0368	1.0000	1.0774	1.0380
DMU3	0.1583	0.9707	0.9153	0.6814
DMU4	0.7103	1.1709	0.9955	0.9589
DMU5	0.4103	1.6863	1.7506	1.2824
DMU6	0.5330	0.9905	0.8968	0.8068
DMU7	0.3183	1.0153	0.8626	0.7321
DMU8	0.7677	1.0057	0.8912	0.8882
DMU9	0.8591	1.1723	0.9949	1.0088
DMU10	0.3185	1.1166	0.8116	0.7489
DMU11	0.4734	1.0205	0.9466	0.8135
DMU12	0.3630	1.0675	1.0760	0.8355
DMU13	0.7848	0.9642	1.3873	1.0454
DMU14	0.3988	1.0070	0.9993	0.8017
DMU15	1.3651	0.9133	1.0188	1.0991
DMU16	0.5040	0.9165	0.7770	0.7325
Average	0.5910	1.0573	1.0182	0.8888
Max	1.3651	1.6863	1.7506	1.2824
Min	0.1583	0.8993	0.7770	0.6814
SD	0.3113	0.1867	0.2407	0.1672

Source: Calculated by researcher.

4.4.3. Malmquist Productivity Index

The Malmquist productivity index is the most important element in the performance evaluation of corporations in the urban development and infrastructure investment sector in Vietnam. The results, as shown in Table 14, indicate that, in the period of 2013–2016, most of the corporations (14/16 DMUs) performed inefficiently with the Malmquist productivity index being smaller than 1 (<1). In particular, DMU1, DMU3, DMU7, DMU10, and DMU14 have a low Malmquist productivity index (with Malmquist productivity index scores of 0.3995, 0.1172, 0.3183, 0.3368, and 0.3544, respectively). However, during the period of 2014–2016, these companies dramatically improved their performance, thus increasing the average Malmquist productivity index (the period 2013–2014 was 0.5713, period 2014–2015 Malmquist productivity index was 1.0610, and period 2015–2016 was 1.0299). Note that DMU3 (Tu Liem Urban Development J.S.C.-NTL) has the highest increased average The Malmquist productivity index (the period 2013–2014 was 0.1583, period 2014–2015 was 0.9707, and period 2015–2016 was 0.9153), and DMU14 (Becamex Infrastructure Development J.S.C-IJC) has the high increased average Malmquist productivity index, with efficiency scores of 0.3988, 1.0070, and 0.9993, respectively, which shows these firms have managed their operations as well.

Table 14. The MPI change over the period 2013–2016.

Malmquist	2013–2014	2014–2015	2015–2016	Average
DMU1	0.3995	0.9842	0.8400	0.7412
DMU2	1.0368	1.0000	1.0774	1.0380
DMU3	0.1172	1.1127	0.8426	0.6908
DMU4	0.6423	1.1841	1.1667	0.9977
DMU5	0.4103	1.6863	1.7506	1.2824
DMU6	0.5545	0.9905	0.8458	0.7969
DMU7	0.3183	1.0153	0.8626	0.7321
DMU8	0.6264	1.0181	1.1014	0.9153
DMU9	0.8591	1.1723	0.9949	1.0088
DMU10	0.3368	1.1166	0.8059	0.7531
DMU11	0.4104	1.0873	0.9820	0.8266
DMU12	0.4016	0.9141	1.1119	0.8092
DMU13	0.8036	0.9642	1.3873	1.0517
DMU14	0.3544	0.9007	0.9139	0.7230
DMU15	1.3651	0.9133	1.0188	1.0991
DMU16	0.5040	0.9165	0.7770	0.7325
Average	0.5713	1.0610	1.0299	0.8874
Max	1.3651	1.6863	1.7506	1.2824
Min	0.1172	0.9007	0.7770	0.6908
SD	0.3140	0.1902	0.2509	0.1731

Source: Calculated by researcher.

In general, the innovation in technology growth of corporations in the urban development and infrastructure investment sector in Vietnam in this period was positive. In the period of 2013–2016 investment corporations focused on technical efficiency in terms of technical experience, management, and organization. That is reflected in the result of changes in their catch-up scores and frontier shift scores leading to the growth in the Malmquist productivity index of corporations. This result reflects the process of socio-economic development in the localities with the building of more urban areas with increasingly modern infrastructure, contributing to boosting socio-economic development and country development.

4.5. Results Forecasting of the Malmquist Productivity Index in the Future

The authors used the output results of the GM (1,1) model to forecast Malmquist productivity index of corporations in urban development and infrastructure investment sector in Vietnam in the period of 2017–2020. Table 15 shows that 2017–2018 had a big change with stable changes in the period of 2018–2020.

Table 15. The MPI change over the period 2017–2020.

Malmquist	2017–2018	2018–2019	2019–2020	Average
DMU1	0.3340	0.9765	0.9728	0.7611
DMU2	0.7597	1.0305	1.0268	0.9390
DMU3	0.2551	1.1260	1.1560	0.8457
DMU4	0.1038	1.4516	1.4562	1.0039
DMU5	0.4963	1.7417	1.6653	1.3011
DMU6	0.6704	0.9928	1.2483	0.9705
DMU7	0.2448	0.9393	0.9388	0.7076
DMU8	0.8115	1.1183	1.1216	1.0171
DMU9	0.7836	1.6098	0.9909	1.1281
DMU10	0.3202	1.0751	1.1066	0.8340
DMU11	0.4078	1.2105	1.2316	0.9499
DMU12	0.5595	1.0918	1.0873	0.9129
DMU13	0.5598	1.1097	0.9427	0.8707
DMU14	0.6600	1.4771	1.7048	1.2806
DMU15	0.2891	1.0983	1.1234	0.8369
DMU16	0.5404	0.9376	0.9338	0.8039
Average	0.4872	1.1867	1.1692	0.9477
Max	0.8115	1.7417	1.7048	1.3011
Min	0.1038	0.9376	0.9338	0.7076
SD	0.2161	0.2470	0.2437	0.1698

Source: Calculated by researcher.

4.6. Discussion

In this study, 16 leading corporations in urban development and infrastructure investment in Vietnam were involved, the results from the super-SBM model show the performance of the Top 3 are DMU5, DMU7, DMU9 from 2013–2016. With the lowest score, three DMUs with inefficient business in the past include DMU14, DMU11, DMU8. However, in the period of 2017–2020, there are small changes, performance scores on the Top 3 in the period include: DMU4, DMU5, DMU7. With the lowest score, three DMUs with inefficient business in the future include DMU1, DMU12, DMU16. They need action with strong improvement to get effective business in the future.

The results of this study can be considered as a foundation for management units, for local government to create planning projects with feasible content, for long-term vision, and practical efficiency to quickly meet the need for urban development plans: DMUs with effective business will have favorable conditions to attain greater achievements, which is helpful for sustainable urban development. Inefficient companies that caused the abandonment of the construction of many buildings and delay of construction affected urban development, wasted land and natural resources, and destroyed the urban structure. They will be restrictively granted permits. However, for the sustainable urban development in Vietnam, it is necessary to inherit the experience of developed countries such as Japan, Singapore, Australia, etc. It is also necessary to balance all cultural values and religious values, ensuring adequate technical, social, and service elements. There must be a combination of technical infrastructure planning and urban landscape design.

This research also gives international readers an additional perspective on the situation of urban development in developing countries in general and in Vietnam in particular. In addition, the research provides an additional means of assessing the investment effectiveness of corporations in urban development and infrastructure investment.

5. Conclusions

In the future, demand for residential real estate in Vietnam will remain high, especially in large urban centers, due to previous relatively small supply and relatively low quality; in addition, living standards will improve, and the process of urbanization will increase as well. The planning and investment in industry zones, urban areas, residential district, and amusement parks at the right time and right place contribute to social stability and economic development, which is an extremely important issue for Vietnam's government to resolve.

Our limitations in this study are due to the specific nature of urban development and the infrastructure investment sector, under the strict management of the provisions of legislation. In this study, the authors only analyze, evaluate, and forecast business results of the groups in the past. Therefore, future research should incorporate analysis of the regulations and policies of the state management for the urban development and infrastructure investment sectors in order to introduce solutions and provide enterprises with a more general perspective for more accurate assessments and decisions. Another limitation is that the study only focuses on quantitative models. The authors will undertake more research of external environmental factors in the future. Comparisons with other quantitative and qualitative approaches will be in addition a worthwhile research direction.

Author Contributions: In this research, Chia-Nan Wang contributed to generating the research ideas and designing the theoretical verifications. Han-Khanh Nguyen analyzed the data, summarized and wrote and formatted the manuscript. Both authors have read and approved the manuscript.

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

Appendix A

Table A1. Data of 16 DMUs in 2013 (Currency unit: Million VND).

DMUs	Inputs				Outputs	
	(I)OE	(I)TA	(I)CS	(I)TE	(O)NS	(O)PT
DMU1	364,972	1,112,361	140,222	41,366	238,066	44,749
DMU2	3,215,849	14,585,799	5,198,012	419,958	7,021,749	1,110,753
DMU3	868,026	1,323,357	350,870	13,554	453,946	91,875
DMU4	1,628,823	5,607,236	374,765	177,180	631,443	70,127
DMU5	171,963	423,897	1,559,802	16,887	1,593,895	26,080
DMU6	437,460	872,182	101,766	41,052	169,987	20,682
DMU7	87,124	171,527	79,723	7671	82,503	1208
DMU8	2,417,833	4,634,308	593,471	181,543	754,950	53,333
DMU9	663,615	1,268,215	136,660	144,083	342,591	82,764
DMU10	1,264,280	2,100,861	1,598,173	65,474	1,744,013	99,117
DMU11	577,910	1,271,924	202,263	39,678	273,126	26,090
DMU12	848,650	2,327,799	805,250	94,766	988,683	122,776
DMU13	577,507	1,845,614	1,620,882	159,270	1,804,414	41,099
DMU14	3,007,699	4,807,856	352,831	108,963	615,153	161,533
DMU15	4,914,775	12,532,339	577,262	444,938	1,072,821	72,499
DMU16	142,783	509,250	86,874	20,233	132,330	19,171

Source: Synthetic by researcher [18–33].

Table A2. Data of 16 DMUs in 2014 (Currency unit: Million VND).

DMUs	Inputs				Outputs	
	(I)OE	(I)TA	(I)CS	(I)TE	(O)NS	(O)PT
DMU1	390,115	1,114,028	195,573	43,110	295,588	57,299
DMU2	2,726,244	15,567,845	4,841,982	1,063,880	6,512,808	498,757
DMU3	861,747	1,367,020	174,517	21,567	228,313	36,675
DMU4	1,765,921	5,419,827	892,867	182,754	1,226,062	156,395
DMU5	181,772	397,461	1,664,585	11,406	1,700,861	27,004
DMU6	545,379	1,392,932	253,451	49,235	448,924	85,090
DMU7	81,584	161,321	93,363	8638	96,190	1366
DMU8	2,458,135	5,034,820	540,795	118,835	691,031	43,921
DMU9	1,072,227	2,160,453	204,365	136,709	506,181	167,834
DMU10	3,915,705	5,403,552	1,805,738	107,434	2,063,590	355,854
DMU11	609,786	1,207,709	325,809	36,536	392,025	22,689
DMU12	1,051,315	2,293,764	1,300,332	79,301	1,554,415	148,275
DMU13	627,893	1,950,652	1,861,845	175,989	2,119,961	90,419
DMU14	3,066,255	6,730,499	641,228	114,830	1,035,575	230,445
DMU15	6,256,482	13,048,822	481,366	390,485	1,069,035	325,617
DMU16	231,191	479,857	145,182	21,595	235,077	51,018

Source: Synthetic by researcher [18–33].

Table A3. Data of 16 DMUs in 2015 (Currency unit: Million VND).

DMUs	Inputs				Outputs	
	(I)OE	(I)TA	(I)CS	(I)TE	(O)NS	(O)PT
DMU1	382,949	1,105,783	186,792	51,776	277,039	54,700
DMU2	7,128,550	25,306,639	3,286,015	1,180,780	4,920,363	795,075
DMU3	892,604	1,277,582	330,708	21,961	473,237	93,954
DMU4	1,990,459	5,734,361	540,712	17,518	855,452	225,105
DMU5	193,955	400,575	1,887,753	31,257	1,945,178	28,913
DMU6	1,099,046	2,621,012	301,505	73,494	639,404	139,432
DMU7	78,031	163,262	97,076	8687	100,020	2038
DMU8	2,656,336	5,089,310	491,248	175,063	655,225	10,461
DMU9	1,771,359	3,573,347	735,260	277,948	1,394,505	336,629
DMU10	6,231,111	9,814,813	4,662,388	205,714	5,326,248	902,186
DMU11	634,389	1,197,205	323,158	42,790	423,552	47,740
DMU12	1,306,733	3,054,981	1,250,096	85,649	1,479,927	123,459
DMU13	1,220,681	3,480,209	2,181,049	314,383	2,543,398	100,163
DMU14	2,958,255	7,330,710	413,047	145,057	686,153	122,021
DMU15	8,036,005	13,653,707	861,405	169,258	1,434,852	611,910
DMU16	405,457	499,712	158,758	24,357	242,135	58,776

Source: Synthetic by researcher [18–33].

Table A4. Data of 16 DMUs in 2016 (Currency unit: Million VND).

DMUs	Inputs				Outputs	
	(I)OE	(I)TA	(I)CS	(I) TE	(O)NS	(O)PT
DMU1	400,377	1,375,058	320,147	41,542	412,151	55,192
DMU2	6,486,159	34,317,744	6,763,559	3,128,873	11,217,376	1,648,549
DMU3	960,240	1,361,034	349,763	21,183	433,359	74,755
DMU4	2,111,372	5,973,319	272,802	35,620	522,934	176,768
DMU5	219,655	418,065	2,173,099	12,382	2,233,442	43,405
DMU6	1,565,350	3,845,534	892,916	209,639	1,389,774	159,497
DMU7	97,067	195,844	105,544	7254	109,313	1022

Table A4. *Cont.*

DMUs	Inputs				Outputs	
	(I)OE	(I)TA	(I)CS	(I) TE	(O)NS	(O)PT
DMU8	2,821,029	5,900,679	845,290	199,359	1,160,790	77,791
DMU9	3,537,355	5,562,791	1,454,880	441,255	2,506,517	537,203
DMU10	8,407,080	17,790,121	4,581,295	878,184	6,284,334	979,250
DMU11	668,047	1,424,087	372,527	40,763	478,861	58,141
DMU12	1,698,364	6,518,163	1,368,415	365,333	1,982,946	202,947
DMU13	2,162,392	5,041,852	3,714,012	312,354	4,046,846	104,962
DMU14	2,978,667	9,123,731	1,599,369	189,242	1,959,659	137,835
DMU15	8,622,076	14,657,548	865,066	252,696	1,972,459	557,957
DMU16	509,974	664,521	189,209	49,318	282,883	43,630

Source: Synthetic by researcher [18–33].

Appendix B

Table A5. Forecasted data of 16 DMUs in 2017 (Currency unit: Million VND).

DMUs	Inputs				Outputs	
	(I)OE	(I)TA	(I)CS	(I) TE	(O)NS	(O)PT
DMU1	401,625.91	1,493,716.17	401,448.05	44,030.38	472,768.12	53,635.64
DMU2	9,599,183.79	49,323,893.70	7,619,434.05	4,820,006.57	14,470,832.58	2,724,994.08
DMU3	1,008,340.96	1,329,105.69	487,146.46	21,192.45	598,982.62	107,328.33
DMU4	2,322,397.48	6,282,729.81	172,325.44	3390.86	365,955.39	205,245.64
DMU5	239,714.55	426,512.99	2,474,423.15	19,066.82	2,552,657.96	54,071.53
DMU6	2,467,059.08	5,994,681.61	1,348,359.99	332,697.37	2,244,721.91	215,828.75
DMU7	102,941.49	211,902.54	111,547.06	6936.69	115,765.27	1211.68
DMU8	3,027,087.41	6,286,282.96	1,031,922.58	257,675.67	1,476,073.78	95,119.83
DMU9	5,858,764.19	8,491,323.52	2,988,004.70	725,207.47	4,670,966.44	880,872.80
DMU10	11,962,047.87	29,519,601.10	6,883,331.46	640,619.30	9,971,156.30	1,505,650.36
DMU11	697,933.26	1,514,906.06	391,083.83	44,283.44	526,196.48	87,804.43
DMU12	2,136,617.49	10,282,494.66	1,377,309.19	266,449.65	2,174,322.28	228,133.96
DMU13	3,636,516.68	7,685,015.54	5,141,238.78	418,143.16	5,487,800.82	113,782.79
DMU14	2,913,864.46	10,491,506.98	2,128,601.23	240,364.68	2,647,888.12	82,396.81
DMU15	10,227,133.89	15,478,539.04	1,162,283.64	140,178.78	2,635,794.46	744,701.53
DMU16	732,552.40	767,500.24	214,006.17	72,361.45	305,969.74	44,645.92

Source: Calculated by researcher.

Table A6. Forecasted data of 16 DMUs in 2018 (Currency unit: Million VND).

DMUs	Inputs				Outputs	
	(I)OE	(I)TA	(I)CS	(I) TE	(O)NS	(O)PT
DMU1	406,985.38	1,672,630.65	538,209.07	43,326.97	572,672.25	52,622.03
DMU2	12,891,994.66	71,262,852.64	9,590,593.64	9,388,769.86	20,954,720.41	5,096,575.57
DMU3	1,065,120.08	1,326,064.51	645,944.95	21,006.33	760,437.87	135,287.74
DMU4	2,534,707.54	6,594,014.25	99,926.75	928.12	244,720.14	215,641.95
DMU5	263,989.56	437,556.71	2,828,537.22	19,437.10	2,925,041.28	70,318.70
DMU6	3,914,309.29	9,492,120.91	2,919,045.02	755,659.86	4,176,431.95	284,494.36
DMU7	113,147.20	234,754.07	118,706.86	6391.06	123,538.23	1099.58
DMU8	3,241,464.44	6,829,971.75	1,352,088.02	326,260.53	2,016,067.99	169,202.95
DMU9	10,809,453.21	13,391,523.79	6,479,164.36	1,229,583.76	9,144,709.47	1,492,764.04
DMU10	17,108,394.17	52,639,620.42	9,554,195.16	2,001,077.48	15,166,884.96	2,185,132.89
DMU11	730,643.35	1,653,269.53	419,589.49	46,601.06	582,392.70	129,144.09
DMU12	2,722,053.14	18,452,454.53	1,414,476.73	720,431.82	2,490,144.95	276,670.84
DMU13	6,514,121.45	11,888,410.03	7,544,169.80	527,726.04	7,787,422.79	122,419.79
DMU14	2,871,351.94	12,294,320.85	4,278,868.76	308,978.82	4,230,600.52	59,802.34
DMU15	11,889,421.27	16,412,834.59	1,475,434.90	103,046.86	3,580,228.41	916,694.81
DMU16	1,039,636.84	914,945.17	245,190.37	117,352.06	336,932.06	41,748.47

Source: Calculated by researcher.

Table A7. Forecasted data of 16 DMUs in 2019 (Currency unit: Million VND).

DMUs	Inputs				Outputs	
	(I)OE	(I)TA	(I)CS	(I) TE	(O)NS	(O)PT
DMU1	412,416.38	1,872,975.17	721,560.38	42,634.79	693,687.86	51,627.58
DMU2	17,314,339.42	102,960,123.09	12,071,695.30	18,288,149.26	30,343,817.82	9,532,161.10
DMU3	1,125,096.40	1,323,030.29	856,508.09	20,821.85	965,413.25	170,530.66
DMU4	2,766,426.66	6,920,721.60	57,944.76	254.04	163,648.22	226,564.86
DMU5	290,722.82	448,886.39	3,233,328.47	19,814.58	3,351,748.11	91,447.76
DMU6	6,210,559.48	15,030,049.18	6,319,398.32	1,716,340.06	7,770,487.64	375,005.82
DMU7	124,364.72	260,069.91	126,326.22	5888.34	131,833.11	997.85
DMU8	3,471,023.56	7,420,683.16	1,771,588.33	413,100.43	2,753,609.06	300,984.95
DMU9	19,943,502.58	21,119,547.35	14,049,365.73	2,084,749.91	17,903,299.54	2,529,700.63
DMU10	24,468,816.23	93,867,448.58	13,261,404.82	6,250,687.54	2,306,9982.30	3,171,258.00
DMU11	764,886.45	1,804,270.38	450,172.89	49,039.97	644,590.50	189,947.10
DMU12	3,467,898.82	33,113,858.99	1,452,647.26	1,947,917.77	2,851,841.20	335,534.23
DMU13	1,166,8797.91	1,839,0892.28	1,107,0191.52	666,027.33	1,105,0684.17	131,712.41
DMU14	2,829,459.67	1,440,6922.24	8,601,290.64	397,179.46	6,759,341.75	43,403.61
DMU15	1,382,1891.80	1,740,3524.88	1,872,957.74	75,750.81	4,863,063.36	1,128,410.98
DMU16	1,475,450.46	1,090,715.83	280,918.61	190,315.49	371,027.58	39,039.06

Source: Calculated by researcher.

Table A8. Forecasted data of 16 DMUs in 2020 (Currency unit: Million VND).

DMUs	Inputs				Outputs	
	(I)OE	(I)TA	(I)CS	(I) TE	(O)NS	(O)PT
DMU1	417,919.85	2,097,316.57	967,373.86	41,953.67	840,276.18	50,651.91
DMU2	2,325,3682.43	148,756,140.88	1,519,4661.87	3,562,3027.09	4,393,9850.41	1,782,8067.87
DMU3	1,188,449.95	1,320,003.01	1,135,709.94	20,638.99	1,225,639.57	214,954.50
DMU4	3,019,329.19	7,263,616.02	33,600.56	69.53	109,434.15	238,041.05
DMU5	320,163.26	460,509.43	3,696,049.29	20,199.39	3,840,703.20	118,925.58
DMU6	9,853,858.31	2,379,8936.04	1,368,0773.95	3,898,345.45	1,445,7431.33	494,313.37
DMU7	136,694.34	288,115.81	134,434.64	5425.17	140,684.93	905.54
DMU8	3,716,839.96	8,062,484.09	2,321,243.28	523,054.28	3,760,965.85	535,404.02
DMU9	3,679,5875.53	3,330,7283.59	3,046,4526.99	3,534,677.62	3,505,0663.50	4,286,936.90
DMU10	3,499,5860.03	167,385,285.69	1,840,7082.44	1,952,5028.49	3,509,1192.73	4,602,409.92
DMU11	800,734.43	1,969,062.85	482,985.48	51,606.53	713,430.85	279,377.08
DMU12	4,418,107.07	5,942,4487.71	1,491,847.84	5,266,818.51	3,266,074.22	406,921.17
DMU13	2,090,2411.14	2,844,9970.86	1,624,4218.18	840,573.28	1,568,1390.87	141,710.41
DMU14	2,788,178.60	1,688,2543.64	1,729,0130.84	510,557.72	1,079,9578.16	31,501.67
DMU15	1,606,8460.25	1,845,4013.94	2,377,584.19	55,685.20	6,605,552.09	1,389,024.26
DMU16	2,093,956.23	1,300,253.90	321,853.04	308,643.83	408,573.37	36,505.49

Source: Calculated by researcher.

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