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Performance Measurement of Vietnamese Publishing Firms by the Integration of the GM (1,1) Model and the Malmquist Model

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Abstract

Background: In the new technology context, the publishing industry cannot continue to maintain its business operations and to develop relying solely on traditional product offerings, such as books, magazines, and newspapers. There needs to be an expansion into innovative products, such as e-books, micro-publishing, and websites. **Objectives:** The paper addresses the factors influencing financial reports of Vietnamese publishing firms using two methodological approaches, namely the Grey first-order one variables (GM,1,1) model in the Grey theory and the Malmquist model in the data envelopment analysis (DEA). **Methods/Approach:** The GM(1,1) model predicts the future period of 2020–2023 based on the historical time series analysis. The Malmquist model presents catch-up, frontier-shift, and Malmquist Productivity Index (MPI) in whole terms. **Results:** The analysis provides an overview of the publishing industry in Vietnam. The final empirical results show that twelve companies reached a production efficiency higher than 1 and fourteen companies are expected to attain a productivity score higher than 1. **Conclusions:** Only a few firms do not need to change significantly; however, the remaining firms must re-evaluate their current operations.

Keywords: Vietnamese publishing firms; GM(1,1) model; Malmquist model; production efficiency
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Introduction

Industry 4.0 affects directly and deeply the publishing industry because it is an effective support tool for the rapid transfer of information. Hence, the number of traditional publications has been reduced and replaced by electronic publications. As the publishing industry applies Industry 4.0, it can bring a high degree of effectiveness around the world. Nowadays, Vietnam has adopted new globally achieved techniques to catch up with the growth of electronic publishing and e-books on the internet.

The development process of the publishing industry has always met with difficulties in the process of change, regarding innovative technology implementation and economic growth (Lacy, 1979). In recent years, digital publishing has had a great effect on publications' market shares (Lin, Chiou & Huang, 2013; Sara & Markus, 2014), and publishing firms need to have a production plan, schedule and control, inventory management, and reverse logistics (Meysam, Mohammad, Ebrahim & Ali, 2013). Besides, they need to investigate the consumer's requirements and optimize excess product offerings (Anat, John & Pat, 2003; Edoardo, Antonello & Laura, 2008). Any nation applying digital techniques to the publishing industry also builds up its growth strategies (McCready & Molls, 2018; Edelmann & Schoßböck, 2020). Operational strategies are a key factor for the maintainability and sustainability development process to occur so that the publishing company can receive good revenues. A publishing firm of educational books (Lee & Liang, 2018), media content (Alexander & Thomas, 2007), software (Matthew, 2008) makes an effort to overcome specific challenges and reach full effectiveness. These previous studies have explored the development of the global publishing industry via many different methods. In this study, we utilize GM(1,1) model in the Grey theory system and the Malmquist model in DEA.

GM(1,1) model is a forecasting tool that can deal with the minimum historical time series as four terms. The Grey theory supports solving characteristics of poor and insufficient information (Wu, Liu, Fang & Xu, 2015), thus it is useful to deal with the lack of available data. Previous research has utilized the GM(1,1) model for predictive purposes. For instance, Liu, Peng, Bai, Zhu & Liao (2014) forecasted future values of the factors affecting the tourist flow by GM(1,1) model. Maciej & Czeslaw (2015) used a set of GM(1,1) models to predict values of vibration symptoms of fan mills in a combined heat and power generation plant. Qian & Wang (2020) approached the GM(1,1) model to predict wind power generation in China based on the historical data from 2013 to 2019. Nguyen (2020) utilized the GM(1,1) model to forecast the operational efficiency of Vietnamese construction companies. Nguyen, Le, Ngo & Hoang (2020) investigate the business efficiency of global electric cars in 14 countries around the world.

Data envelopment analysis (DEA) is a statistical analysis method that can be applied to various industries, such as economics (Gunes & Guldal, 2019), education (Montoneri, Lin, Lee & Huang, 2012), manufacturing (Ehsan & Hadi, 2014), banking (Bošković & Krstić, 2020), and others. Therefore, DEA is a useful method allowing the efficiency of a specific decision-making unit (DMU) to be measured by the ratio between virtual output and virtual input. The relative efficiency of a homogenous set of a specific DMU is computed by the presence of multiple inputs and outputs. DEA has many different models so that each model may have a separate functionality. For example, Liu & Wang (2008) evaluated the efficiency of Taiwanese semiconductor companies when using the Malmquist model with three components, including technical change, frontier forward shift, and frontier backward shift. Chen, Tzeremes & Tzeremes (2018) discovered the productivity levels of the Chinese airline market

through the Malmquist model. Mavi, et al., (2019) found out the efficiency of freight transportation in Iran and determined a declining trend in terms of eco-innovation and environmental efficiency when observed by the Malmquist model approach. Wang, Tibo, Nguyen & Duong (2020) measured the relative performance of New Zealand universities by use of a Malmquist productivity approach.

This study uses the GM(1,1) model to forecast the main factors of financial reporting, including current assets, non-current assets, fixed assets, liabilities, owner's equity, net revenue, gross profit, and net profit- after-tax in Vietnamese publishing firms. With the actual and forecasted data, the DEA has been applied. Whereas to have a good economic comparison of productivity efficiency among Vietnamese publishing companies, the Malmquist model in DEA is used to compute the score in every term, and the average score in whole terms. The estimated values throughout 2020–2023 are predicted utilizing the GM(1,1) model based on historical data obtained from 2015 to 2019, and then the productivity efficiencies in both previous and future terms are conducted by the Malmquist model. Combining the two above models, namely GM(1,1) model, and the Malmquist model, we can figure out the overall picture of Vietnamese publishing firms from the past to the near future. The empirical results reveal effective variations and identify the operational trends. Research results may serve as references that can help publishing firms in emerging economies foresee their operational processes and make a suitable plan for future development. Besides, the investors may choose the best partners in future terms for better profitability based on the presented analysis.

The paper is arranged as follows. The introduction gives an overview of the publishing industry, the background of GM(1,1), and the Malmquist model. The second chapter sets up the conceptual research, materials, and methods. The third chapter presents the results of the empirical results. The fourth chapter discusses the main analysis results, while the last chapter summarizes the key empirical results, and it indicates the limitations and future research directions.

Materials and methods

Research process

The research process is carried on a step-by-step basis, as shown in Figure 1.

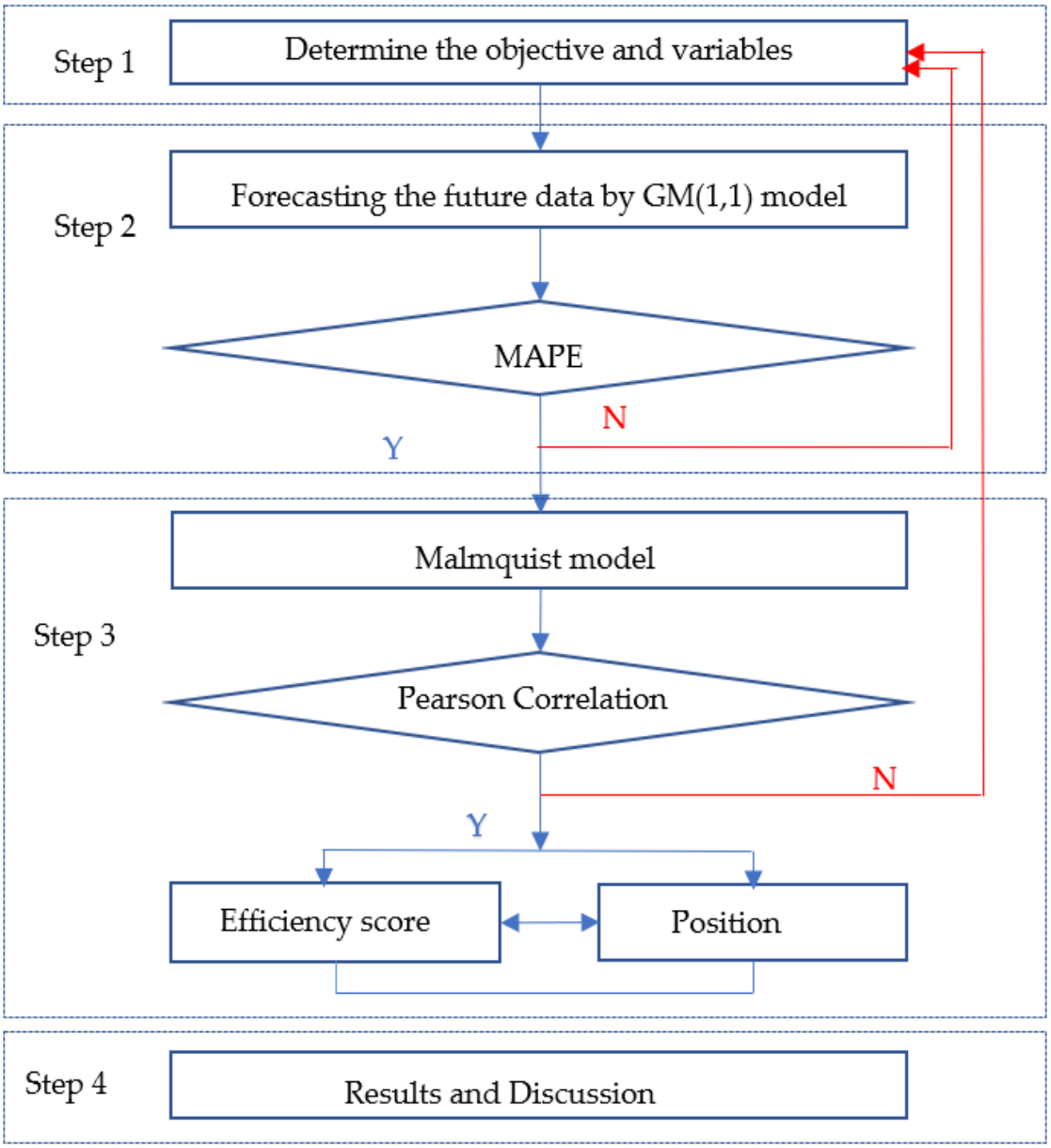
Step 1. The study determined the objective research, and then it collected all related data including inputs and outputs. All selected data must be positive values, and they must be removed and reselected if they are positive values.

Step 2. The estimated data from 2020 to 2023 are calculated by a GM(1,1) model based on the primary data. These predicted values must check the accuracy level through the Mean Absolute Percentage Error (MAPE). All forecasted values owning unsuitable MAPE are removed and used with another forecast model.

Step 3. The Malmquist model in DEA is used for conducting the efficiency score and determining the position of the publishing firms under consideration. Before the actual and forecasted data are utilized to conduct the scores, they must test the Pearson correlation between variables. Any unappreciated values must be returned and re-selected as other values. The appreciated data is applied to computing the productivity efficiency from past to future time.

Step 4. Major analysis results are given and discussed, which can be used to define the extent of efficient and inefficient cases.

Figure1
Research framework



Source: Author's illustration

Materials

The global publishing industry includes newspapers, periodicals, books, directories, and software. The growth of companies in the Vietnamese publishing industry is analyzed based on the actual data published on Vietstock (2020).

The purpose of this study is to measure the financial performance of publishing firms in Vietnam throughout 2016–2023. The input and output variables of nineteen Vietnamese publishing firms are taken and then collected from 2016 to 2019. The names of nineteen companies are given, as shown in Table 1.

Table 1
List of publishing firms

No.	Firm code	Name of publishing firms
1	ADC	Art Design And Communication JSC
2	BDB	Binh Dinh Book & Equipment Joint Stock Company
3	BED	Danang Books & School Equipment JSC
4	BST	Binh Thuan Book And Equiptment JSC
5	DAD	Da Nang Education Development & Investment JSC
6	DAE	Educational Book JSC in Da Nang City
7	EBS	Educational Book JSC in Hanoi City
8	EID	Education Cartography And Illustration JSC
9	HAP	Hanoi Education Development & Investment JSC
10	HBE	Ha Tinh Book And Equipment Education JSC
11	KBE	Higher Education And Vocational Book JSC
12	LBE	Long An School Book & Equipment JSC
13	NBE	North Books and Educational Equipment Joint Stock Company
14	QST	Quang Ninh Book & Educational Equipment JSC
15	SED	Phuong Nam Education Investment & Development JSC
16	SGD	Educational Book JSC in Ho Chi Minh City
17	SMN	South books and Educational Equipment JSC
18	STC	Book & Education Equipment JSC Of HCMC
19	TPH	Ha Noi Textbooks Printing Joint Stock Company

Source: Vietstock (2020)

The following input and output factors have been taken into the consideration, which are the key parts of a financial statement that can help to give a deeper identification of an enterprise's operational enterprise. These indexes equip to calculate the performance in operating progress that displays upward or downward trends in each term. Each of the highest and lowest efficiency points is identified to observe the worst or best business status in every term. All historical data are gathered from Vietstock and summarized as shown in Table 2. Table 2 indicates that the minimum value of CA, NA, FA, LS, OE, NR, GP, and PT is 8623; 1463; 621; 1342; 12698; 16619; 3911; 693, respectively. Therefore, all historical data realize positive values, they are appreciable to use for forecasting future data via the LTS (A, A, A) model and to measure the efficiency via the Malmquist model as well as the GM(1,1) model.

Input factors:

- Current assets (CA): Cash, cash equivalents, accounts, stock inventory, marketable securities, and other liquid assets.
- Non-current assets (NA): The long-term investments made by a specific publishing firm.
- Fixed assets (FA): The long-term tangible assets that are comprised of property, facilities, and equipment.
- Liabilities (LS): Loans, mortgages, deferred revenues, bonds, warranties, and accrued expenses.
- Owner's equity (OE): The owner's investment in the operational business of the enterprise.

Output factors:

- Net revenue (NR): Total sales of a company are received from selling the goods.
- Gross profit (GP): The profit of a publishing firm after deduction of the charges for making and selling products.

- Net profit-after-tax (NT): The net income of a publishing firm after deducting taxes.

Table 2
Historical data of publishing firms

Code	CA	NA	FA	LS	OE	NR	GP	PT
2016								
Max	283150	140198	41922	190209	233138	516773	142396	36504
Min	8623	1872	940	1764	12959	16619	3911	1072
Ave	64480	29805	10271	32599	61687	180175	38930	8512
SD	72056	30062	10126	43442	57503	154352	38439	10030
2017								
Max	306786	121173	40172	181606	246353	577062	159499	36223
Min	10561	1590	621	2164	12779	19203	4107	760
Ave	70959	28218	10285	33976	65201	194884	43002	8637
SD	85262	26327	11104	45775	63944	165895	43333	10016
2018								
Max	340056	106057	38331	183902	262211	599103	163408	40947
Min	11084	1463	864	1487	12698	23200	4430	707
Ave	76252	26824	11585	34043	69034	206116	45731	10609
SD	92511	23979	10775	48671	67717	176569	46316	11864
2019								
Max	372315	95769	38590	185068	283016	652590	174643	45363
Min	12405	1484	747	1342	12993	26322	5464	693
Ave	77590	28906	12777	36628	69868	225307	49314	9702
SD	99761	24275	11549	53582	71268	197027	51390	11845

Note: Ave: average; SD: Standard deviation
Source: Vietstock (2020)

GM(1,1) model

The GM(1,1) model is a forecasting tool based on the Grey theory system utilizing the previous time series (Deng, 1989). This model only calculates future data when the historical time series maintains positive data and is computed in the following order:

From the primary data $A^{(0)} = (A^{(0)}(1), A^{(0)}(2), ..., A^{(0)}(n))$, the consequence $A^{(1)}$ is calculated by:

$$A^{1}(h) = \sum_{i}^{k} A^{(0)}(1) / (h = 0,1,...,n) \quad (1)$$

where,

$$h = 0, A^{1}(1) = A^{0}(1)$$
$$h = 1, A^{1}(2) = A^{0}(1) + A^{0}(2)$$
$$h = n, A^{1}(n) = A^{0}(1) + A^{0}(2) + ... + A^{0}(n)$$

when having $A^{(1)}$ series, the mean equation $Z^{(1)}$ is built up:

$$A^{(1)}(h) = \frac{1}{2}(A^{(1)}(h) + A^{(1)}(h-1)) / (h = 1,2,...,n) \quad (2)$$

where,

$$h=1, A^{(1)}(1)=\frac{1}{2}(A^{(1)}(1)+A^{(1)}(0))$$

$$h=2, A^{(1)}(2)=\frac{1}{2}(A^{(1)}(1)+A^{(1)}(2))$$

$$h=n, A^{(1)}(2)=\frac{1}{2}(A^{(1)}(1)+A^{(1)}(2)+A^{(1)}(n))$$

The mathematical equation for a and b is determined by:

$$A^{(1)}(h)+a\times Z^{(1)}(h)=b/(h=2,3,...,n) \quad (3)$$

where a and b are coefficients.
The linear equation of a matrix is presented by:

$$E=\begin{bmatrix}A^{(0)}(2)\\A^{(0)}(3)\\\vdots\\A^{(0)}(h)\end{bmatrix}, D=\begin{bmatrix}-Z^{(0)}(2) & 1\\-Z^{(0)}(3) & 1\\\vdots\\-Z^{(0)}(h) & 1\end{bmatrix}/(h=1,2,...n) \quad (4)$$

$$and\,\theta=\begin{bmatrix}a\\b\end{bmatrix}(D^TD)^{-1}D^TE$$

The whitening equation is formed:

$$\frac{dA^{(1)}}{dt}+a\times A^{(1)}=b \quad (5)$$

Set up the estimated values $A^{(0)}=\left\{a^{(0)}(1),a^{(0)}(2),...,a^{(0)}(n)\right\}(n=0,1,2,...,n)$, the predicted equation is built up:

$$A^{(1)}(h+1)=\left[\left(A^{(0)}(1)-\frac{b}{a}\right)e^{-ah}+\frac{b}{a}\right]/(h=1,2,..,n) \quad (6)$$

The forecasted values must examine the accuracy level via the mean absolute error percentage (MAPE):

$$MAPE=\frac{100}{n}\sum_{t=1}^{n}\left|\frac{A^{(0)}(h)-A^{(0)}(h)}{A^{(0)}(h)}\right|/(h=1,2,..,n) \quad (7)$$

According to Lewis (1982), the MAPE indicator may be used to distinguish four groups, such as the excellent group (smaller than 10%); good group (10-20%); reasonable group (20-50%); and, poor group (higher than 50%). The unsuitable tested values require the usage of another forecast model or reselection of the primary data.

Malmquist model

The Malmquist model defines the efficiency change of a DMU between two consecutive periods (Tone, 2004). This study uses the Malmquist-radial model for measuring the efficiency of publishing firms in Vietnam over the period from 2016 to

2023. The distance functions of inputs and outputs at t and $t+1$ is $DF_0^t(x_0, y_0)$, and $DF_0^{t+1}(x_0, y_0)$, respectively. The catch-up effect is estimated as follows:

$$CUI = \frac{DF_0^{t+1}(x_0^{t+1}, y_0^{t+1})}{DF_0^t(x_0^t, y_0^t)} \quad (8)$$

The frontier-shift effect is computed:

$$FSI = \left[\frac{DF_0^t(x_0^t, y_0^t)}{DF_0^{t+1}(x_0^t, y_0^t)} \times \frac{DF_0^t(x_0^{t+1}, y_0^{t+1})}{DF_0^{t+1}(x_0^{t+1}, y_0^{t+1})} \right]^{1/2} \quad (9)$$

The Malmquist Productivity Index (MPI) has four terms including $DF_0^t({}_0^t, y_0^t)$, $DF_0^{t+1}({}_0^t, y_0^t)$, $DF_0^t({}_0^{t+1}, y_0^{t+1})$ and $DF_0^{t+1}({}_0^{t+1}, y_0^{t+1})$, the mathematical equation of MPI is calculated:

$$MPI = \left[\frac{DF_0^t(x_0^{t+1}, y_0^{t+1})}{DF_0^t(x_0^t, y_0^t)} \times \frac{DF_0^{t+1}(x_0^{t+1}, y_0^{t+1})}{DF_0^{t+1}(x_0^t, y_0^t)} \right]^{1/2} \quad (10)$$

Let input and output matrices at the period (p) as $X^p = (x_1^p, x_n^p)$ and $Y^p = (y_1^p, y_n^p)$ respectively. The input-oriented radial MPI is presented by the scores (θ) that are given by the linear programs as follows:

$$\min_{\theta,\lambda} \theta = DF^p(x_0^p, y_0^p) \quad (11)$$

where,

$$\theta x_0^p \geq X^p \lambda, y_0^p \leq Y^p \lambda, \lambda \geq 0$$

Results

Based on the collected data of nineteen Vietnamese publishing companies, we predict the future values. When having appreciated actual and forecasted data, the technical efficiency scores are computed by the Malmquist model.

Estimated values

The primary data of nineteen publishing companies in Vietnam is used for predicting the forecasted values utilizing the GM(1,1) model. We utilize the input variable (CA) of the ADC firm to illustrate the predictive process.

Let the primary time series $A^{(0)}$.

$$A^{(0)} = (66{,}306; 80{,}055; 88{,}350; 96{,}533) \quad (12)$$

Calculate time series $A^{(1)}$.

$$A^{(1)} = (66{,}306; 146{,}361; 234{,}711; 331{,}244) \quad (13)$$

Count the mean sequence $Z^{(1)}$.

$$Z^{(1)} = (106{,}334; 190{,}536; 282{,}978) \quad (14)$$

Formulate a and b.

$$\begin{aligned} b &= 80,055 + a \times 106,334 \\ b &= 88,350 + a \times 190,536 \\ b &= 96,533 + a \times 282,978 \end{aligned} \tag{15}$$

Compute the linear equation.

$$E = \begin{bmatrix} 80,055 \\ 88,350 \\ 96,533 \end{bmatrix}, D = \begin{bmatrix} -106334 & 1 \\ -190536 & 1 \\ -282978 & 1 \end{bmatrix}, ET = \begin{bmatrix} -106334 & -190536 & -282978 \\ 1 & 1 & 1 \end{bmatrix} \tag{16}$$

Determine a and b values.

$$\theta = \begin{bmatrix} a \\ b \end{bmatrix} (D^T D)^{-1} D^T E = \frac{-0.09321}{70297.55} \tag{17}$$

Formulate the whitening equation.

$$\frac{d\,66,306}{dt} + -0.09321 \times 66,306 = 70297.55 \tag{18}$$

Estimate the forecasted value.

$$\begin{aligned} h = 1, A^{(0)}(1) &= 66,306 \\ h = 2, A^{(0)}(2) &= 80,155 \\ h = 3, A^{(0)}(3) &= 87,985 \\ h = 4, A^{(0)}(4) &= 96,580 \\ h = 5, A^{(0)}(5) &= 106,015 \\ h = 6, A^{(0)}(6) &= 116,372 \\ h = 7, A^{(0)}(7) &= 127,740 \\ h = 8, A^{(0)}(8) &= 140,218 \end{aligned} \tag{19}$$

Upon application of these steps, the forecasted data are formulated, these forecasted data are summarized in Table 3; however, all of them must check the MAPE indicator to ensure the accuracy standard is adhered to, as shown in Table 4.

Table 3
Forecasted data of publishing firms from 2020 to 2023

Year / Statistics	CA	NA	FA	LS	OE	NR	GP	PT
2020								
Max	410263	102874	79266	213281	302679	689545	187637	50790
Min	12416	1408	665	964	13040	30861	5691	590
Ave	82486	29624	16680	38760	72943	242247	52938	10804
SD	108044	25973	19309	58584	75373	214358	56121	13024
2021								
Max	451747	135352	191741	249647	324517	733992	215770	56788
Min	10247	1358	588	744	13150	36003	6157	464
Ave	87235	31663	24782	41963	75682	262469	57114	11524
SD	117201	30937	42719	65139	79809	235549	61993	14273

Table 3
Forecasted data of publishing firms from 2020 to 2023 (continued)

2022								
Max	497425	178083	463814	292213	347930	781304	248122	63495
Min	8456	1311	380	574	13260	42001	6619	365
Ave	92597	34661	42853	46007	78602	285084	61796	12340
SD	127279	39210	102511	73305	84600	259455	68815	15699
2023								
Max	547723	234305	1121946	342037	373032	831665	285323	70993
Min	6979	1265	216	299	13372	48519	6223	287
Ave	98616	38867	83851	51063	81714	310374	67054	13267
SD	138380	51210	248416	83524	89773	286417	76732	17327

Source: Author's calculation

MAPE indicators in Table 4 show that the minimum and maximum values are 0.30504% and 12.13654%, respectively. According to Lewis (1982), we could conclude that the highest value of MAD (12.1365 for firm BAD) is still acceptable. Other firms obtain an excellent level because their MAPEs are lower than 10%. Besides, the average MAPE for all observations is 3.00176%. Therefore, the estimated data summarized in Table 3 have a good forecasting performance. These values are appreciated to apply to the Malmquist model in DEA.

Table 4
MAPE indicators (%)

DMU codes	MAPE
ADC	1.08478
BDB	1.78103
BED	12.1365
BST	3.46064
DAD	3.12158
DAE	2.62495
EBS	0.66254
EID	0.36527
HAP	2.12362
HBE	0.96593
KBE	2.40343
LBE	3.1183
NBE	6.17556
QST	0.61211
SED	1.77095
SGD	0.83829
SMN	8.7351
STC	0.30504
TPH	4.74778
Average	3.00176

Source: Author's calculation

Performance measurement

With the purpose of efficiency measurement, all actual and predicted data are used in the Malmquist model. These variables need to contain not only positive data but also demonstrate a significant correlation; thus, they must be checked using Pearson's correlation. The relationship between input and input, input and output, output and output must be isotonic, with the correlation coefficient limitation demonstrated from -1 to +1. The relationship is defined as good relation when it is close to ± 1. In this study, the correlation ranges from -0.2286 to 1, which is acceptable for the Malmquist model.

As shown in Table 5, there are six DMUs including ADC, BED, BST, NBE, SED, and SMN that indicate no significant progress of the technical efficiency in the entire previous period, as well in the future terms. HAP reached the efficiency from 2016 to 2017, but it declines and maintains a performance score value of 1 from 2018-to-2023. LBE keeps a stable state but predicted as an inefficient score. Although the score of TPH fluctuates sharply, it always obtains efficiency in the whole term. Other companies exhibited minor downward and upward trending in every term; therefore, they did not attain adequate performance in the whole term. Whereas, BDB, DAD, EID, KBE, and QST are expected to extend the scores and obtain the efficiency scores in all of the future terms. This result implies that these firms will achieve good conditions. DAE, EBS, HBE, LBE, SGD, and STC are seen to exhibit a downward trend in the future. The empirical result denotes that their operational process can be greatly affected by fluctuations occurring in the previous term.

Table 5
Catch-up performance

DMU code	2016 =>2017	2017 =>2018	2018 =>2019	2019 =>2020	2020 =>2021	2021 =>2022	2022 =>2023
ADC	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
BDB	1.0018	0.6581	1.0986	0.9512	1.1013	1.1121	1.1111
BED	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
BST	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
DAD	1.0000	0.7901	1.2656	0.9070	1.0776	1.0231	1.0000
DAE	1.0000	1.0000	1.0000	1.0000	0.9568	0.8884	0.8119
EBS	1.2355	0.9988	1.0012	0.9682	0.8870	0.8751	0.8726
EID	0.9613	1.0571	1.0629	1.0000	1.0000	1.0000	1.0000
HAP	1.2384	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
HBE	0.9572	0.6463	0.9967	0.8148	1.0398	0.9653	0.9804
KBE	1.0000	0.9705	1.0304	1.0000	1.0000	1.0000	1.0000
LBE	1.0000	1.0000	1.0000	1.0000	1.0000	0.9992	0.9825
NBE	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
QST	1.0000	1.0000	1.0000	0.9815	1.0189	1.0000	1.0000
SED	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
SGD	1.1810	0.8910	1.0023	0.9367	0.9301	0.9569	0.9652
SMN	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
STC	1.0294	0.8160	1.0887	0.8823	0.9800	0.9797	0.9827
TPH	1.0679	1.0147	1.6431	1.2340	1.3690	1.3171	1.0000

Source: Author's calculation

Operational progress corresponding to the effect of technology innovation, raw material and product price, etc., makes the financial indicators of publishing firms the efficiency scores of DMUs change. They are measured by the frontier-shift index, as shown in Table 6. There are five DMUs including BDB, EBS, EID, HAP, and SMN, which always gain efficiency, as indicated by the scores above 1 from 2016-to-2023. The

remaining firms have a high degree of changing scores between 0.5637 and 2.0519. These values describe an unstable movement.

Table 6
Frontier-shift efficiency score

DMU code	2016 =>2017	2017 =>2018	2018 =>2019	2019 =>2020	2020 =>2021	2021 =>2022	2022 =>2023
ADC	1.2351	0.7331	0.9892	0.9032	0.9198	0.9256	0.9437
BDB	1.0111	1.4231	1.0397	1.1510	1.0465	1.0418	1.0483
BED	0.9722	2.0519	0.5637	1.4850	1.0666	1.0724	1.0744
BST	1.1478	0.9141	1.1399	0.9972	1.0510	1.0481	1.0448
DAD	0.9553	1.4672	0.7055	1.2807	1.0608	1.1029	1.1227
DAE	1.0548	1.0955	0.8127	0.9986	1.0179	1.0911	1.1867
EBS	1.0944	1.0423	1.0032	1.0791	1.1526	1.1714	1.1843
EID	1.0152	1.0667	1.0179	1.3091	1.4229	1.4206	1.4137
HAP	1.0981	1.1891	1.2766	1.1755	1.2109	1.2368	1.2476
HBE	0.9769	1.4967	1.1211	1.267	0.9890	1.0632	1.0562
KBE	1.0826	1.0900	0.9938	1.0573	1.0393	1.0417	1.0457
LBE	1.0114	1.0232	0.8319	1.0115	0.8654	0.9067	0.9555
NBE	1.2593	0.9673	1.1038	1.6175	1.2226	1.1427	1.0904
QST	0.8738	1.0276	0.9710	1.0809	1.0443	1.0727	1.0774
SED	1.1222	1.3987	0.8772	1.0888	1.1050	1.1106	1.1146
SGD	1.0221	1.1774	0.9169	1.0845	1.0690	1.0435	1.0415
SMN	1.0064	1.0364	1.2014	1.1663	1.1913	1.1926	1.1933
STC	1.0859	1.1961	0.8906	1.1891	1.0830	1.0741	1.0603
TPH	0.9103	1.3879	0.8651	1.1153	1.0286	0.9985	1.2482

Source: Author's calculation

After the catch-up and frontier-shift scores are provided, the Malmquist productivity index (MPI) is calculated through catch-up and frontier-shift techniques, as seen in Table 7. Four DMUs, including EBS, HAP, KBE, and SMN, attain the performance in the whole term and have a slight change of their efficiency score between terms from 1.0044 to 1.36. The remaining DMUs have a variation of scores that both increase and decrease continuously and slightly. In addition, they own both efficient and inefficient terms over the period 2016–2023.

ADC and BDB experience the same situation by showing an upward and downward trend in every year in the previous time; and, they are expected to extend consecutively in the future time. ADC demonstrated efficiency with 1.2351 in 2016–2017. BDB obtained adequate performance in most terms except during 2017–2018.

The historical scores of BED, BST, DAD, EID, HBE, NBE, QST, SED, STC, and TPH increased and decreased slightly, with both efficient and inefficient terms being present. All of the firms are expected to hold their technical efficiency in the future period of 2020–2023. The score of SGD exhibits a dramatic consecutive change in which efficient and inefficient scores occur in long term.

Although DAE, ADC, and LBE generate a marked change in progress during the past, with both efficient and inefficient terms being present, they reveal that they will not likely reach adequate performance demonstrated by scores under 1 in the future. These publishing firms will have the lowest operational progress and require definite and immediate improvement.

Table 7
Malmquist productivity efficiency score

DMUs	2016=> 2017	2017=> 2018	2018=> 2019	2019=> 2020	2020=> 2021	2021=> 2022	2022=> 2023
ADC	1.2351	0.7331	0.9892	0.9032	0.9198	0.9256	0.9437
BDB	1.0129	0.9366	1.1422	1.0948	1.1525	1.1586	1.1647
BED	0.9722	2.0519	0.5637	1.485	1.0666	1.0724	1.0744
BST	1.1478	0.9141	1.1399	0.9972	1.0510	1.0481	1.0448
DAD	0.9553	1.1593	0.8929	1.1615	1.1432	1.1284	1.1227
DAE	1.0548	1.0955	0.8127	0.9986	0.9739	0.9694	0.9635
EBS	1.3522	1.0411	1.0044	1.0448	1.0224	1.0251	1.0334
EID	0.9759	1.1276	1.082	1.3091	1.4229	1.4206	1.4137
HAP	1.36	1.1891	1.2766	1.1755	1.2109	1.2368	1.2476
HBE	0.9351	0.9674	1.1174	1.0324	1.0283	1.0263	1.0355
KBE	1.0826	1.0578	1.0241	1.0573	1.0393	1.0417	1.0457
LBE	1.0114	1.0232	0.8319	1.0115	0.8654	0.9059	0.9387
NBE	1.2593	0.9673	1.1038	1.6175	1.2226	1.1427	1.0904
QST	0.8738	1.0276	0.9710	1.0609	1.0640	1.0727	1.0774
SED	1.1222	1.3987	0.8772	1.0888	1.1050	1.1106	1.1146
SGD	1.2071	1.0490	0.9190	1.0159	0.9943	0.9986	1.0052
SMN	1.0064	1.0364	1.2014	1.1663	1.1913	1.1926	1.1933
STC	1.1178	0.9759	0.9696	1.0492	1.0614	1.0522	1.0420
TPH	0.9721	1.4084	1.4214	1.3763	1.4081	1.3152	1.2482

Source: Author's calculation

Discussion

Results evident in Tables 5–7 indicate that the catch-up shows "no-change", and the frontier-shift and MPI are going to either extend or decrease. The overall observation of operating progress from past to future is drawn by the average score of each index, as shown in Table 8 which gives a comparison of the average scores of catch-up, frontier-shift, and MPI.

Table 8
Average scores of catch-up, frontier-shift and MPI

DMUs	Catch-up	Frontier-shift	MPI
ADC	1.0000	0.9500	0.9500
BDB	1.0049	1.1088	1.0946
BED	1.0000	1.1837	1.1837
BST	1.0000	1.0490	1.0490
DAD	1.0091	1.0993	1.0805
DAE	0.9510	1.0367	0.9812
EBS	0.9769	1.1039	1.0748
EID	1.0116	1.2380	1.2503
HAP	1.0341	1.2049	1.2423
HBE	0.9144	1.1386	1.0203
KBE	1.0001	1.0501	1.0498
LBE	0.9974	0.9436	0.9412
NBE	1.0000	1.2005	1.2005
QST	1.0000	1.0211	1.0211
SED	1.0000	1.1167	1.1167
SGD	0.9804	1.0507	1.0270
SMN	1.0000	1.1411	1.1411
STC	0.9655	1.0827	1.0383
TPH	1.2351	1.0791	1.3071
Average	0.9845	1.0947	1.0931

Source: Author's calculation

As seen in Table 8, the total average of catch-up is lower than 1 with 0.9845, the average of frontier-shift and MPI is higher than 1 as 1.0947 and 1.0931, respectively. The average score of all publishing companies among frontier-shift and MPI has a smaller difference than that of frontier-shift, which is higher than MPI, at 0.0016. The efficiency indexes point out progress, regression, and no-change. The score of catch-up divides into three classifications. The first group has seven companies, including ADC, BED, BST, NBE, QST, SED, and SMN with an average score of "no change", shown as 1. The second group has six companies, including BDB, DAD, EID, HAP, KBE, and TPH, with average scores from 1.0001 to 1.2351; and, the third group has six companies, including DAE, EBS, HBE, LBE, SGD, and STC with average scores under 1. The frontier-shift and MPI only have two classifications. For the frontier-shift, the first group has seventeen companies, including BDB, BED, BST, DAD, DAE, EBS, EID, HAP, HBE, KBE, NBE, QST, SED, SGD, SMN, STC, and TPH with an efficiency score above 1; and, two companies, including ADC and LBE, have an average score under 1. For the MPI, three companies possess average scores under 1, including ADC, DAE, and LBE; the remaining companies have an average score above 1.

According to the equation of the Malmquist model, MPI is determined based on the catch-up and frontier shift. The final empirical result of productivity efficiency in Table 7 indicates a soft fluctuation of operations for each publishing firm every year. Four excellent publishing firms reached good progress with their efficiency score in both previous and future periods. The integration of the GM(1,1) model and Malmquist model explores the productivity efficiency for all Vietnamese publishing firms from 2015 through 2023. The analysis results exhibit the best and worst firms in each term or whole term as well. The average MPI in the whole term revealed the three worst firms, as their average scores are less than one number. Based on the score of production efficiency, these firms should make plans to improve their productive efficiency in the future by increasing the values of their output variables and reducing the values of their input variables immediately.

Implications for practice

From a practical point, two models, namely GM(1,1) model in Grey theory and the Malmquist model in DEA were applied in this research. The Malmquist model in DEA can measure the technical efficiency of each period based on a consecutive timeframe; thus, this model calculates the productivity efficiency of the publishing firms in each year from past to future. The ratio between the sum of outputs and the sum of inputs evaluates the operational process of firms; moreover, the average score exhibits an overview of development in the entire time. The notion of technical efficiency helps these publishing firms make an effective and profitable operational plan for the future. The described procedure can be used to predict future values in the publishing industry in other countries, as well as in other industries, such as with pharma (Wang, Wei, Sun & Li, 2016), logistics (Wang, Day & Nguyen, 2018), or energy (Qian & Wang, 2020).

Contributions to the literature

This paper contributes to the literature as follows. Firstly, previous papers have given an evaluation of the publishing industry by qualitative methods (Maxim, 2012; Lin, Chiou & Huang, 2014), while our paper analyses the quantitative data from the financial statements, which measures the operational process of a firm. Secondly, Lee and Liang (2018) only forecasted manufacturers' printing methods to reduce the manufacturer's inventory in the educational publishing industry. Our paper has an

overall picture of the publishing industry. Thirdly, our paper not only uses the actual data and forecasts the future data but also measures the performance of publishing firms by using the Malmquist model approach. We built a set of variables that are related to the operational process, and the findings evaluate the efficiency level of these firms and recommend a strategy to develop and improve their efficiency score in the future.

Conclusion

This research integrates GM(1,1) model and the Malmquist model to observe the publishing firms in Vietnam. The GM(1,1) model estimates the high degree of accuracy, as indicated by the average MAPE of 3.00176%. The operational progress of nineteen publishing companies in Vietnam is measured by the technical efficiency (catch-up), technological change (frontier-shift), and MPI when applying the Malmquist model in DEA.

An analysis of actual and predicted data by the use of the Malmquist model describes a picture of the Vietnamese publishing industry. The catch-up efficiencies of publishing firms indicate that six firms are in no need of substantial change; however, remaining firms must re-evaluate current operations since these firms can improve their performance by employing increased values of revenue and profitability while reducing the values of assets, equity, and liability.

On the other hand, frontier-shift results describe only a slight change for all publishing firms. Similarly, MPI also denotes that in recent years, publishing companies have experienced considerable fluctuation. Nine publishing companies, including BDB, BED, DAD, EID, HBE, NBE, QST, SED, and STC did not reach the desired efficiency level in previous years, but they are expected to have a good result in the future when their forecasted efficiency scores will be higher than one number. There are four publishing companies including EBS, HAP, KBE, and SMN that always attain adequate performance in every term where they experienced progress.

Although the study estimates the future values and computes the performance of publishing firms, it still has some limitations. First, the research is focused on only one country, while the publishing industry formally exists, and is developed in all countries around the world. The next study can expand the scope of research to point out how the different national characteristics of publishing industries between Vietnam and others countries around the world differ. Second, the study measures the technical efficiency in each term, but it does not determine the relative position for all publishing firms. Further research should be conducted using more models, such as a super slacked-based measurement model, a super slacked-based measurement max model, etc., to afford appropriate ranking.

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