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Efficiency and Productivity of Local Educational Administration in Korea Using the Malmquist Productivity Index

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Abstract: As local governments around the world struggle to finance and deliver quality education under fiscal constraints, pressures mount to increase efficiency and productivity in order to obtain more output from the same or fewer resources. Focusing on the case of Korea, this study investigates the productivity of outputs in local offices of education (OEs) through the analysis of personnel and financial factors by year (2012–2016). Overall, the results indicate the efficient operation of the OEs in Korea. The Malmquist productivity index (MPI) mean decreased from 2012 to 2014, increased from 2014 to 2015, and decreased from 2015 to 2016. The rate of chronological change in each OE's MPI showed the same pattern of change in the distribution ratio of school expenditures. Finally, the MPI had the same pattern as the Technical Change Index. Policy implications are provided.

Keywords: Malmquist productivity index (MPI); metropolitan and provincial offices of education; productivity; educational investment

MSC: 97B20

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1. Introduction

A primary responsibility of local governments around the world is to ensure the effective delivery of essential public services such as equitable access to education. Since the global financial crisis of 2008, and with the continuing competing demands for government funding, governments worldwide have struggled with public finances [1]. Thus, as the financing of local educational administration is an international problem, increased efficiency and productivity are needed in order to ensure the effective delivery of quality education to all. The productivity of educational organization management, such as in closing and new schools due to a decrease in the school-age population and the development of new towns over the past 10 years, has been actively discussed.

Efficiency and productivity have been considered to be of great value in the public sector, have provided governments and public organizations with their major purpose, and have been utilized as standards of the evaluation of potential outputs [2]. Efficiency and productivity have also been important goals, especially in education, in that the ways in which limited resources are utilized can have an effect on the efficient achievement of the purpose of education. Focusing on the case of South Korea, this study investigates this problem by examining the efficiency of outputs in local offices of education (OEs) through the analysis of personnel and financial factors over a five-year period (2012–2016). The OEs are local educational administration agencies that were set up in a metropolitan government. These local agencies are in charge of kindergarten, elementary, and secondary education and curriculum affairs, as delegated by the Ministry of Education and under the supervision of the Superintendent of Education [3].

In South Korea, various data related to efficiency and productivity have been provided on governmental websites such as School Info (www.schoolinfo.go.kr, accessed on

2 April 2022) and Edu Info (www.eduinfo.go.kr, accessed on 2 April 2022) The School Info website provides information at least once a year about the status of students and teachers, facilities, school violence, hygiene, educational conditions, financial status, food service status and academic achievement. The Edu Info website is designed to encourage the public's participation and communication in financial management, in order to enhance fiscal soundness and efficiency by transparently disclosing the operation status of local education finances. It also provides local education finance statistics and analysis data on various subjects, along with budget and account disclosure information.

The provision of information on students and schools, and financial data on each metropolitan and provincial OE can satisfy parents' right to know, and can increase expectations for efficient financial operations. However, one concern about making this information available to the public is that it could lead to the instigation of a ranking among schools and regions [4], and this comparison could lead to the public's awareness of inferior conditions in their local schools. Given Korean parents' intense concern about their children's education, the disclosure of this information could cause additional pressure and frustration for parents. Despite this potential negative effect, having to provide such important information to the public has forced every OE and government to find the best ways to support students and schools with limited resources.

Thus, the questions arise as to what constitutes efficient support for students and schools, and how the efficiency of each metropolitan and provincial OE can be measured. Efficiency is an economic concept of the measurement of the rate of inputs to outputs in terms of the achievement of the purpose of the organization [5,6]. The outcomes established for each OE should be evaluated through a process of measuring whether such outcomes were achieved. Ever since the scientific management theory was developed by Taylor to address the efficient use of governmental resources in the public sector, there has been growing interest in the application of this theory for the improvement of efficiency in education as well [7].

However, there have been limitations to finding the proper ways to evaluate efficiency in education due to the various inputs and outputs in education, the various variables to be considered, and the insufficient research on efficiency and productivity [7,8]. However, given the limited resources in education, serious efforts have been made to evaluate the inputs and outputs in order to improve efficiency, such as by establishing a clear concept of efficiency and elaborating the method of measuring efficiency [4].

In order to measure the efficiency in education, two main methods have been used: parametric and non-parametric methods. Parametric methods include production function or regression analysis, while non-parametric methods include Data Envelopment Analysis (DEA) and Malmquist productivity analysis. Numerous studies have compared the efficiency scores generated by both techniques for a specific sample [9–11]. Rather than using only student achievement to measure the efficiency of education, other valid measurements include the analysis of the relationships between various input variables and output variables from cognitive and financial perspectives.

The Malmquist index method has been considered appropriate for the analysis of factors influencing the development of productive forces; it relies on technological progress or management-level improvement. Moreover, this method has been widely used in finance, medical treatment, enterprise, and other related areas [12]. Moreover, the previous studies using the Malmquist productivity index (MPI) focused on public or private corporations, but no research has utilized the MPI to analyze the efficiency and productivity of metropolitan and provincial OEs. Furthermore, the previous studies have considered output variables from cognitive perspectives, but not from the financial perspective that this study intends to analyze.

As some OEs have been shown to have low scale efficiency, the offices showing an increasing return scale are required to improve the efficiency of output through increasing returns to scale. For example, the improvement of the organizational operations by reorganizing the systems is needed in order to meet the various educational demands.

Furthermore, the causes of management inefficiency need to be investigated in order to determine ways to improve the operational efficiency. Therefore, to this end, this study attempts to analyze the efficiency of outputs through the analysis of personnel and financial factors by year (2012–2016), by considering groups of kindergarten, primary, and secondary schools in each metropolitan and provincial OE. Input and output variables are proposed in order to measure the efficiency of the provision of financial support for schools in OEs. Furthermore, employing the MPI, this study attempts to analyze productivity over time through time-series analysis, and explores the decisive factors influencing the changes in outputs by diagnosing technical progress and technical efficiency.

Providing education as efficiently as possible is critically important at the national, local, and individual levels, given the current competing demands for government funding. Thus, the theoretical and empirical importance of this study lies in its potential contribution to the improvement of the operations of educational organizations, which in turn would contribute to the response to various educational demands, and ultimately to increasing educational equity. The advantage of the utilization of the MPI—the productivity of the t and $t + 1$ DMUs—to examine the productivity and efficiency of 17 metropolitan and provincial OEs, is that it is capable of evaluating productivity increase or decrease based on '1' by analyzing and decomposing productivity changes into technological changes and efficiency changes [13,14].

2. Literature Review

With the competing demands on local governments to support various essential public services with limited financial resources, it is important that these services be provided as efficiently as possible [1]. Generally, efficiency means spending less while producing the same level of output, while productivity includes technology changes, effectiveness, and output quality [15].

2.1. Efficiency

Efficiency is defined as the performance measure to maximize outputs using limited resources [16]. Technical efficiency, which is the proportion of inputs to outputs, refers to the production of the maximum outputs through combinations of various inputs for the evaluation of the internal operations of an organization. Therefore, measuring efficiency is required in order to find the best ways to maximize the technical efficiency by considering the most effective methods to produce outputs, making the best decisions about the input ratio of capital to labor, and choosing appropriate production equipment and materials. An efficient organization that attains technical efficiency is an organization that achieves its goals through the use of the minimum inputs.

The assertion is that many attempts to combine the measurements of the multiple inputs and outputs into any adequate measure of efficiency had failed. Farrell developed a concept of efficiency that distinguished efficiency as technical efficiency, price efficiency, and overall efficiency, with the latter term referring to both technical and price efficiency [17]. Farrell's concept was restricted to the use of linear programming techniques [18]. However, Charnes, Cooper, and Rhodes reinterpreted Farrell's concept as being a relative notion, and suggested a new ratio model based on non-linear programming, known as the CCR ratio [19]. Furthermore, Park maintained that measuring efficiency requires an examination of the production process through which an organization produces outputs by utilizing its own limited resources [20].

Most interestingly, in a study by Ammons and King, a random sample of local chief administrators were asked to choose from 12 different definitions of productivity. Of the 319 respondents, 54% selected the phrase "the efficiency with which resources are consumed in the effective delivery of services" [21] (p. 115).

2.2. Productivity

Productivity is defined as the proportion of inputs to outputs. That is, productivity is the value of outputs divided by inputs, and thus can be viewed as a concept which is similar to efficiency. However, productivity is the more inclusive concept compared to efficiency, in that it includes not only efficiency but also the technological change, effectiveness, and quality of products [2,22,23]. In order to distinguish the terms more simply, productivity is defined as the quantity of work produced by a business, team or individual. On the other hand, efficiency focuses on making sure that the resources are well used in order to produce a product in terms of time. Productivity improvement comes not from working harder, but from working smarter [15].

The analysis of productivity is the investigation of the relationship between inputs and outputs over time using time-series analysis, including the examination of the technical improvement. In addition, the influence of technical progress and the change of scale for outputs should be included in the analysis of productivity [24]. In a study conducted to produce a report commissioned by the United Kingdom, Atkinson examined UK government output and productivity in multiple areas, including education [25]. The purpose of this report was to enable more sophisticated analyses of government productivity by establishing guidelines for government output to be measured in a manner similar to output in the private sector. As Atkinson explained, "we start from Principle A: the measurement of government non-market output should, as far as possible, follow a procedure parallel to that adopted in national accounts for market output" [25] (p. 36).

In the Atkinson Report, as a means of calculating UK government productivity in education, the total government expenditure was used as the input measure and the number of full-time equivalent students in the UK was used as an output measure [25]. Atkinson asserted that progress towards improved measures of government inputs and outputs strongly depends on cooperation between government departments. He emphasized the critical role played by this cooperation [26].

2.3. Malmquist Productivity Index (MPI)

This study analyzes the productivity of 17 metropolitan and provincial OEs by evaluating the MPI through time-series analysis (2012–2016). As this study deals with the process of the change in productivity, the MPI is needed; it allows the evaluation of the change in efficiency over time. This index, first introduced by Malmquist in 1953 in the context of consumer theory, was further divided into two subsections: efficiency changes (EC) and technical changes (TC) [27]. The MPI can be defined as the index of outputs to input factors based on a distance function, rather than a specific production function. Thus, unlike the Growth Accounting Method (GAM), the measurement of efficiency by the Malmquist method does not need data for the rate of income distribution or the cost of input factors. The distance function used in the MPI is divided into Input-based Distance Function and Output-based Distance Function. The Input-based Distance Function is used to find the minimum inputs necessary for the production of a certain level of outputs, while the Output-based Distance Function is used to estimate the maximum outputs with the limited inputs.

The MPI decomposes the total factor productivity using the factors of technical progress and technical efficiency to provide policy implications related to the improvement of productivity. When technical progress influences productivity, policies including technical innovation need to be introduced. However, when technical inefficiency interrupts the sufficient use of production technology, it is necessary to raise productivity through policies that introduce, extend, and utilize new technology [20]. As shown in Equation (1), productivity is decomposed into the Pure Efficiency Change Index (*PECI*), Scale Efficiency Change Index (SECI), and Technical Change Index (TCI). In Equation (1), if $M_I\ (x^{t+1}, y^{t+1}, x^t, y^t) > 1$, this indicates that productivity is increased at $t + 1$. If $M_I\ (x^{t+1}, y^{t+1}, x^t, y^t) < 1$, this means that productivity is decreased at $t + 1$. If $M_I\ (x^{t+1}, y^{t+1}, x^t, y^t) = 1$, there is no change in productivity.

$$M_I(x^{t+1}, y^{t+1}, x^t, y^t) = \frac{V_I^{t+1}(x^{t+1},y^{t+1})}{V_I^t(x^t,y^t)} \cdot \left[\frac{V_I^t(x^t,y^t)}{D_I^t(x^t,y^t)} \cdot \frac{V_I^{t+1}(x^{t+1},y^{t+1})}{D_I^{t+1}(x^{t+1},y^{t+1})} \right] - \left[\frac{D_I^t(x^{t+1},y^{t+1})}{D_I^{t+1}(x^{t+1},y^{t+1})} \cdot \frac{D_I^t(x^t,y^t)}{D_I^{t+1}(x^t,y^t)} \right]^{\frac{1}{2}} = PECI \cdot SECI \cdot TCI \quad (1)$$

where M refers to measuring productivity, x represents the input variables, y represents the output variables, and t represents the time period.

2.4. Financial Efficiency

Calculated tax surplus is the surplus in the settlement of revenue and expenditure accounts in every fiscal year, i.e., the balance remaining after the subtraction of expenditure from revenue. The surplus can be used as available funds for the next year. The pure calculated tax surplus of a local government is the surplus after the exclusion of specified carry-over costs, accident carry-over costs, continuing carry-over expenditures, national subsidy, and city and provincial subsidies [28].

Even though the pure calculated tax surplus is used as available funds for provincial finance, this surplus can be considered to be either efficient or inefficient. For example, the tax surplus can be considered as an institutional advantage in that this surplus can provide continuing public service for people through the flexibility of the budget execution. On the other hand, this surplus could be considered the result of the inefficiency of planning, the predictability of financial management, and the financial inefficiency of the organization, as this surplus means that the revenue in the current year is the amount carried forward [29]. In addition, the pure calculated tax surplus determined after the settlement of accounts is complete at the end of the current year. This surplus reflects the budget for the next year; that is, this surplus is used for the revised supplementary budget or the revenue for the next year. Thus, the calculated tax surplus prevents the effective utilization of revenue under rational planning [28]. This study focuses on the inefficiency of the pure calculated tax surplus, and utilizes the rate of this surplus as an output variable to examine the efficiency of financial operations in each city or provincial policy project.

2.5. Previous Research

As a nonparametric method, the MPI has been considered "an acceptable measure for firms that are exposed to exclusive or semi-exclusive conditions in give-and-take markets where the prices are not real" [30] (p. 3152). This method has been widely used around the world in hospitals, banks, insurance companies, industries, and other firms such as distribution companies and power and water generation.

For example, the MPI has been proven to be a practical method to measure productivity in industry fields such as the cement industry. Some studies (e.g., Long et al.) utilized the total productivity index in comparison with the environmentally friendly productivity index [31]. As the research findings suggested, the utilization of modern technology could help to correct the shortcomings of the previous research. The MPI was also employed by Zhang et al. to evaluate the performance of activities, including CO_2 emissions in the field of the transportation industry in China [27]. Their evaluation, which occurred in several time periods, revealed a decline of 32.8% in the performance of the Chinese transportation industry, and attributed this to a lower level of technology in the field. In the education sector, there are several examples, such as the productivity of library operation and the productivity of high schools and universities of education [32–34].

The research measuring efficiency and productivity in education has mostly dealt with elementary or middle schools as the subject of study. However, the current study attempts to analyze the efficiency of each metropolitan and provincial OE, and therefore considers various factors related to personnel and financial resources in order to support each school as influential input variables. Furthermore, in this study, cognitive and financial variables are considered as outputs of schools in each metropolitan and provincial OE. The input and

output variables in this study were selected based on the validity drawn from the analysis of previous studies.

Furthermore, this study considers the 17 metropolitan and provincial OEs in South Korea as analysis units, and analyzes the efficiency and productivity of these OEs from 2012 to 2016. Based on the previous studies, this study attempts to overcome the limitations of time-series analysis utilized for Malmquist analysis [6,35].

The input variables that have been used in the analysis of efficiency in education are various. For example, teachers and students were considered the personnel resources, while the administration, budget, facilities, and equipment were considered as the material resources [4,15,36]. Therefore, in addition to personnel resources, the current study also utilizes financial resources as a main independent variable, because the financial resources are considered an influential factor for the analysis of efficiency and productivity. The financial factors employed in previous research have included educational expenses per student [24,37–39] including welfare expenses per student [40], expenses for instruction [36], funds for supporting afterschool activities [38], scholarships [36], total annual expenditure per student, the ratio of expenses for instruction to total annual expenditures [39], and the average budget allocation for vocational schools [35]. Even though various financial variables can be used for MPI studies, we should be cautious that the ratio of specific expenses to the total annual expenditures is more suitable in order to avoid the biases of location and school size.

A variety of output variables have also been used in the analysis of efficiency in education in order to diagnose cognitive and affective efficiency. The variables used in previous studies for the diagnosis of cognitive efficiency have included a four-year college entrance rate [4,24,40,41] and national average student achievement scores [24,38]. In addition, variables for the estimation of affective efficiency have included emotionality and satisfaction but have not utilized financial efficiency as a dependent variable, as this study attempted.

Grifell-Tatjé and Lovell argued that the Malmquist index has several advantages [42]. First, only a limited number of inputs and outputs, as well as few modifications, are required for MPI calculations. Secondly, the evaluator is not required in order to try to maximize the outputs or minimize the inputs. A third advantage is that the MPI does not rely on fixed weights for the inputs and outputs.

Based on the review of previous studies, the influential input factors utilized in the current study include the number of students per teacher as the personnel factor; the ratio of expenses for early childhood, primary, and secondary schools to the total annual expenditures; and the ratio of expenses for general operation to the total annual expenditures as the material factor. As the output variables, cognitive and financial efficiency and productivity are examined.

3. Research Method

3.1. Subject of Analysis

This study analyzes the efficiency and productivity of 17 metropolitan and provincial OEs from 2012 to 2016. This particular five-year analysis period was used because it provided the most recent data released by the Student Info and Edu Info websites at the time this study was conducted.

These OEs are used as the subject of analysis, i.e., the analysis units responsible for producing various outputs by using various input factors. The analysis using the MPI model requires that the character of each unit should be similar, and thus a sufficient sample size is needed to obtain the stability of the data. Furthermore, Banker, Charnes, and Cooper argued that the number of units should be at least three times greater than the sum of the number of input and output variables [43]. Other studies also maintained that the number of units should be at least two times greater than the product of the number of inputs and the number of outputs [44,45]. However, the validity of the analysis should be considered based on the character of the data and the context of the research, because there is no absolute standard for the number of analysis units and the number of inputs

and outputs. As this study uses three input variables, four output variables, and 17 units for five years (total 85 analysis units), there is no problem with the stability of the model.

3.2. Input and Output Variables

This study establishes an MPI model, using three input and four output variables to measure the efficiency of the provision of financial support for schools in the metropolitan and provincial OEs. The number of students per teacher, as provided by the Korean Statistical Information Service (http://kosis.kr, accessed on 2 April 2022), was used as the personnel variable. As previous studies have shown the apparent positive impact of reducing the number of students per teacher on students' achievement, the student–teacher ratio was selected as an important input variable to be included in this study [46–48].

The ratio of kindergarten, primary, and secondary expenses, and the ratio of general operating expenses to the total annual expenditures were used as the material variables, as found on the Local Educational Financial Statistics Information System website (http://www.eduinfo.go.kr, accessed on 2 April 2022). A number of studies have shown that meaningful and effective educational reform requires a significant investment (e.g., [49–51]).

Cognitive and financial outputs have been considered as the main output variables in numerous studies (e.g., [52–56]). The cognitive output data in the current study consisted of the rate of the average scores for Korean, math, and English of each metropolitan and provincial OE, and their four-year college entrance rates. Additionally, the ratio of the budget to the settlement of accounts as a rationality criterion, and the ratio of the pure tax surplus to the total budget as an efficiency criterion were used for the financial outputs. Table 1 shows the summary of the input variables and output variables of the MPI model.

Table 1. The summary of the input variables and output variables of the DEA model.

	Variable Name Title 3	
Input Variables	(1) The number of students per teacher	
	(2) The ratio of kindergarten, primary, and secondary expenses to total annual expenditures	
	(3) The ratio of general operation expenses to total annual expenditures	
Output Variables	Cognitive output	(1) The rate of average scores of Korean, math, and English of each metropolitan and provincial Office of Education
		(2) Four-year college entrance rates
	Financial output	(3) The ratio of budget to settlement of accounts
		(4) The ratio of the pure tax surplus to total budget

3.3. Data Analysis

The MPI model is divided into the input-oriented model and the output-oriented model. The input-oriented model minimizes the inputs for a desired level of output to be achieved, while the output-oriented model maximizes the outputs whilst the inputs are kept at a constant level. This study utilizes the output-oriented model for the analysis of output maximization.

The data were extracted from the local education finance alert (https://eduinfo.go.kr, accessed on 2 April 2022); they are data refined through cross-validation in KERIS (Korea Education and Research Information Service). In the field of education finance, the information disclosure system for education finance and education statistics is implemented by law, such that the disclosed data are internally and externally confirmed several times.

EnPas v1.0 (Enpass Technologies Inc., Wilmington, NC, USA) and Excel 2014 (Microsoft, Redmond, WA, USA) were utilized in the Malmquist analysis of the relative efficiency and productivity, while SPSS 22.0 (IBM, New York, NY, USA) was used for the descriptive statistics. The changes in productivity over time were examined through the

analysis of the MPI. Whether the changes in productivity were influenced by internal factors or external factors was also investigated.

4. Results

4.1. Descriptive Statistics

Table 2 shows the descriptive statistical data for this study. As shown, there were wide variations in the financial data for the 17 metropolitan and provincial OEs. Thus, this study utilized the ratios reported in Table 2 as the input and output variables.

Table 2. The descriptive statistical data for this study.

Division			Minimum Value	Maximum Value	Average	Standard Deviation
Input variables	Number of students per teacher		12.78	18.74	15.8720	1.216
	Ratio of kindergarten, primary, and secondary expenses to total annual expenditures		86.61	98.09	95.27	2.04
	Ratio of general operation expenses to total annual expenditures		1.61	12.85	4.43	2.04
Output variables	Cognitive output	Rate of average scores of Korean, math, and English	79.00	92.75	85.49	3.20
		Four-year college entrance rates	54.80	82.80	73.69	5.93
	Financial output	Ratio of budget to settlement of accounts	59.38	118.65	94.33	7.25
		Ratio of the pure tax surplus to total budget	0.16	6.09	2.82	1.25

4.2. An Analysis of the Changes in the Malmquist Productivity Index

Table 3 shows the changes in the productivity index of 17 metropolitan and provincial OEs from 2012 to 2016 by using the MPI. If MPI > 1, this indicates that the productivity increased compared to that in the previous year. If MPI = 1, this shows that the productivity was the same as that in the previous year. If MPI < 1, the productivity decreased compared to that in the previous year. The results presented in Table 3 show the changes in productivity by year based on the personnel/material inputs and cognitive/financial outputs of the 17 metropolitan and provincial OEs. Through the analysis from 2012 to 2016, the results indicate that productivity decreased 0.23% from 2012 to 2013 and 8.02% from 2013 to 2014. There was a 17.17% increase in outputs from 2014 to 2015, but a 4.71% decrease from 2015 to 2016. The average of the MPI showed that there was a 1.05% increase in productivity from 2012 to 2016, while productivity fluctuated from 2012 to 2016 for each year period.

Table 3. Malmquist productivity index and component-by-time change rate.

Year	MPI	TECI	TCI	PECI	SECI
2012–2013	0.9977	0.9834	0.9966	0.9912	0.9919
2013–2014	0.9198	0.9215	0.9125	0.9231	0.9959
2014–2015	1.1717	1.1631	1.1309	1.1749	0.9877
2015–2016	0.9529	0.9763	0.9469	0.9271	1.0523
Average	1.0105	1.0111	0.9967	1.0041	1.0070

Table 4 shows the summary of the rate of changes in the MPI in each metropolitan and provincial OE. The results show that the average of the changes in the MPI of 14 OEs increased, while the average of the changes in the MPI of three OEs decreased. Among the 14 OEs, the productivity index of the Seoul OE was the highest. In particular, the results indicate that the percentage of the outcomes from 2014 to 2015 was 37.86%. However, from 2013 to 2014, the outcomes decreased by 19.42% in the Gyeonggi OE. Notably, the sharpest decline in outcomes (49.43%) was shown for the Gyeonggi OE in 2014 to 2015. The productivity of 16 OEs, with the exception of the Gyeonggi OE, was higher than 1, which

means that there is a positive relationship between the productivity index and the ratio of expenses of kindergarten, primary, and secondary schools.

Table 4. Analysis of the change rate of the Malmquist productivity index by year.

Region	T2 (2012–2013)	T3 (2013–2014)	T4 (2014–2015)	T5 (2015–2016)	Average
Seoul	0.9963	1.1168	1.3786	0.9827	1.1186
Busan	0.9826	0.7474	1.1939	1.0781	1.0005
Daegu	0.9694	0.8831	1.285	0.9866	1.0310
Incheon	1.1718	0.7216	1.1575	1.0215	1.0181
Gwangju	0.9778	0.8015	1.3517	0.9044	1.0089
Daejeon	0.9639	0.8674	1.4026	0.7577	0.9979
Ulsan	1.0387	0.8729	1.3427	0.9367	1.0478
Sejong	0.9441	1.0699	1.0699	1.1413	1.0563
Gyeonggi	1.0115	0.8058	0.5057	0.8323	0.7888
Gangwon	1.0016	0.9896	1.0519	1.0102	1.0133
Chungbuk	0.9685	0.9509	1.1307	1.0227	1.0182
Chungnam	0.9501	1.0034	1.083	1.0068	1.0108
Jeonbuk	0.9802	0.9737	1.0769	0.9907	1.0054
Jeonnam	0.9835	0.9814	1.0988	0.9950	1.0147
Gyeongbuk	1.0000	0.7954	1.1326	0.9622	0.9726
Gyeongnam	0.9996	0.9878	1.4852	0.7462	1.0547
Jeju	1.0218	1.0683	1.172	0.8240	1.0215
Average	0.9977	0.9198	1.1717	0.9529	1.0105

Table 5 shows the changes in the proportion of educational expenditure of kindergarten, primary, and secondary schools for each year. As shown in Tables 4 and 5, interestingly, there were positive relationships between the changes in the proportion of educational expenditure and the time-series productivity index. For example, the proportion of educational expenditure decreased by 3.04% from 2013 to 2014, and the times-series productivity index (0.9198) also decreased during the same period of time. In addition, the proportion of educational expenditure increased by 3.21% from 2014 to 2015, and the times-series productivity index (1.1717) also increased during the same period of time.

Thus, increasing the investment in kindergarten, primary, and secondary schools tends to improve productivity in OEs. In other words, this can be a significant way to improve the productivity of metropolitan and provincial OEs, e.g., by supporting the budget for the operation of teacher professional development, educational facility development, and support for education welfare such as meal plans, health services, and sports activities.

4.3. Impact Factors for the Improvement of Outputs

In order to find the most effective ways to improve efficiency and productivity, this study explored efficiency changes and technology changes, and examined whether such changes have influenced the MPI. The analysis of the Technical Efficiency Change Index (TECI) can reveal whether internal adjustment or innovative operations improve the effectiveness, while the analysis of the Technical Change Index (*TCI*) can show whether the changes in the external environment of metropolitan and provincial OEs influence the productivity.

Table 6 shows the average scores of the rate of change in the productivity index and the index of other components such as the TECI, the *TCI*, the Pure Efficiency Change Index (PECI), and the Scale Efficiency Change Index (SECI). Fourteen OEs, excluding Daejeon,

Gyeonggi, and Gyeongbuk, showed an MPI lower than 1. The low productivities of Daejeon and Gyeonggi were due to their technical inefficiency and retrogression; however, the low case of Gyeongbuk was caused by the technical retrogression only. Overall, the changes in the MPI tend not to be influenced by the TECI, while the changes in the MPI were likely to be influenced by the *TCI* in Korea. These findings indicate that the MPI varied depending on the *TCI* as the main factor. In these results, the TECI shows whether internal adjustment or innovative operations in OEs influence the improvement in efficiency, while the *TCI* shows the effect of the changes in the external environment on the productivity.

It seems that the changes in the external environment—such as governmental financial policies, the central government's financial transfers, and the local government's financial transfers—influence the outputs of each OE.

Table 5. The changes in the proportion of educational expenditure of kindergarten, primary, and secondary education.

Region	T2 (2012–2013)	T3 (2013–2014)	T4 (2014–2015)	T5 (2015–2016)	Average
Seoul	0.24	−2.13	2.79	−0.91	−0.002
Busan	0.10	−2.42	1.61	1.19	0.170
Daegu	−0.33	−3.85	5.04	−0.43	0.108
Incheon	0.39	−6.86	7.09	−0.27	0.163
Gwangju	0.54	−3.48	4.13	−0.82	−0.078
Daejeon	−1.34	−4.36	3.81	−0.28	−0.073
Ulsan	0.02	−2.9	3.81	−1.99	−0.265
Sejong	6.26	0.56	−1.70	−5.32	0.450
Gyeonggi	−5.56	−3.29	3.95	−0.63	0.058
Gangwon	0.23	−0.45	−0.85	−1.70	−0.580
Chungbuk	0.47	−3.44	3.84	−0.75	0.030
Chungnam	1.14	−3.86	4.11	−0.45	0.585
Jeonbuk	−0.78	−4.52	4.83	−1.32	−0.398
Jeonnam	0.22	−3.37	4.43	−0.80	0.035
Gyeongbuk	−3.36	−4.05	2.74	−0.41	−0.375
Gyeongnam	0.42	−3.86	4.41	−1.87	−0.225
Jeju	0.24	0.67	0.49	−0.63	0.393
Average	−0.06	−3.04	3.21	−1.02	−0.0003

Table 6. Malmquist productivity index and component change rate.

Region	MPI	TECI	TCI	PECI	SECI
Seoul	1.1186	1.0290	1.1080	1.0195	1.0093
Busan	1.0005	1.0142	0.9850	1.0000	1.0142
Daegu	1.0310	1.0166	1.0187	1.0099	1.0067
Incheon	1.0181	1.0278	0.9879	1.0186	1.0091
Gwangju	1.0089	1.0208	0.9863	1.0131	1.0076
Daejeon	0.9979	0.9784	0.9709	0.9601	1.0191
Ulsan	1.0478	1.0297	1.0214	1.0200	1.0095
Sejong	1.0563	1.0000	1.0518	1.0000	1.0000
Gyeonggi	0.7888	0.9872	0.7653	0.9871	1.0001

Table 6. *Cont.*

Region	MPI	TECI	TCI	PECI	SECI
Gangwon	1.0133	1.0049	1.0131	1.0008	1.0041
Chungbuk	1.0182	1.0083	1.0144	1.0035	1.0049
Chungnam	1.0108	1.0058	1.0088	1.0000	1.0058
Jeonbuk	1.0054	1.0041	1.0046	1.0000	1.0041
Jeonnam	1.0147	1.0073	1.0115	1.0027	1.0046
Gyeongbuk	0.9726	1.0056	0.9629	1.0101	0.9955
Gyeongnam	1.0547	1.0348	1.0228	1.0240	1.0106
Jeju	1.0215	1.0136	1.0113	1.0000	1.0136
Average	1.0105	1.0111	0.9967	1.0041	1.0070

5. Discussion and Conclusions

This study analyzed the efficiency and productivity of 17 metropolitan and provincial OEs. In order to measure the efficiency and productivity of metropolitan and provincial OEs from 2012 to 2016, this study examined the change in productivity by utilizing the MPI and the index of other components such as TECI, TCI, PECI, and SECI. These analyses revealed several significant findings.

First, the analysis of the measurement of the MPI based on the average of the MPI showed an increase of 1.05% in the change in outputs from 2012 to 2016. Specifically, the outputs were likely to decrease in 2012 to 2014, while the outputs tended to increase from 2014 to 2015. The outputs again tended to decrease from 2015 to 2016.

Secondly, the analysis of the chronological change rate of the MPI for each of the metropolitan and provincial OEs indicated that the average change in the MPI by year of 14 OEs decreased, while three OEs showed a decrease in the MPI by year. In particular, the MPI of 13 OEs was lower than one from 2013 to 2014, while the MPI of 16 OEs was higher than one from 2014 to 2015. In addition, this study revealed a positive relationship between the change in educational expenditure of kindergarten, primary, and secondary schools and the change in the MPI. Thus, the results showed that the efficiency and productivity of metropolitan and provincial OEs can be improved by providing a sufficient budget for the operation of human resources, school finance management, and any other supports such as education welfare, meal plans, health, and sports activities.

Thirdly, through the analysis of the MPI, TECI, TCI, PECI, and SECI, a positive relationship was found between the change in the MPI and the change in the TCI. Furthermore, the change in the MPI influenced by the TCI was the main factor of the change in outputs. Thus, the empirical analysis revealed that changes in the external environment, such as governmental financial policies, the central government's financial transfers, the local government's financial transfers, may have an effect on the outputs of each metropolitan and provincial OE.

These findings have significant policy implications. First, even though the productivity of most OEs was over one, some OEs were shown to have low scale efficiency. Thus, the offices showing an increasing return scale are required to improve the efficiency of their output through increasing returns to scale. For example, the improvement of organizational operations through the reorganization of the systems is needed in order to respond actively to the various educational demands. On the other hand, the OEs showing a decreasing return scale need to examine their bloated organizations and the causes of the inefficiency of management in order to establish the ways to improve operational efficiency.

Secondly, the reconsideration of increasing investment for kindergarten, primary, and secondary education is needed. This study divided the items related to the settlement accounts of annual expenditure into two categories as input factors, and found that the changes in budget for kindergarten, primary, and secondary schools are related to the

changes in productivity. Thus, in order to improve the productivity and to achieve the goals of education, the OEs need to increase the budget for the kindergarten, primary, and secondary education.

Thirdly, the financial support for each OE should be consistent, in that the MPI was likely to be influenced by the TCI, but not the TECI. The improvement in efficiency is possible when a reasonable amount of budget is increased at the proper time, as more than 95% of the main budget of metropolitan and provincial OEs is from external financial transfers. Furthermore, in addition to the external financial support, the OEs must reduce their inefficiency through the reorganization of systems or management innovations in order to improve efficiency and outputs. Thus, each OE should seek consultation from management experts in order to secure the maximum external resources for the efficiency and productivity of education.

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