Methods for Comprehensive Analysis of the Economic Effectiveness of Business Activities: Special Reference to R & D Expenditure

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DOI:https://doi.org/10.38157/business-perspective-review.v3i1.224

Citation: Kim, G.S., Kim, G.I., Rim, G.N., & Jang, S.N. (2021). Methods for Comprehensive Analysis of the Economic Effectiveness of Business Activities: Special Reference to R & D Expenditure. *Business Perspective Review 3(1),* 1-14. DOI: https://doi.org/10.38157/business-perspective-review.v3i1.224

Research Article

Abstract

Purpose: *This paper suggests the methodology for comprehensively and dynamically evaluating the economic effectiveness of business activities in a view of scientific and technological development.*

Methods: *Authors analyze the previous studies related to evaluating the economic effectiveness of business activities and suggest the methodology using the weight coefficients and pair-evaluation standards.*

Results: *The findings reveal that comprehensive economic effectiveness of business activities reflects the effective use of various resources including labor, material, fixed asset, liquid materials, and R&D expenditure into the business activities in a certain period of time and it must be assessed by using the integrated indicator.*

Implications: *The findings may contribute to the theories related to the economic effectiveness of business activities. It is also likely to improve organizational decision-making.*

Keywords: Science and Technology; R&D expenditure; Economic Effectiveness; Efficiency of Resources; Business Activities.

1. Introduction

It is important in business management to analyze and evaluate Economic Effectiveness (EE) of Business Activities (BA), and to make realistic business decisions. To this end, it is necessary to set the indicators reflecting EE of BA and to analyze and evaluate the reality of BA by applying

different methodologies. Until now, there have been many discussions on EE and its analysis and evaluation.

Some authors discussed efficiency, EE, and the significance of EE analysis. Other authors set different indicators reflecting EE and based on them, suggested different methodologies for evaluating EE of BA. These studies made a great advancement in scientifically analyzing and evaluating the reality of BA and served as preconditions for further developing the methodology of analyzing and evaluating EE of BA. However, we think that there is less study of whether BA was conducted effectively in a certain period of time and on how the level of its EE should be evaluated in a comprehensive way. Also, previous studies include the methodology of evaluating EE of BA at a certain point of time, and they analyzed and evaluated EE in individual aspects by using different indicators reflecting different aspects of BA. As mentioned, earlier studies fail to explain a list of economic indicators necessary to analyze and evaluate EE comprehensively, the method of scientifically setting weight coefficients reflecting the importance of indicators used for a comprehensive evaluation, and the methodology of applying it to analyze EE of BA comprehensively from the dynamic point of view.

This paper deals with an important matter arising in analyzing EE of BA comprehensively in a view of various indicators of production resources including the indicator reflecting the development of science and technology. In other words, the paper aims at setting a list of the right economic indicators necessary to analyze and evaluate EE of BA comprehensively and presenting a dynamic methodology of calculating and applying authentic weight coefficients that show the importance of EE indicators. For this, the first section of the paper is devoted to the theoretical research for comprehensively analyzing and evaluating EE of BA. In this part, we analyze previous studies of efficiency and EE and on this basis, define the comprehensive EE of BA from the dynamic point of view. In the second section, we suggest the methodology of comprehensively analyzing and evaluating EE of BA in a view of the development of science and technology. In this part, we suggest the method of setting indicators and calculating weight coefficients needed in comprehensively analyzing and evaluating EE of BA.

2. Theoretical background for comprehensively analyzing and evaluating EE of BA

2.1. Previous studies of EE and its classification

Many authors studied EE in the past. Typical among them are those related to the essence of efficiency and EE, their classification, the significance of EE analysis, and so on.

First of all, there were many studies on the concept of efficiency and EE. Some authors defined efficiency as follows: In general, the representation of efficiency characterizes the development of systems, processes, and events. Efficiency broadly describes the qualitative aspect of the development of enterprise by showing what combination of public resources helped to receive the final result. Quantitatively, the efficiency is expressed by the ratio between the results obtained in the production process, and the costs of social labor, associated with the achievement of these results. Therefore, the meaning of increasing efficiency of production is a more rapid growth of the result (effect) as compared to the cost (Petrosyan et al. 2016a).

Studying the production process efficiency, some authors discussed the concept of efficiency and EE in more detail. Generally, efficiency can be defined as a measurement (usually expressed as a percentage) of the actual output to the standard output expected. Efficiency measures how well something is performing relative to existing standards (Koliński and Śliwczyński, 2016a).

In the economic aspect, efficiency is the result of the company's activity, which is a proportion of the achieved effect on borne spending (Koliński and Śliwczyński, 2016b). Koliński et al. (2014) classified production efficiency into economic and operating efficiency. According to his discussion, while an example of economic efficiency is the efficiency of the organization, that of operating efficiency is the efficiency of the workstation. And the efficiency of the process goes into both economic efficiency and operating efficiency.

Koliński et al. (2016c) also defined different efficiencies in the aspect of managing production after analyzing the data of APICS. According to his definition, efficiencies can be classified into allocative efficiency, efficiency variance, line efficiency, manufacturing cycle efficiency, materials efficiency, operating efficiency, performance efficiency, productivity, worker efficiency, labor efficiency, and labor efficiency variance. Petrosyan et al. (2016b) classified efficiency into cost-based efficiency for economists and objective efficiency for management and explained their contents. Cost-based efficiency for economists is defined in terms of performance and the model is costs to results. Objective efficiency estimates the degree of achievement of goals or deviation from them.

Some authors classified economic efficiency into technical and allocative efficiency and said that economic efficiency was determined by these two efficiencies. According to Farrell (1957), the author who first introduced these concepts, the technical efficiency is measured by the way that a firm chooses the quantity of inputs that is used in the production process when the factors' use propositions are given. Economic efficiency is determined by the combination of technical efficiency with allocative efficiency. Other authors also studied technical and allocative efficiency. Following N'Gbo's (1991) and Atkinson et Cornwell's (1994) studies, a production unit is effective technically if from the inputs it possesses, it produces the maximum of possible outputs or if, to produce outputs given quantity, it uses the smallest possible quantities of outputs. Briec et al. (2006) explain that the technical efficiency degree measure of a production unit permits to surround if this last one can increase its production without consuming, at the same time, more resources, or reduce the use of at least one input by conserving at the same time, the same level of production. Rodriguez-Alves, Tovar, and Trujillo (2007) considered that allocative efficiency was necessary if the firm maximized its profits or minimizes its costs at a given level of production. Coelli et al. (1998), Amara and Robert (2000) agreed with the view that economic efficiency could be separated into two distinct criteria and was therefore only the resultant of those two measures.

On the other hand, treating productivity and efficiency without discrimination, Daraip and Simar (2007) distinguished between partial productivity, when it concerned a sole production factor, and a total factor (or global) productivity when referred to all (every) factors, and made mention of scale, allocative and structural efficiency.

Some books defined efficiency, technical efficiency, allocative efficiency, and economic efficiency in detail. For example, APICS discussed efficiency as follows; 1) actual units produced to the standard rate of production expected in a period of time, 2) standard hours produced to actual hours worked (taking longer means less efficiency), and 3) actual volume of output in value to a standard volume in a period time in value (APICS Dictionary, 2004). Efficiency is producing the desired results with a minimum of effort, expense, or waste. Efficiency is getting any given results with the smallest possible inputs or getting the maximum possible output from given resources (Black, 2002).

Technical efficiency is a measure of the ability of a manufacturer to produce the maximum output of acceptable quality with the minimum of inputs. Economic efficiency is a measure of the ability of an organization to produce and distribute its product at the lowest possible cost. Productivity is a measure of the output of an organization or economy per unit of input (labor, raw materials, capital, etc.) (Black et al, 2009).

David (2007) classified different efficiency ratios into five groups; liquidity, leverage, activity, profit, and growth. Various international organizations defined the efficiency of resources and established indicators of characterizing it. Its purpose is in achieving sustainable development. For example, According to the United Nations Environment Programme (UNEP), resource efficiency is about ensuring that natural resources are produced, processed, and consumed more sustainably, reducing the environmental impact from the consumption and production of products over their full life cycles. By producing more wellbeing with less material consumption, resource efficiency enhances the means to meet human needs while respecting the ecological carrying capacity of the Earth (UNEP, 2012).

In industry, resource efficiency is often defined in supply chain terms, highlighting a firm's material, natural resource and energy efficiencies, and the generation and impact of waste. In some cases, only the resource efficiency of non-energy carrying materials is considered. In this case, the term 'material productivity' is used. Indeed, the majority of firms are currently measuring the number of resources they consume, but not their level of efficiency (ECORYS, 2011). The European Commission is using resource productivity as its lead indicator. This is calculated by dividing gross domestic product (GDP) by domestic material consumption (DMC), which provides a figure in euros/tonne (European Commission, 2011). This indicates when less material is being used to provide the same economic output.

Next, researchers discussed methods of improving efficiency in various aspects. Introducing different concepts of production, Koliński (2013a) described the efficiency-improving methods according to them. According to his description, production can be classified into lean and agile production and according to them, methods of improving the efficiency of actions can include those such as; 1) lowering spendings and keeping the level of effects at the same time, 2) lowering spendings and raising the level of effects at the same time, 3) keeping the level of spendings and raising the level of effects at the same time, and 4) raising the level of spendings and raising drastically the level of effects at the same time.

Also, defining the production diversification, Kenny (2009) said that raising effects were possible thanks to increasing spending. On the other hand, discussing efficiency like productivity, some

authors described methods of increasing productivity (For example, Waters, 2012). Those are as follows: 1) improve effectiveness with better decisions, 2) improve efficiency using fewer inputs to achieve the same outputs, 3) improve performance in some other way such as higher quality, fewer accidents, less disruption, and 4) improve morale to give more co-operation and incentives. Next, there were discussions on the significances of efficiency and EE analysis in previous studies. For example, Petrosyan et al. (2016c) say as follows: "An analysis of the overall effectiveness of economic activity is the prerogative of the senior management and linked to the definition of the product price, lot size of purchases of raw materials and supplies products, equipment replacement or technologies." They described the main objectives of efficiency analysis as follows: assessment of the economic situation; detection factors and causes of the state of progress; preparation and justification for management decisions; identification and mobilization of reserves.

As is shown in prestudies, many authors made great advances in studies on efficiency, its classification, and its definitions. However, we conclude that a unified view is not yet found in studies on comprehensive EE of BA. Regarding the analytic method of EE, too, there are no discussions except for simply setting the ratio of input and output as the indicator to evaluate the economic efficiency at the corporate level and for its analytic method in static aspect. Therefore, we define the comprehensive EE of BA and set indicators reflecting efficiency in various aspects of BA. Then we suggest the methodology of analyzing and evaluating EE of BA comprehensively and dynamically in a view of scientific and technological R&D expenditure (hereafter, R&D expenditure).

2.2. Comprehensive EE of BA

To analyze and evaluate the comprehensive EE of BA, it is necessary to define its concept.

First of all, the meaning of BA can include an organizational, regional, macroeconomic level, and so on according to its coverage. The only difference is found in indicators reflecting the coverage of BA of the level involved. When it comes to the comprehensive EE of BA, effectiveness is expressed as the correlation between input and output in general meaning. Such efficiency can be expressed as output/input or its reciprocal that is, input/output.

Second, the meaning of EE can include efficiency in an economic aspect, that is, the above-mentioned technical and allocative efficiency. And effectiveness can be classified into social effectiveness and EE in another aspect.

Third, the meaning of the term "comprehensive" includes not any one aspect of BA but various space-time aspects. This means, in other words, that EE of BA is analyzed and evaluated in a view of the efficiency of resources spent in BA and its changes in time elapse. In this case, the resources spent in BA mainly refers to production resources.

In this sense, we say that the comprehensive EE of BA is the concept of comprehensively reflecting the effective use of various resources input into the BA process in a certain period of time. Analyzing the comprehensive EE of BA makes it possible to analyze all the above-mentioned efficiencies and help to make decisions necessary for BA. However, such a comprehensive

analysis needs a methodology. In other words, individual and comprehensive indicators reflecting EE of BA must be set and its analytic method should be produced.

3. Methodology of Comprehensively Analyzing and Evaluating EE of BA

3.1. Previous Studies on Method of Analyzing EE

Regarding EE analysis, there have been a few studies of setting efficiency indicators, effectiveness analysis methods, and so on. First of all, various effectiveness indicators were set with the definition and classification of efficiency. A typical one is an indicator expressed as the correlation between input and output. This indicator can be expressed in physical or monetary aspects on the one hand, and in positive or reciprocal number on the other. For example, Nábrádi et al. (2007) systemized efficiency indicators. They divided the most basic indicators into physical and economic efficiency indicators and defined them. According to their definitions, physical efficiency means that in input-output relations, both input and output are measures expressed in the physical dimension and if any of the elements (input-output) is expressed in money value, economic or business efficiency is mentioned. And they discussed the general formula of efficiency as follows:

Efficiency = Output/Input or Efficiency = Input/Output, or Efficiency = Output/Output, or Efficiency = Input/Input.

Discussing various methods of improving efficiency, Koliński (2013a) also suggested the indicator of efficiency as output/input relation. Such an indicator is the most basic one reflecting EE. However, to reflect the comprehensive EE of BA, we think that the indicators reflecting EE must be systemized. These indicators should reflect general output/input and various production resources on the one hand and a certain point of time and dynamics on the other.

Second, there have been certain studies of the efficiency analysis method. Typically, Ouattara (2012) suggested the frontier estimation methods as efficiency analysis method and said that they could be classified according to the frontier form, according to the estimation technique used to get it, and according to nature and the supposed properties of the gap between the observed production and the optimal production. The classification according to the frontier form permits to distinguish between the parametric approaches and the nonparametric approaches. Nuama (2006) indicated that the parametric approach is the one that presents a function including explicit parameters and Murillo-Zamorano (2004) said that the nonparametric approach is then used when the production process cannot be identified by a functional form.

On the one hand, Petrosyan et al. (2016d) introduced various efficiency analysis methods such as DEA (Data Envelopment Analysis) and TOPSIS (Technique for Order Preference by Similarity to Ideal Solution). DEA is a method based on linear programming, needed to determine the relative effectiveness of different means implemented enterprise products and TOPSIS is based on the principle, that the object, which showed the best results, is being as close as possible to the best object and as far from the worst of the objects. As shown above, we think that a methodology has not yet been raised for comprehensively analyzing and evaluating EE of BA in a view of the weight of various efficiency indicators. We are going to tabulate various efficiency and result indicators and comprehensively analyze EE by using weight coefficients.

3.2. System of Indicators Reflecting EE of BA

Because BA is affected by various interrelated factors, the use of any indicator does not lead to the right analysis and evaluation of EE of BA. It should be analyzed and evaluated comprehensively, taking account of political and economic benefits and the long- and short-term benefits of economic development and closely associating various economic indicators with each other. EE indicators of the development of science and technology and the use of resources that affect the results of BA and the indicators of results from enhancing EE can be set as follows. (See Table 1).

Table 1. EE indicators of the use of resources result from the enhancement of EE and their interrelations

EE Indicators of the use of resources		
Product per unit of resources input	Labor productivity (N/R) and the amount of labor employed for the unit product (R/N)	Resources consumed for the unit product
	Efficiency of materials consumed (N/M) and the quantity of materials consumed for the unit product (M/N)	
	Depreciation efficiency (N/A) and the amount of depreciation for the unit product (A/N)	
	The efficiency of liquid materials (N/E) and the amount of liquid materials for the unit product (E/N)	
	The efficiency of R&D expenditure (N/H) and the amount of R&D expenditure	

↓

Final results of BA
The volume of BA (N=R×N/R=M×N/M=H×N/H)
Effectiveness of BA: profitability (P/K)

Source: Own study

In table 1, N refers to the magnitude of production in a given period, R - the number of employers in a given period, M - the magnitude of materials spent in a given period, A – the magnitude of depreciation in a given period, E - the magnitude of liquid assets spent in a given period, H - the magnitude of R&D expenditure in a given period, P - the magnitude of net income in a given period and K - the magnitude of productive assets in a given period.

The direct and reciprocal EE indicators showing the degree of the intensive use of main resources are grouped in the first rectangle, and the indicators showing the results from enhancing EE of BA and their correlations in the second one. The improvement of economic management is related

to all the intensive factors of BA. On condition that there exist commodity-money relations, the turnover of productive resources finds its expression in the turnover rate of financial resources and this makes it possible to characterize the consumption of production means and labor force, as well as the use of productive fixed and liquid assets.

The use of productive resources may assume an extensive and intensive character. The enhancement of the EE of production is mainly linked with the intensive use of resources, that is, the development of science and technology. The correlation between intensiveness and extensiveness of production can be analyzed by the correlation between qualitative and quantitative indicators of the use of resources. The final results of BA are obtained by the action of extensive factors as well as intensive ones and also, qualitative and quantitative indicators for the use of resources. The character of intensive and extensive use of resources is shown in the mutual substitution of resources. This can be explained by the fact that the lack of labor can be offset by the enhancement of productivity. Extensive factors of the use of resources, as well as intensive ones, act on the indicator of the magnitude of BA.

Here, the portion of the influence given to the increase in production by the development of science and technology which is an intensive factor can be said to be the portion concerned with EE. For example, the net income indicator is affected by intensive factors as well as extensive ones. Accordingly, the EE should not be evaluated not by absolute indicators of net income but by the part of net income determined by indicators reflecting the development of science and technology.

Net income reflects initial cost, magnitude, quality, kind, etc. of products but fails to reflect the result from the use of resources. This is shown by the profitability indicator. It is theoretically clear that the organizational and technical level of production and the dynamic states of other conditions are shown through the indicators of the intensive use of productive and financial resources. Therefore, the improvement of economic management by all the intensive factors should be reflected in the dynamic states of the indicators such as labor productivity, the efficiency of materials, depreciation efficiency of productive fixed assets, the efficiency of R&D expenditure, and the efficiency of liquid assets. As seen, the indicators of the efficiency in the use of resources can characterize EE of BA, as well as the effectiveness in the improvement of economic management.

3.3. Setting the Integrated Indicator

One of the important problems arising in analyzing and evaluating EE of BA comprehensively in close connection with various indicators of EE is to set an integrated indicator scientifically. The integrated indicator used to analyze and evaluate EE of BA in a comprehensive way can be set based on the weight coefficient which shows how important various indicators of EE are.

Generally, it is never easy in economic practice to calculate the correct weight coefficient that reflects the importance of various economic purposes. Given in this paper is the method of calculating weight coefficients reflecting the degree of importance of EE indicators by using a one-to-one comparative standard which helps to express those coefficients relatively clearly and quantitatively (Rim et al. 2019).

The first thing to do this is to make out a following pair-evaluation standard to compare the degree of importance of EE indicators on a one-to-one basis.

Table 2. Pair-evaluation standard

Evaluation standard	Meaning
1	The importance of the two EE indicators is equal.
3	The first indicator of the two is slightly more important than the second.
5	The first indicator of the two is a little more important than the second.
7	The first indicator of the two is quite a bit more important than the second.
9	The first indicator of the two is much more important than the second.
2, 4, 6, 8	Mean value of two evaluations

Source: From Rim et al. (2019)

The next thing is to make out D, the one-to-one comparative standard matrix for the indicators of EE of n pieces, using the given pair-evaluation standard.

$$D = (d_{ij})_{n\times n} \qquad i,j = 1,2,\cdots,n$$

$$d_{ij} = \frac{1}{d_{ji}}, \qquad i > j \qquad i,j = 1,2,\cdots,n$$

$$d_{ii} = 1, \qquad i = 1,2,\cdots,n$$

Where,

d_{ij} $(i,j = 1,2,\cdots,n)$ refers to the evaluation value expressing the degree of importance of the i*th* indicator compared with j*th* indicator.

With D, the one-to-one comparative standard matrix, weight coefficient (G_k) expressing the degree of importance of various indicators of EE is calculated in the following way.

$$G_k = \frac{\left(\sum_{j=1}^{n} \frac{d_{kj}}{C_j}\right)}{n}, \qquad k = 1,2,\cdots,n$$

where

$$C_j = \sum_{i=1}^{n} d_{ij} \qquad (j = 1,2,\cdots,n)$$

The method of analyzing EE of BA comprehensively and dynamically in a view of R&D expenditure should, in general, include the system of the analytic indicators related to EE of the use of resources.

The system of the indicators for analyzing EE of the use of resources comprehensively and dynamically in a view of R&D expenditure should include the indicators of EE of the use of resources and their dynamic states. And the increased rate of resources corresponding to the 1% increase in the magnitude of production, the degree of the influence by the extensive and intensive factors to the increase in production magnitude, the indicators of relative saving of resources, and so on can be included.

3.4. Method of Comprehensive Analysis and Evaluation

An example is given for the method of analyzing and evaluating EE of BA comprehensively and dynamically in a view of R&D expenditure. Let us say that the conditional data are given as seen in table 3.

Table 3. Analytic data of the indicators of EE

Form of resources	The dynamic state of indicators of the effectiveness in the use of resources	
	1st year	2nd year
1.staff 2.labor object 3.depreciation expense 4. liquid fund 5. R&D expenditure	1.052 1.032 0.987 1.046 1.041	1.095 1.076 0.960 1.018 1.085
Comprehensive evaluation of EE	1.039 6	1.064 0

The following is the analysis of the dynamic state of the indicators of EE of the use of individual resources, based on the given data. Compared with the base year, labor productivity is 105.2% in the first year and 109.5% in the second year. The materials efficiency witnesses 103.2% and 107.6% in the first and second year respectively. As for depreciation efficiency, 97.7% and 96% are recorded in the first and second years respectively. The efficiency of the liquid fund is seen as 104.6% and 101.8% in the first and second years respectively. The efficiency of R&D expenditure is 104.1% in the first year and 108.5% in the second year. This shows that in the given period, EE of the use of labor force, labor object, and R&D expenditure has been enhanced, and the reverse case is true to the use of depreciation expenses and liquid fund. In other words, labor force, labor object, and R&D expenditure have been used effectively in the second year as compared with the first year, but depreciation expenses and liquid fund ineffectively. Therefore, only with the dynamic indicators of EE of the use of individual resources shown in Table 3, can it be impossible to analyze the comprehensive EE of the use of resources correctly in a quantitative way.

To evaluate the comprehensive EE of the use of resources correctly in a view of R&D expenditure, it is necessary to calculate the weight coefficient reflecting the importance of individual indicators of EE. Suppose that the indicator of labor productivity is 2 times as important as the indicator of the efficiency in the use of materials, 5 times as important as the indicator of depreciation efficiency, 2 times as important as the indicator of liquid fund efficiency, and 5 times as important as the indicator of the efficiency of R&D expenditure; the indicator of the efficiency in the use of materials is 3 times as important as the indicator of depreciation efficiency, equivalent to the indicator of liquid fund efficiency, and 2 times as important as the indicator of the efficiency of R&D expenditure. And the indicator of depreciation efficiency is half less important than the indicators of liquid fund efficiency and R&D expenditure, and the indicator of liquid fund efficiency is 2 times as important as the indicator of the efficiency of R&D expenditure.

The following is the one-to-one comparative standard matrix D worked out in a view of the importance of the indicators of the EE of the use of individual resources.

$$D = \begin{pmatrix} 1 & 2 & 5 & 2 & 5 \\ \frac{1}{2} & 1 & 3 & 1 & 2 \\ \frac{1}{5} & \frac{1}{3} & 1 & \frac{1}{2} & \frac{1}{2} \\ \frac{1}{2} & 1 & 2 & 1 & 2 \\ \frac{1}{5} & \frac{1}{2} & 2 & \frac{1}{2} & 1 \end{pmatrix}$$

The following is obtained when weight coefficient G_1 which reflects the degree of the importance of individual indicators of EE is calculated, using the comparative standard matrix D.

$$G_1 = \left(\frac{1}{1+\frac{1}{2}+\frac{1}{5}+\frac{1}{2}+\frac{1}{5}} + \frac{2}{2+1+\frac{1}{3}+1+\frac{1}{2}} + \frac{5}{5+3+1+2+2} + \right.$$
$$\left. + \frac{2}{2+1+\frac{1}{2}+1+\frac{1}{2}} + \frac{5}{5+2+\frac{1}{2}+2+1} \right) \div 5 = 0.418$$

If the remaining weight coefficients - G_2, G_3, G_4, G_5 are calculated in the above method, $G_2 \approx 0.207$, $G_3 \approx 0.075$, $G_4 \approx 0.192$ and $G_5 \approx 0.107$.

If these weight coefficients are used to calculate the 1st year's comprehensive EE of the use of resources, 0.418×1.052 + 0.207×1.032 + 0.075×0.987 + 0.192×1.046 +0.107×1.041 = 1.039 604.

If the 2nd year's comprehensive EE of the use of resources is calculated, 0.418×1.095 + 0.207×1.076 + 0.075×0.960 + 0.192×1.018 +0.107×1.085 = 1.064 043.

The calculated results are recorded in the 2nd and 3rd boxes of the last row in Table 3.

The result shows that EE of the use of depreciation expenses and the liquid fund is lower in the 2nd year than in the 1st year, but the comprehensive EE of the use of resources is increased to 102.35% in the 2nd year than that of the 1st year.

The comprehensive analytic method of EE of BA in a view of R&D expenditure is important for the analysis of the real state of BA. The application of this method makes it possible to evaluate BA of past days scientifically as required by the era of the knowledge economy, look for ways to raise the effectiveness of BA, and provide grounds for the improvement of BA.

4. Conclusion

Until now, many studies have been devoted to the study of efficiency. Typical success includes classifying efficiency into various types, defining them, and setting indicators characterizing them. Also, different methods of analyzing efficiency have been raised. However, we think that the methodology of analyzing and evaluating the EE of BA comprehensively and dynamically in a view of the degree of scientific and technological development has not yet been suggested.

At present, when science and technology is an important resource, we think that the comprehensive EE of BA in a view of R&D expenditure is the concept of comprehensively

reflecting the effective use of various resources affecting the results of BA. The analysis of the comprehensive EE of BA in a view of R&D expenditure makes it possible to analyze all the above-mentioned efficiencies and help with decision-making necessary for BA.
However, such a comprehensive analysis method needs a certain methodology. In other words, it is necessary to set detailed indicators of scientific and technological development reflecting EE of BA and prepare a method of measuring them. In this paper, we set R&D expenditure as the indicator of expressing the degree of scientific and technological development. But we don't consider the delay, presupposing that the investment in science and technology will necessarily yield products soon. This paper has given the methodology of analyzing the comprehensive EE of BA in a view of scientific and technological development and set the corresponding indicators as relative values. In this case, we referred to the previous study (Rim et al. 2019) for the use of concrete scale methods and their conversion method.
We have tabulated the system of indicators reflecting the comprehensive EE of BA with several indicators reflecting economic efficiency and result indicators in a view of R&D expenditure.
Then, to consider the degree of importance of the indicators reflecting EE of the use of resources, we have set weight coefficients using pair-evaluation standards. And we have analyzed and evaluated the comprehensive EE of BA by applying weight coefficients to own-elaborated data.

5. Limitation and Further Research.
We have suggested a methodology of analyzing and evaluating EE of BA comprehensively and dynamically in a view of the development of science and technology. For this, we have analyzed previous studies, set the indicators for analyzing and evaluating comprehensive EE of BA which includes R&D expenditure, and suggested a method of setting weight coefficients based on the pair-evaluation standards. Finally, we have applied weight coefficients to own-elaborated data, to analyze EE comprehensively and dynamically. We think that our methodology has not yet been perfect and there are some problems to be solved.
First of all, the coverage of effectiveness should be studied further. In other words, social effectiveness ought to be considered, because various social factors affect BA and the results of BA also affect society.
Second, evaluating the efficiency of science and technology needs further research. Today is the era of the knowledge economy and knowledge resource has emerged as the chief resource for production. The scientific and technological capacity of a product is increasingly enhanced. This requires the analysis and evaluation of the comprehensive EE in a view of scientific and technological efficiency in production.
The EE-evaluating methodologies suggested so far have dealt with traditional resources and production factors. To escape these shortcomings, we have set the indicator of R&D expenditure and used its EE without consideration of delay. Therefore, we think that when deeply analyzing and evaluating EE in future economic research, the features of scientific and technological development must be characterized in a more detailed way as required by the era of the knowledge economy.

Third, the magnitude of weight coefficients of indicators should be determined, considering socioeconomic factors altogether. In this paper, we have dealt with the methodology of comprehensively analyzing and evaluating EE of BA in a certain economic unit based on the weight coefficients considering individual EE indicators and economic factors. However, analysis and evaluation of the comprehensive EE require that the weight coefficients reflecting the degree of the importance of indicators should be calculated in a view of socioeconomic factors. Thus, we think that the solution to the above-mentioned problems is the main direction of future research concerned with analyzing and evaluating the comprehensive EE in a view of the development of science and technology.

Authors' Contributions: Gang-Sok Kim conceived the idea and collected data; Gwang-Ik Kim wrote the paper; Gwang-Nam Rim analyzed the data; Sun-Nam Jang edited and reviewed the paper.

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

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