

Article

Efficient Expenditure Allocation for Sustainable Public Services?—Comparative Cases of Korea and OECD Countries

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Abstract: There have been contrasting trends in government expenditures spending among OECD countries. This study analyzed and compared the efficiency of government expenditures of OECD countries and Korea, focused on the health and welfare and social overhead capital (SOC) sectors, using data envelop analysis (DEA) and Tobit methods. Based on the indicator values of national ranking, Korea ranked 19th in the health and welfare sector and 10th in the SOC sector. However, compared to other countries in the OECD, Korea's government expenditure has shown the highest efficiency in health and welfare (rank 1 with efficiency score of 2.401), while transportation SOC was at a level below the average (rank 13 with efficiency score of 0.813). In order to maintain a high level of efficiency in health and welfare expenditures, it is important for the Korean government to understand and improve conditions of the rates of poverty, unemployment, life expectancy, and low fertility. Moreover, in order to overcome the low level of efficiency in the SOC sector, the government needs to improve the quality of transport infrastructures along with implementation of an effective infrastructure-linking system between various modes of transportation, thereby enhancing its transport network density.

Keywords: expenditure efficiency; social overhead capital; public health and welfare; data envelop analysis; tobit model; OECD

1. Introduction

With the progress of economic advancement and social demand for better public services, there has been consequential changes in Organization for Economic Co-operation and Development (OECD) countries concerning government expenditure and its allocation. Based on 20 years of their expenditure trends, most of the spending in public services has declined except for public health, social welfare, and education (see Figure 1). The share of government expenditures for health, social protection, economic affairs, and general public services in OECD countries had noticeable changes from 1995 to 2014. On the other hand, the expenditure ratios of education, national defense, public order and safety, environment protection, housing and community amenities, and culture have not changed as much.

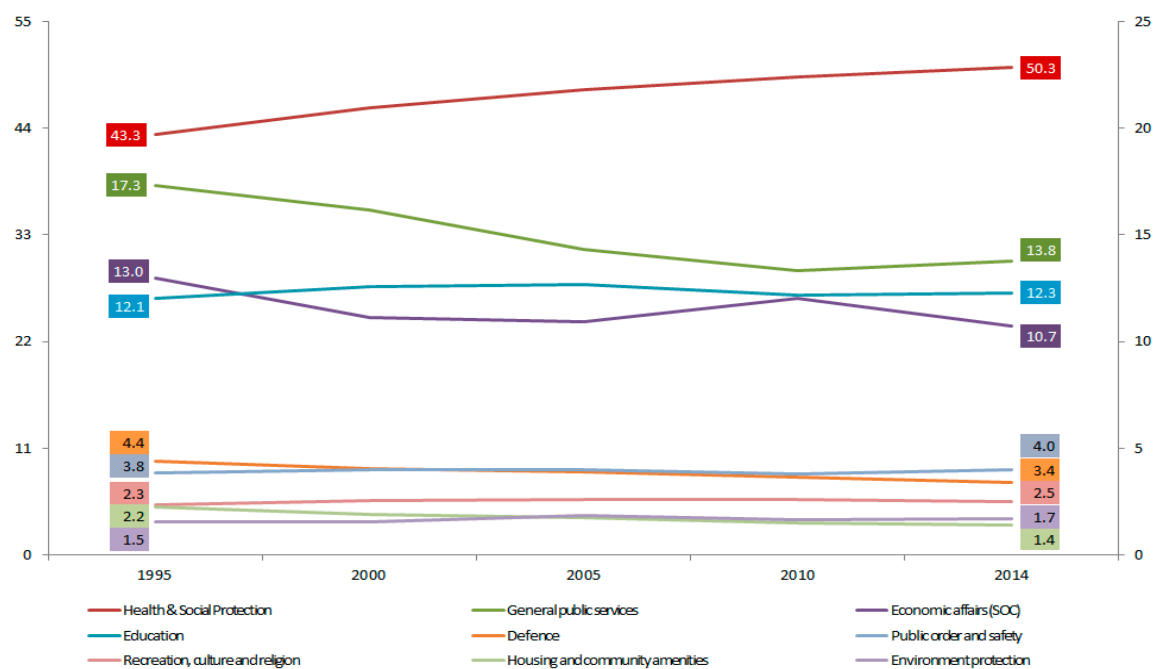


Figure 1. Expenditure weight in relation to total government expenditure of OECD countries (units in %). Source: Organization for Economic Co-operation and Development (OECD) [1].

The share of expenditures in health and social protection sectors tends to rise and most benefited within OECD countries, with its continual increase in its shares of total government expenditures. The share of health and social protection rose by 7.2% from 43.5% in 1995 to 50.7% in 2014. However, the share of economic affairs and general public services has decreased during the same period. The general public service expenditures have shown a continual declining trend, even as total government expenditure continues to increase. The share of economic affairs decreased by 2.6%p from 13.1% in 1995 to 10.5% in 2014, while that of general public services dropped by 3.2%p from 17.3% to 14.1% during the same period. Such trend can be viewed as a priority shift in OECD governments' finance allocation, from economic affairs to health and social protection. In the midst of such shift in priority of financial resource allocation, it is important to observe each countries' position in allocating their budget.

Korea has emerged as one of the fastest growing countries among OECD members and their tax revenues also have shown strong growth in the last 20 years (see Figure 2). With the increase in tax revenues of nearly 350%, government expenditures have also changed significantly, by shifting budget allocation from economic affairs to health and social protection sectors. The share of health and social protection sectors' expenditures increased by 14.2% from 17.7% in 1995 to 31.9% in 2014, while the share of economic affairs decreased by 7.8%p from 23.9% in 1995 to 16.1% in 2014. One of the interesting trends in Korea is that the changes in the share of expenditure in national defense and general public services have shown different trends compared to other OECD countries. The share of national defense decreased by 3.3% from 11.1% in 1995 to 7.8% in 2014 and the share of general public services remained the same during the same period. These changes of national defense and general public services are unique for Korea in terms of its budget and resource allocation.

Even though Korea's expenditure on its national defense ordinarily increases every year due to Korea's special circumstance of being a divided country, the expenditure weight of defense (in relation to total government expenditure) has been declining—contrary to other OECD nations—due to a rapid rise in public health and welfare spending. General public services are an area in which a typical amount of government expenditure is spent. However, due to the recent increase in decentralization of the central government and expansion of local governments' finances, the weight of general public

services expenditure with respect to total government expenditure appears to remain about the same, unlike other OECD nations.

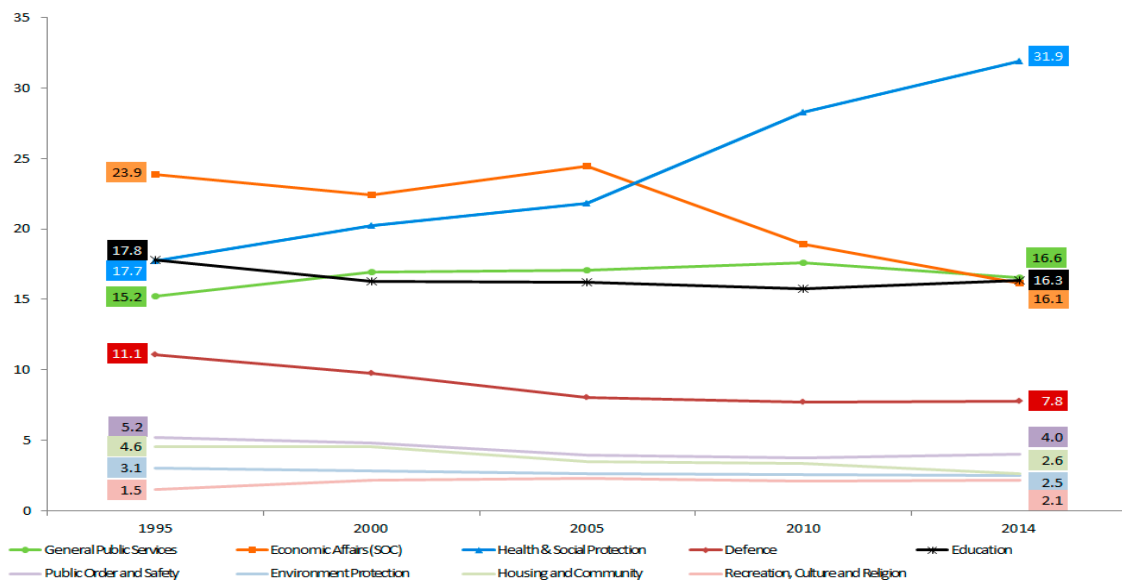


Figure 2. Expenditure weight (by each area) in relation to total government expenditure in Korea (units in%). Source: OECD [1].

Because of its continual commitment in health and social protection sectors, it is important for the Korean government to secure their stable tax revenues in the forthcoming years. However, they may face difficulties due to uncertain and unstable domestic and global economic conditions. The possibility of unstable tax revenues could weaken its current commitment in many of the programs in each sector. It is important for the government to understand the need to operate finance allocation more efficiently as the cost of public welfare is also increasing.

The objective of this study is to analyze the government expenditure efficiency of OECD countries for the past 10 years (2005~2014), focused on governments' expenditures on health and welfare and social overhead capital (SOC). These two sectors have shown contrasting trends in their share of total government expenditures, and the size of financial allocation in these two sectors can be adjusted at the government's own discretion.

In Section 2, the resource allocation in OECD countries is investigated, and in Section 3, other previous studies are examined to see how the present study is distinct from those studies. Section 4 examines the Composite Indicator created by Afonso et al. [2] in 2006 and Data Envelopment Analysis (DEA) by Fare et al. [3]. Additionally dealt with in this section is the Tobit Model, which can be used to analyze, via output indicators, the determinant factors of efficiency values derived from the DEA. Meanwhile, Section 5 is dedicated to analysis of the efficiency of Korea's public social expenditure and spending on SOC (transportation). By comparing efficiency scores and rankings obtained from spending efficiency measurements for each of the major areas of OECD countries including Korea, the efficiency of Korea's expenditure in relation to other OECD nations can be determined. Furthermore, determinant factors that contribute to DEA efficiency values for each of the function areas are analyzed. From such assessment, in Section 6, conclusions, as well as policy implications, are drawn.

2. Previous Studies

The previous studies on efficiency of spending mostly dealt with cases involving other countries and mainly focused on analysis for international comparison of their findings. Some of the previous studies on the efficiency of social expenditure are the International Monetary Fund (IMF) [4], Mattina and Gunnarsson [5], Afonso et al. [6], Monfort [7], Halaskova et al. [8], and Antonelli

and Valeris [9]. These studies analyzed the efficiency of expenditure on social protection, as well as the efficiency of expenditure in education and health. The studies on efficiency of social overhead capital (SOC) expenditures include those by Coelli and Perelman [10], Pestieau [11], and the European Commission [12]. These studies for the most part concentrated on European nations—mainly analyzing and comparing the spending efficiency of railroads, among various SOC expenditures.

There are very limited studies for the case of Korea focused on SOC expenditures. Park and Ryu [13] used the statistical data from IMD (International Institute for Management Development), WEF (World Economic Forum), WDI (World Development Indicator) of the World Bank, and OECD, and estimated the efficiency of government expenditure of OECD nations from 1996 to 2007 utilizing the Composite Index Creation (CIC) and DEA methods. Their estimated results showed that Korea's expenditure efficiency in health and social protection ranked one of the highest (1st~2nd) among 30 OECD nations. As for its SOC, however, it was among the lowest ranked, ranking between 25th and 28th. Cho [14] used the DEA method to analyze the efficiency of the expenditure on health and social protection among various functional government expenditures. Using this method, it generates a convex piecewise linear frontier of input–output combinations that dominate the results of other OECD countries in the sample. Therefore, DEA is a powerful measure to assess the relative efficiency of government expenditure in OECD countries. The results of Cho [14] showed that Korea is ranked 1st in health among 34 OECD nations. However, for social protection, Korea is ranked either 7th or 14th, depending on whether it was input-based or output-based, respectively.

This study is distinct from previous studies because we are using public social expenditure and more comprehensively analyze the efficiency of public health and welfare spending with a broader scope. In contrast, most of the previous studies analyzed the spending efficiencies of health and welfare separately (Mattina and Gunnarsson [15], Monfort [7], IMF [4], Park and Ryu [13], and Cho [14]). Afonso et al. [6] employed social expenditure as the input indicator for their efficiency analysis. This study also applied one unified set of data as the input indicator, instead of using all sorts of different data from various sources. Moreover, we treated health and welfare together as one functional area.

Another distinction in this study compared to previous studies is that we utilized not only income redistribution-related indicators, but also employment-related as well as public health-related indicators as our output indicators. Using various output indicators on public social expenditure gave us the advantage of comparing spending efficiencies more objectively over other studies such as those by Monfort [7], Park and Ryu [13], Cho [14], Halaskova et al. [8], and Antonelli and Valeris [9]. By including health, social expenditure could be dealt with more broadly.

Meanwhile, a number of previous studies on SOC (transportation) (i.e., European Commission [12] and Park and Ryu [13]) used survey-based indicators. However, due to possible bias that can arise in survey-based indicators, this study utilized restricted output indicators in order to overcome the analytical limitations. For WEF, the data used were restricted to only those data on quality assessment of road, railroad, port, and air transport. In the case of IMD, the data used were restricted only to quantitative data on network densities of road, railroad, and air transportation (km/km² area). As for already quantified data from the World Bank, the “number of passenger usage per 1 km distance in relation to total population”—re-derived by considering “number of passengers carried per 1 km of road, railway, and air transport”, “freight volume carried via road, rail, air, and maritime port”, and population density—were used in the analysis.

3. Data

3.1. Public Social Expenditure

Various indicators can be used to analyze the efficiency of expenditure in sustainable public services and welfare. The available indicators are largely divided into input and output indicators, and the related indicators in the dataset are used to evaluate the efficiency. This study used various

data sources from the OECD that provide input and output indicators for the public health and welfare sector (Table 1).

Table 1. Types of input and output indicators for public welfare sector and their sources.

Input Indicator		Output Indicator	
Indicator	Data Source	Indicator	Data Source
Public Welfare Expenditure	OECD's Social Welfare Statistics (SOCX)	Income Distribution Index	GINI Coefficient after Taxes
			Poverty Rate after Taxes
			Poverty Gap after Taxes
			Disposable Income after Taxes
		Employment Index	OECD Better Life Index (BLI)
			Employment Rate
			Unemployment Risk
		Public Health Index	OECD Employment/Labor Market Statistics
			Life Expectancy
			Infant Fatality Rate
			Low Birth Weight Rate

The higher values of GINI coefficient after taxes, poverty rate after taxes, poverty gap after taxes, and unemployment risk has more negative significance. Therefore, the reciprocal of those values is used.

One of the main data sources used in this study is the OECD's social welfare statistics (SOCX). This is the only set of internationally comparable data which provides comprehensive financial scale of the member countries' health and welfare sectors. Among the various available indicators in SOCX, public welfare expenditure is used as an input indicator and for the output indicator, income redistribution, employment, and public health indices are used to evaluate the efficiency of the expenditure for the public welfare.

There are four indicators for income distribution—the GINI coefficient after taxes, the poverty rate after taxes, the poverty gap after taxes, and the disposable income after taxes. The after-tax indicators are used because they reflect all taxes and public/private transfers in the income so that the output (result) can be compared to the input in analyzing the efficiency of public welfare expenditure. The studies by Afonso et al. [6], Cho [14], and Monfort [7] also used the GINI coefficient, the poverty rate, and the poverty gap for the output indicators to examine the efficiency of social welfare spending. Disposable income after taxes is one of the OECD's Better Life Index (BLI) indicators. It was pointed out by David [15] that disposable income is the most basic indicator in measuring public welfare level of a society.

The data sources for the employment index (employment rate and unemployment risk) are from the OECD employment and labor market statistics and for the public health index (infant fatality rate, life expectancy, and low birth weight rate), they are from the OECD public health statistics. These data, including public social expenditure, are only available on 31 OECD nations from 2005 and 2014. However, some output indicators are not provided by Finland, France, Latvia, and the Netherlands, and are therefore excluded.

3.2. Social Overhead Capital (Transportation)

For analysis of the efficiency of investment in the SOC (transportation) sector, the OECD data for the years from 2005 to 2014 on 19 OECD nations are used (see Table 2). Excluded countries from the list are Chile, Canada, Czechia, Denmark, Hungary, Iceland, Israel, Latvia, Luxemburg, the Netherlands, New Zealand, Norway, Slovakia, Spain, Sweden, and Switzerland. The input indicator applied to analyze the efficiency of SOC (transportation) infrastructure investment spending is Transport Expenditure from the OECD's Transport Infrastructure data. This study, as its output indicators of SOC, utilizes various materials from officially recognized international organizations. They are "The Global Competitiveness Report" of WEF, "World Competitiveness Yearbook" from IMD, and "World Development Indicators" of the World Bank, to name a few. The World Economic Forum (WEF) and International Institute for Management Development (IMD) prepare and provide the Global

Competitiveness Index (on public services in each countries) based on surveys, thereby contributing to transparent and efficient operation of public services worldwide. In WEF's case, the data on quality of road, railroad, maritime port, and air transport are used, while the length of road and railway per square km area (including number of airline passengers carried) are used in the case of IMD. As for the World Bank, the data used are: the number of passengers carried per every km of road, railway, and air transport in relation to the total population; and the volume of goods via road, railway, and air transport. For maritime port data, container port traffic was used.

Table 2. Types of input and output indicators for social overhead capital (SOC) (transportation) and their sources.

Input Indicator		Output Indicator	
Indicator	Data Source	Indicator	Data Source
Expenditure on Transport in relation to GDP	OECD	Quality of roads, Quality of railroad infrastructure, Quality of port infrastructure, Quality of air transport infrastructure	WEF
		Roads Density of the network km per square km, Railroads Density of the network km per square km, Air Transportation	IMD
		Air transport (freight), Air transport (passengers carried), Railways (goods transported), Railways (passengers carried), Roads (goods transported), Roads (passengers carried), Container Port Traffic	World Bank/International Road Federation (IRF)

4. Analytical Method

4.1. Data Envelope Analysis (DEA)

In this analysis, composite indicator methodology is used to show the national ranking of Public Sector Expenditure Efficiency (PSE) intuitively. The efficiency indicates the possible outcome attainable (Production Possibility Frontier) for a given level of input. Therefore, to increase efficiency means generating maximum output with a given input, or minimizing input for a given output. The composite indicator method is an analysis method in which efficiency can be estimated in terms of output percentage with respect to input. It represents efficiency in a broader sense and therefore, makes an intuitive comparison of efficiencies possible.

To analyze the efficiency of expenditure for each area, input and output indicators are constructed into a composite indicator following the 4-stage procedure as proposed by the OECD and European Commission [10] guidelines: (1) selection of output indicators for each area, (2) normalization of output indicators, (3) weighting, and (4) aggregation into composite indicator values. As for input and output indicators, the data provided by international organizations relating to the areas of interest have been selected in order to be able to compare the results internationally. The output indicators which carry more negative significance as their value increases are reversed so that the bigger value represents more positive significance. In order to adjust for outliers of input and output indicators, the data are normalized and uniformly weighted according to the Equal Weight (EW) method. For normalization, the ratio with respect to the mean value of each indicator is used. Finally, input and output indicators are aggregated into one composite indicator through a final 2-stage procedure: The first stage is to separate output indicators into groups depending on their characteristics or their sources, then for each group, apply identical weight and calculate the arithmetic mean. In the second stage, identical weight is applied to indicators of each group, then their arithmetic mean is calculated to obtain a final aggregate composite indicator.

According to Afonso et al. [16], the Public Sector Expenditure Efficiency (PSE_i) of a country i is estimated by Public Sector Performance ($PSE_i = \sum_{j=1}^n PSP_{ij}$) and Public Sector Expenditure (PEX_i).

$$PSE_i = \frac{PSP_i}{PEX_i} \quad (1)$$

where PSE_i represents the public sector expenditure efficiency of a country i ; PSP_i is the sum of j outputs and represents the total performance indicator of a country i . PEX_i represents the public sector expenditure of a country i . The PSE of a country will be higher when output is greater in relation to input or when input is smaller in relation to output.

However, such analysis does not provide any indication as to exactly how much a country's expenditure exceeds or how lacking its outputs are compared to other nations with different economy sizes or with better efficiencies. In order to overcome such limitation with the composite indicator construction method, Data Envelopment Analysis (DEA) is used to internationally compare the expenditure efficiencies of the nations. We used DEAP Version 2.1 of Coelli [17] in this study. The DEA makes it possible to compare expenditure efficiency of one country in relation to that of other countries. When assessing the efficiency through international comparison, biases arise due to differences in currency values or cost of living between the countries. In order to resolve such bias, the analysis in this study is carried out in terms of technical efficiency (Cho [14]). The technical efficiency is a maximum level of output attainable with the input of production factors in a given level of technology.

In this study, we differentiate Production Possibility Frontiers (PPF) of Constant Returns to Scale (CRS) and those of Variable Returns to Scale (VRS). According to Figure 3, a generic country C is the only country with high efficiency under CRS. However, under VRS, the countries A, C, E, and G all exhibit high efficiency in the operation of their finances. Whereas CRS estimates PPF while assuming production technology to be a constant return with respect to the economic size, the VRS does so by assuming production technology as a variable return. Therefore, if CRS is used, only the country C having a constant return in relation to its economic size appears to be most efficient. However, under VRS, along with country C with constant return on investment, the countries A, E, and G that have variable returns also can be considered highly efficient.

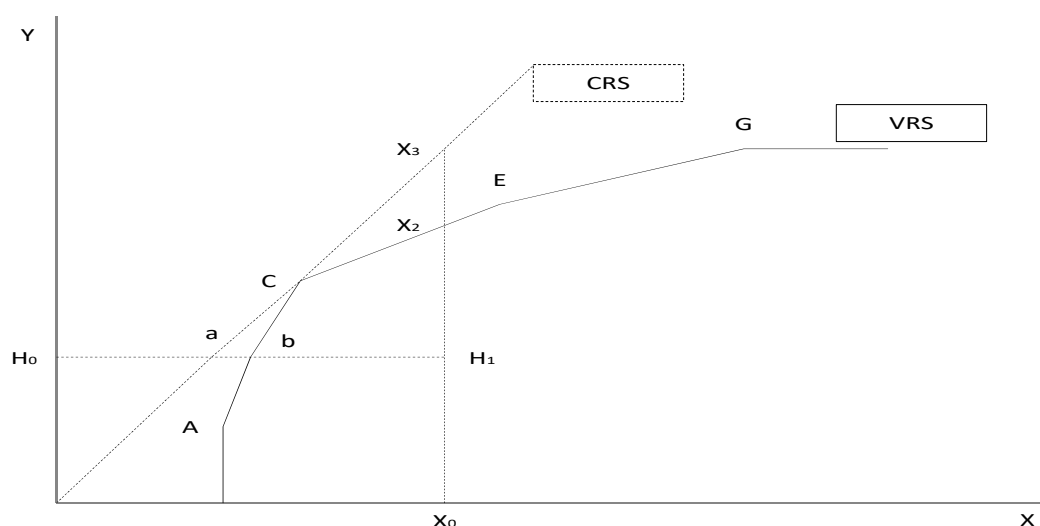


Figure 3. Types of data envelope analysis (DEA) and efficiency. Source: Cho [12].

The inefficiency in input and output occurs in the following way. For a country whose input and output figures are found at point H_1 , as shown in Figure 3, the same output can be attained

even with the reduction in input by bH_1 . The expenditure efficiency and inefficiency for input- and output-oriented countries are as follows:

$$\begin{aligned} \text{(Input – oriented country) efficiency : } & \frac{H_0H_1}{H_0b} \text{ and inefficiency : } 1 - \frac{H_0H_1}{H_0b} \\ \text{(Output – oriented country) efficiency : } & \frac{X_0H_1}{X_0X_2} \text{ and inefficiency : } 1 - \frac{X_0H_1}{X_0X_2} \end{aligned}$$

There exists room to increase output by H_1X_2 even with less input than X_0 ; therefore, there exists inefficiency in revenue spending.

4.2. Tobit Model

Since the data analyzed in this study yield DEA efficiency values between 0 (minimum) and 1 (maximum), the censoring occurs on both ends (left and right). Such censored data are generally analyzed using the Tobit model. The determinant factors that contribute to DEA efficiency values are analyzed via Pooled Tobit analysis. In contrast to this study, Afonso et al. [2] evaluated the importance of non-discretionary inputs via Tobit regressions, where output efficiency scores are regressed on their choice of exogenous, non-discretionary factors.

Among all the national data to be analyzed, only those from the years, in which all the values of variables (individual sub-indicators) are available, are selected. Of these, certain individual indicators that have large values (unit) or negative significance have been changed by either adjusting their units or converting them into their log values or into values of opposite (positive) significance. They are then grouped by year and normalized (K_i/K) by the mean of each variable. After they had been normalized, the individual sub-indicators are grouped and converted into indicator values, thereby obtaining output indicators. The regression formula of the Tobit Model is as follows:

$$y_i = \alpha_i + \sum_{n=1}^k \beta_{in}x_{in} + \theta_i Z_i + \tau_i \quad (2)$$

y_i : efficiency value (from DEA analysis) by each country;

x_{in} : sub-indicators of output indicator by each country;

Z_i : dummy variable—country (welfare state) and/or year.

Table 3 shows that the country dummy, Z_i , is differentiated into 6 model types: the first type is liberalistic countries such as United Kingdom and the US; second, conservative nation-models such as Germany and Japan; third, social-democratic nations such as Sweden and Denmark; fourth, southern Europe nations such as Greece and Italy; fifth, transition countries such as Poland and Hungary; and finally, sixth is the other type which includes Korea and Israel.

Table 3. Country dummy variable.

Model Type	Countries
Liberalistic Countries (Reg = 1)	US, United Kingdom, Canada, Ireland, Australia, New Zealand
Conservative Countries (Reg = 2)	Japan, Germany, France, Switzerland, Luxemburg
Social Democratic Countries (Reg = 3)	Sweden, Denmark, Norway, Finland, Austria, Belgium, the Netherlands
Southern Europe Countries (Reg = 4)	Italy, Greece, Portugal, Spain
Transition Countries (Reg = 5)	Poland, Hungary, Slovakia, Czechoslovakia
Other Countries (Reg = 6)	Korea, Israel, Iceland, Mexico

Source: Cha and Lee [18].

In addition, the individual indicators are divided into two areas—public health and welfare and SOC (transportation). First, in Table 4, the number of observed values of public welfare-related output indicators for our Tobit model is 138; the mean value of their output-based efficiencies is 0.936,

while that of their input-based efficiencies is 0.576. Since GINI coefficient after taxes, poverty rate after taxes, poverty gap after taxes, unemployment risk, and low birth weight rate all have more positive significance as their values decrease, the term “opposite” (“OPP”) is added to each of the names of those variables so that a greater value will have more positive significance. According to the basic statistics, their mean values are found to be greater than other ordinary indicator values.

Table 4. Statistics of public welfare.

Variables	Obs	Mean	Std. Dev.	Min	Max
Efficiency (output-based)	138	0.936	0.036	0.824	1.000
Efficiency (input-based)	138	0.567	0.214	0.269	1.000
GINI Coefficient after Taxes (OPP)	138	0.700	0.049	0.490	0.764
Poverty Rate after Taxes (OPP)	138	0.895	0.038	0.791	0.955
Poverty Gap after Taxes (OPP)	138	0.776	0.056	0.622	0.866
Employment Rate	138	0.572	0.076	0.395	0.813
Unemployment Risk (OPP)	138	0.916	0.038	0.755	0.977
Life Expectancy	138	4.377	0.030	4.293	4.421
Infant Fatality Rate (OPP)	138	0.961	0.018	0.849	0.991
Low Birth Weight Rate (OPP)	138	0.937	0.014	0.900	0.968

The number of observations for SOC-related basic statistics is 69, as shown in Table 5. The mean value of output-based efficiency is 0.663, while input-based mean is 0.596. The variables are quality of roads, quality of railroads infrastructure, quality of air transport infrastructure, road and railroad network density, volume of freight and number of passengers carried via roads, freight and passengers carried via air transport, passengers carried via railways, and container port traffic.

Table 5. Statistics of SOC.

Variables	Obs	Mean	Std. Dev	Min	Max
Efficiency (output-based)	69	0.663	0.211	0.365	1.000
Efficiency (input-based)	69	0.596	0.265	0.167	1.000
Quality of Roads	69	5.197	1.148	2.200	6.700
Quality of Railroads Infrastructure	69	4.583	1.504	2.200	6.800
Quality of Air Transport Infrastructure	69	5.574	0.823	3.600	6.700
Quality of Port Infrastructure	69	5.117	0.959	3.100	6.500
Roads Density	69	1.462	1.204	0.110	5.080
Railroads Density	69	0.049	0.033	0.001	0.117
Ln (Air Transportation Density)	69	5.241	1.746	1.708	8.915
Ln (Road Freight Transport)	69	4.308	1.661	1.796	8.356
Road Passengers Transport	69	69.939	164.19	0.058	801.62
Ln (Air Transport, Freight)	69	6.227	2.771	0.039	10.612
Ln (Air Transport, Passengers Carried)	69	7.560	1.752	4.064	11.218
Ln (Railways, Goods Transported)	69	7.220	2.069	2.067	12.550
Railways, Passengers Carried	69	265.260	479.68	0.840	2535.55
Ln (Container Port Traffic)	69	5.413	1.735	2.058	8.408

5. Results

5.1. Composite Indicator and DEA Analysis Method Results

5.1.1. Health and Welfare Sector

Korea's composite index of output indicators in the health and welfare sector was found to be in a mid to lower level, ranking 19th among 31 OECD countries, as shown in Table 6. However, when that composite index was broken down into income redistribution, employment, and health indicators, and viewed separately, Korea ranked 27th with respect to income redistribution, while ranking 8th in terms of employment and 19th in the case of health.

Table 6. Indicator values and national rankings in health and welfare sector.

	Composite Indicator		Income Redistribution Indicator		Employment Indicator		Health Indicator	
	Value	Ranking	Value	Ranking	Value	Ranking	Value	Ranking
Australia	1.067	6	1.085	10	1.062	6	1.053	6
Austria	1.055	9	1.098	6	1.025	14	1.042	9
Belgium	1.013	14	1.094	7	0.934	24	1.010	14
Canada	1.053	10	1.063	11	1.055	7	1.042	10
Chile	0.881	30	0.784	30	0.949	22	0.910	30
Czech Republic	0.993	18	0.991	18	0.995	18	0.992	18
Denmark	1.065	7	1.093	8	1.051	9	1.049	7
Estonia	0.958	21	0.893	28	1.017	15	0.966	21
Germany	1.045	11	1.107	4	0.992	19	1.034	11
Greece	0.895	29	0.941	23	0.824	31	0.920	29
Hungary	0.938	25	0.936	24	0.931	26	0.947	26
Iceland	1.104	2	1.026	14	1.202	1	1.083	2
Ireland	1.005	15	1.040	12	0.969	21	1.006	15
Israel	0.963	20	0.909	26	1.007	16	0.973	20
Italy	0.947	24	0.992	17	0.887	28	0.963	22
Japan	1.004	16	0.980	19	1.028	11	1.004	16
Korea	0.982	19	0.904	27	1.054	8	0.989	19
Luxembourg	1.083	4	1.186	1	0.998	17	1.064	4
Mexico	0.905	28	0.765	31	1.027	13	0.923	28
New Zealand	1.043	12	1.010	16	1.085	4	1.034	12
Norway	1.118	1	1.118	2	1.145	2	1.092	1
Poland	0.935	26	0.932	25	0.924	27	0.948	25
Portugal	0.950	23	0.941	22	0.947	23	0.961	23
Slovak Republic	0.953	22	0.966	21	0.934	25	0.959	24
Slovenia	0.999	17	1.011	15	0.986	20	0.999	17
Spain	0.924	27	0.971	20	0.856	30	0.945	27
Sweden	1.078	5	1.087	9	1.084	5	1.063	5
Switzerland	1.093	3	1.107	5	1.099	3	1.073	3
Turkey	0.861	31	0.827	29	0.868	29	0.887	31
United Kingdom	1.028	13	1.036	13	1.028	12	1.022	13
United States	1.064	8	1.107	3	1.039	10	1.045	8
Average	1.000		1.000		1.000		1.000	

The efficiency change curve (efficient frontier graph) of the composite index of output indicators in social expenditure is shown in Figure 4 below. It is a dispersion graph of OECD countries with social expenditure along the X-axis and composite index of output indicators as its Y-axis. Korea, Iceland, and Norway are on the frontier line, and thus, deemed efficient.

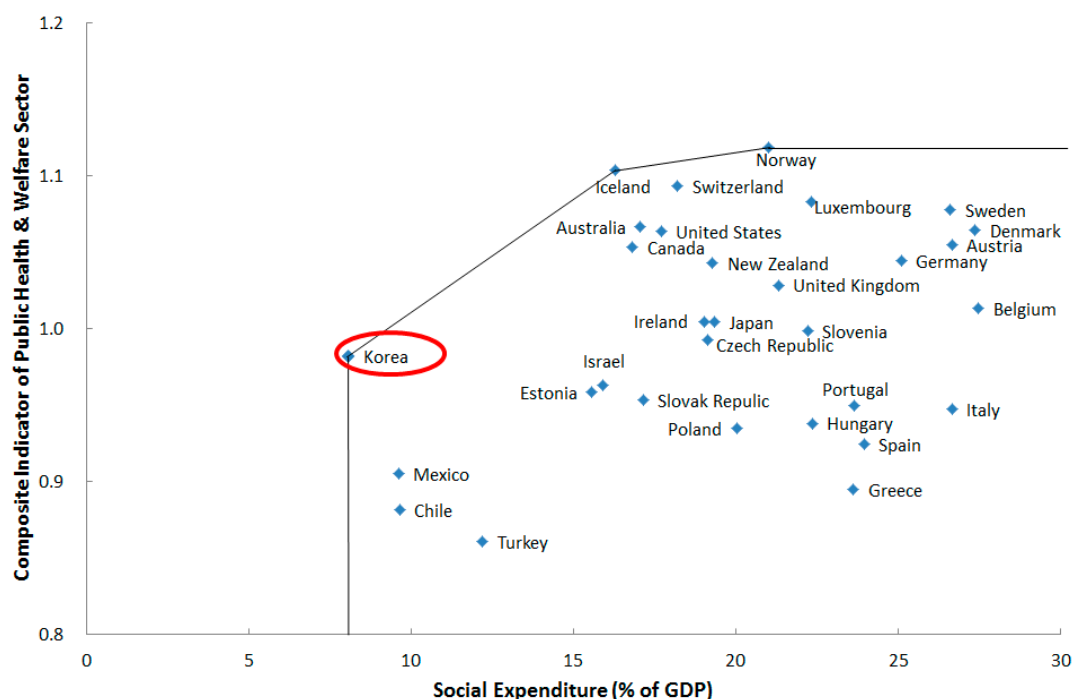


Figure 4. Efficient frontier graph of public health and welfare sector.

When efficiency of public social expenditure with respect to composite indicator—the same data used to create efficient frontier—was measured via composite indicator analysis, Korea exhibited the highest efficiency (ranked 1st among 31 countries), as shown in Figure 4.

Even through a non-parametric analysis—DEA—the efficiency of Korea's social expenditure was shown to be the highest—again ranking 1st among 31 countries (see Table 7). Along with Korea, Iceland and Norway also had the highest efficiency according to DEA. Esanov [19] also found Korea to have the highest efficiency (ranking 1st among 20 countries) based on 2006 data. Here, when efficiencies of Korea and Norway are compared, despite Norway's much bigger expenditure scale, because of its high output indicators, both countries have maintained number 1 ranking. However, Korea's mandatory expenditure is expected to rise rapidly. Therefore, in order for Korea to maintain as high efficiency as Iceland and Norway, the output (e.g., income distribution, job creation, and promotion of health) must be improved greatly, as the input becomes increased.

Table 7. Analysis of efficiency of social expenditure on public health and welfare.

	Composite Indicator Analysis		DEA (VRS)			
			Input-Based		Output-Based	
	Efficiency Score	Rank	Efficiency Score	Rank	Efficiency Score	Rank
Australia	1.233	7	0.809	7	0.964	6
Austria	0.780	26	0.487	21	0.943	11
Belgium	0.727	30	0.370	26	0.906	15
Canada	1.236	6	0.768	8	0.953	9
Chile	1.798	3	0.835	6	0.877	21
Czech Republic	1.024	16	0.460	23	0.892	20
Denmark	0.768	27	0.499	18	0.952	10
Estonia	1.215	8	0.519	15	0.877	21
Germany	0.820	23	0.490	20	0.934	13
Greece	0.747	29	0.342	28	0.800	31
Hungary	0.828	22	0.361	27	0.839	27
Iceland	1.335	5	1.000	1	1.000	1
Ireland	1.042	15	0.505	17	0.903	16
Israel	1.193	9	0.507	16	0.877	21
Italy	0.700	31	0.302	31	0.847	26
Japan	1.023	17	0.494	19	0.902	17
Korea	2.401	1	1.000	1	1.000	1
Luxembourg	0.957	18	0.666	10	0.968	5
Mexico	1.852	2	0.837	5	0.900	18
New Zealand	1.067	13	0.633	12	0.937	12
Norway	1.050	14	1.000	1	1.000	1
Poland	0.920	20	0.402	25	0.838	28
Portugal	0.793	25	0.341	29	0.849	25
Slovak Republic	1.096	12	0.471	22	0.861	24
Slovenia	0.887	21	0.414	24	0.893	19
Spain	0.760	28	0.337	30	0.826	29
Sweden	0.799	24	0.547	13	0.964	6
Switzerland	1.184	11	0.855	4	0.985	4
Turkey	1.392	4	0.661	11	0.825	30
United Kingdom	0.952	19	0.526	14	0.919	14
United States	1.184	10	0.768	8	0.960	8
Mean	1.089		0.587		0.909	

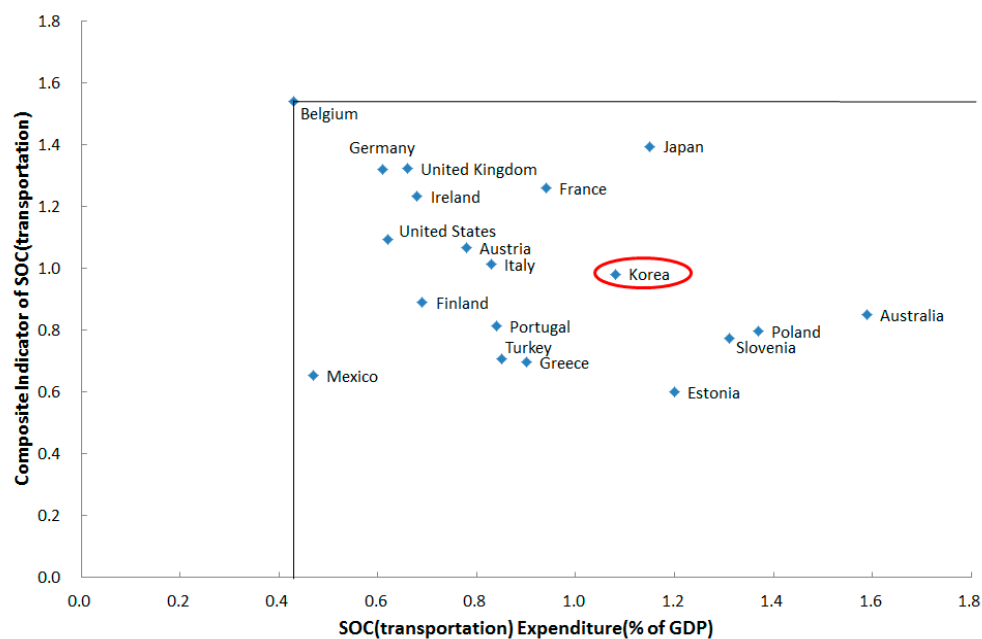
5.1.2. SOC (Transportation) Sector

According to the values and national rankings of the SOC sector by indicator sources in Table 8, Korea ranked 10th among 19 OECD countries in the composite indicator of the SOC (transportation) sector. When the composite indicator was examined separately by each data source, Korea ranked 7th among 19 OECD countries according to WEF indicators, which are a numerical representation of transportation-quality-related output indicators. However, in IMD's case—which is based on transportation network density related output indicators—Korea's ranking was below the median at 11th. With respect to WB/IRF indicators, those relating to freight transportation volume, Korea ranked 12th.

Table 8. Values and national rankings of SOC (Transportation) sector by indicator sources.

	Composite Indicator		WEF		IMD		WB/IRF	
	Value	Ranking	Value	Ranking	Value	Ranking	Value	Ranking
Australia	0.850	12	1.007	11	0.418	19	1.125	7
Austria	1.066	8	1.107	8	1.115	7	0.978	11
Belgium	1.541	1	1.174	5	2.402	1	1.045	9
Estonia	0.599	19	0.894	12	0.574	16	0.329	19
Finland	0.890	11	1.212	3	0.47	18	0.987	10
France	1.260	5	1.254	2	1.246	5	1.28	5
Germany	1.320	4	1.257	1	1.404	3	1.301	4
Greece	0.698	17	0.829	15	0.647	14	0.617	17
Ireland	1.234	6	0.892	13	0.957	10	1.854	1
Italy	1.014	9	0.787	17	1.195	6	1.061	8
Japan	1.394	2	1.175	4	1.626	2	1.382	3
Korea	0.981	10	1.124	7	0.895	11	0.924	12
Mexico	0.654	18	0.745	18	0.492	17	0.725	16
Poland	0.796	14	0.631	19	1.015	9	0.741	14
Portugal	0.812	13	1.036	10	0.656	13	0.745	13
Slovenia	0.772	15	0.883	14	1.033	8	0.4	18
Turkey	0.705	16	0.794	16	0.591	15	0.731	15
United Kingdom	1.321	3	1.072	9	1.377	4	1.515	2
United States	1.092	7	1.128	6	0.887	12	1.262	6
Average	1.000		1.000		1.000		1.000	

The efficiency change curve (efficient frontier) in Figure 5 below is a dispersion of OECD countries plotted against SOC (transportation) expenditure (X-axis) and composite indicator values of output indicators (Y-axis). Belgium is found on the efficient frontier line, indicating high efficiency, while Korea is found below the line, and therefore, deemed inefficient.

**Figure 5.** Efficient frontier graph of SOC (Transportation) sector.

The expenditure values and composite indicators of SOC (transportation) used to create the above efficient frontier line, when measured as output with respect to input, yielded the following result. As shown in Table 9 below, Korea's expenditure efficiency of SOC (transportation) infrastructure ranked 13th among a total of 19 countries. Even the DEA results showed Korea ranking near the bottom at 14th (input-based) and 13th (output-based) in its SOC (transportation) expenditure efficiency.

Table 9. Analysis of SOC (transportation) expenditure efficiency (19 countries).

	Composite Index Analysis		DEA (VRS)			
			Input-Based		Output-Based	
	Efficiency Score	Rank	Efficiency Score	Rank	Efficiency Score	Rank
Australia	0.478	18	0.27	19	0.149	18
Austria	1.223	7	0.551	8	0.382	7
Belgium	3.206	1	1	1	1	1
Estonia	0.447	19	0.358	16	0.139	19
Finland	1.153	9	0.623	7	0.36	9
France	1.199	8	0.457	13	0.374	8
Germany	1.937	2	0.705	3	0.604	2
Greece	0.694	15	0.478	12	0.216	15
Ireland	1.624	4	0.632	6	0.507	4
Italy	1.093	10	0.518	9	0.341	10
Japan	1.085	11	0.374	15	0.338	11
Korea	0.813	13	0.398	14	0.254	13
Mexico	1.245	6	0.915	2	0.388	6
Poland	0.52	17	0.314	18	0.162	17
Portugal	0.865	12	0.512	10	0.27	12
Slovenia	0.527	16	0.328	17	0.164	16
Turkey	0.742	14	0.506	11	0.232	14
United Kingdom	1.791	3	0.652	5	0.559	3
United States	1.576	5	0.694	4	0.492	5
Mean	1.117		0.541		0.365	

5.2. Analysis of Determinant Factors of Efficiency

5.2.1. Health and Welfare Sector

In analyzing determinant factors of efficiency in the health and welfare sector via the Tobit Model, the output-based efficiency values from DEA were used as dependent variables—as was done by Afonso et al. [6]. The results of the analysis using the pooled Tobit model on the health and welfare sector are presented in Table 10. The sigma value was found to be 0.012, indicating significance at or below the 1% range. The factors that had less than 5% influence on DEA efficiency values were Poverty Rate after Taxes (OPP), Employment, Unemployment Risk (OPP), Life Expectancy, and Low Birth Weight Rate (OPP). Their values all exhibited numerical signs that were expected theoretically.

It was found that when poverty rate after taxes (OPP) increases by 1 unit (standard deviation 0.038), the efficiency increases by 0.008. Since OPP is the rate increase as the number of people who are under the poverty line decreases, the results suggest that the efficiency decreases as poverty rate after taxes increases. As for employment rate, it was found that efficiency increases by 0.019 for every one-unit (standard deviation 0.076) increase. In other words, an increase in employment improves efficiency. Layoffs or unemployment risk (OPP), for an increase of 1 unit (standard deviation 0.038), caused efficiency to increase by 0.012, which can be interpreted to mean that as unemployment risk

decreases, the efficiency increases. Furthermore, when low birth weight rate (OPP) increases by 1 unit (standard deviation 0.014), there is an increase of 0.012 in efficiency—the lower the low birth weight rate, the higher the efficiency. On the other hand, the increase of 1 unit (standard deviation 0.030) in life expectancy causes decrease in efficiency by 0.007. Even though the increase in life expectancy may indicate a greater number of healthy individuals and therefore, have a reducing effect in economic or social costs, the negative effects due to ageing society exceed the positive effects, ultimately causing efficiency to decrease.

Table 10. Analysis result of pooled Tobit on health and welfare sector.

Dependent Variable	Efficiency
	(Output-Based)
GINI Coefficient after Taxes (OPP)	0.019 (0.050)
Poverty Rate after Taxes (OPP)	0.207 *** (0.070)
Poverty Gap after Taxes (OPP)	0.044 (0.036)
Employment Rate	0.251 *** (0.031)
Unemployment Risk (OPP)	0.312 *** (0.046)
Life Expectancy	−0.226 ** (0.107)
Infant Fatality Rate (OPP)	−0.047 (0.169)
Low Birth Weight Rate (OPP)	0.834 *** (0.137)
Constant Term	0.577 * (0.342)
Sigma	0.012 *** (0.001)
Number of Observations	138

Values in () are robust standard errors. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. In the actual analysis, country and year dummies were included; however, they are excluded from the table due to limitations in space.

5.2.2. SOC (Transportation) Sector

The efficiency values from DEA were again used as dependent variables in the Tobit Model analysis of determinant factors that contribute to efficiency in the SOC sector. As shown in Table 11, the resulting sigma value was 0.018, indicating significance at less than the 1% range. The factors having influence on DEA efficiency values were Quality of Roads, Quality of Railroads Infrastructure, Quality of Air Transport Infrastructure, Network Density of Roads and Railroads, Freight Transfer and Passengers Carried via Road, Passengers Carried via Air Transportation, Passengers Carried via Railways, and Container Port Traffic.

Table 11. Results of pooled Tobit analysis on SOC sector.

Dependent Variable	Efficiency
	(Output–Based)
Quality of Roads	−0.025 *** (0.007)
Quality of Railroads Infrastructure	0.035 *** (0.013)
Quality of Air Transport Infrastructure	0.030 ** (0.013)
Quality of Port Infrastructure	−0.011 (0.014)
Road Density of Network	0.063 *** (0.009)
Railroad Density of Network	1.730 *** (0.293)
Air Transportation	0.014 (0.022)
Road Freight Transport	0.015 * (0.008)
Road Passengers Transport	0.002 ** (0.001)
Air Transport, Freight	−0.002 ** (0.007)
Air Transport, Passengers Carried	−0.055 ** (0.027)
Railways, Goods Transported	−0.005 (0.006)
Railways, Passengers Carried	0.00009 * (0.000)
Container Port Traffic	0.018 *** (0.006)
Constant Term	0.477 *** (0.118)
Sigma	0.018 *** (0.002)
Observations	69

Values in () are robust standard errors. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. In the actual analysis, country and year dummies were included; however, they are excluded from the table due to limitation in space.

An increase of one unit (1 point) in quality of roads caused efficiency to decrease by 0.025. The main mode of transportation is automobile and most OECD countries' roads are already at a high level of quality. Therefore, it can be interpreted that further improvement in the quality of roads caused efficiency to decrease—in line with the Law of Diminishing and Marginal Utility. Unlike the roads, the increase of 1 unit (1 point) in the quality of railroads infrastructure increased efficiency by 0.035,

while a 1 unit (1 point) increase in the quality of air transport infrastructure caused efficiency to increase by 0.030.

A unit increase in road network density (standard deviation 1.204) and in railroad network density (standard deviation 0.033) caused efficiencies to increase by 0.076 and 0.057, respectively.

When quantity of freight transported via road increased 1 unit (standard deviation 1.661), efficiency increased 0.025. A one unit increase in passengers carried via road (standard deviation 164.190) made efficiency increase by 0.328, while a one unit increase in freight transported via railways (standard deviation 479.680) increased efficiency by 0.043. An increase in container port traffic by 1 unit (standard deviation 1.735) caused efficiency to rise by 0.031.

It was, however, found that a 1 unit increase in passengers carried via air transportation (standard deviation 2.771) reduced efficiency by 0.152. This is probably due to tightening of airport security with the recent increase in terrorism. As the number of airline passenger increases, airports become more crowded—thus, lower efficiency.

6. Conclusions

This study analyzed the efficiencies of social expenditures focusing on health and welfare and the transportation SOC sector, which represents more than one-half of total expenditures. These two areas have exhibited opposite trends in their share of total government expenditure in OECD countries for the past 20 years (1995–2014).

The results of DEA analysis on expenditure efficiency in the health and welfare sector have shown that Korea, along with Iceland and Norway, has the highest efficiency among 31 OECD nations. While social welfare expenditure in Korea was much less compared to that of other major OECD countries, the output indicators of Korea as a whole were found to be at the level or close to that of the OECD average. This indicates Korea exhibited high efficiency in expenditure for the social welfare sector, despite its smaller expenditure compared to other OECD countries.

For the expenditure efficiency in the SOC (transportation) sector, it was found that Korea ranked 14th (input-based) among 19 OECD nations. The country with the highest efficiency in this area was Belgium. Therefore, in order to improve SOC expenditure efficiency in Korea, the government needs to consider different ways to either reduce its input or increase its output.

As for health and welfare, an area in which the government's spending continues to increase rapidly, the Korean government has to examine which areas need to be improved to maintain its high efficiency. The determinant factors were used as output indicator variables in our Tobit Model. Those output indicator variables comprise welfare-related indicators—such as GINI Coefficient after Taxes, Poverty Rate after Taxes, Poverty Gap after Taxes, Employment Rate, and Unemployment Risk—and health-related indicators—such as Life Expectancy, Infant Fatality Rate, and Low Birth Weight Rate. The results indicated that Poverty Rate after Taxes, Unemployment Risk, Life Expectancy, and Low Birth Weight Rate had a meaningful effect on efficiency value. Therefore, the efficiency of government expenditure on health and welfare can be improved with the following conditions: (1) Income redistribution—blind spots in social welfare can be removed by extending the recipients of government benefits as the government's expenditure on public welfare increases. Such efforts must be made to reduce income inequality such as poverty rate after taxes. (2) The government must minimize possible fraudulent or unfair receiving of those benefits. (3) The government must raise the employment rate and lower unemployment risk through its expansion of employment-friendly social services. (4) The government has to strengthen the basic health insurance needs to include coverages that help reduce low birth weight rate (Lee [20]).

Meanwhile, the Korean government, in coping with increasing demand for social welfare, had decided to progressively reduce its investment in the SOC (transportation) sector. Therefore, this study aimed to propose efficiency-improving measures, focusing on ways to increase SOC (transportation) output rather than on those to reduce input expenditure. The determinant factors were analyzed via the Tobit Model. As its output indicator variables, the WEF index indicating the

quality of transport infrastructure, WB/IRF indexes which represent the quantity of passengers and freight carried via transport infrastructure, and the IMD index reflecting the density of transport network, were used. The results of our analysis have shown that Quality of Roads, Quality of Railroads and Air Transport Infrastructures, Network Density of Roads and Railroads, Passengers and Freight Carried via Road, Number of Passengers Carried via Air Transport and Railroad, and Container Port Traffic had impacts on the efficiency of transportation infrastructure. Therefore, in order to improve the efficiency in Korea's expenditure on SOC (transportation), the quality, density, as well as the quantity of those determinant factors must be improved. The government has to come up with a system and clear outlines of its goal in infrastructure investment and an improved system that also constantly checks the performance status of its goals. The following measures can be taken to improve efficiency: (1) the government has to increase the network density of roads and railroads by creating an effective infrastructure-linking system between all modes of transportation, improving accessibility and convenience (quality of transport infrastructure) for the consumers; (2) based on accurate projections of future demand in quantity of transport infrastructure—such as the volume of freight and passenger use of roads, passengers to be carried via railroads, and container port traffic—the government has to select transportation infrastructure projects that are high in efficiency and make new investments accordingly; and (3) in order to improve the efficiency of the government's investment in transport infrastructure, it is necessary for the Korean government to set up a national transport infrastructure plan regarding the quality and network density of roads, railroads, air transport, and maritime ports, as well as the number of passengers and volume of freight carried. It is necessary to establish a system in which performance can be assessed against its initially planned goal periodically, on a yearly basis.

The strength and contribution of this paper is exploring the efficiency of public social expenditure among OECD countries and the defined relative position of Korea. The policy implications are derived from the results of the relative efficiency in OECD countries and suggest efficient expenditure allocation for sustainable public services in Korea. However, there is a limitation in this study because of limited available data. This study examined 10 years of data from 2005 to 2014. Including more available data with expanded periods, the results can be influenced for relative efficiency of public social expenditure, SOC spending, and policy implication. Possible future work for this research can be evaluating the relative efficiency of government expenditure for manufactured and non-manufactured sectors and industries in OECD countries with economic crises after the COVID-19 pandemic.

Author Contributions: All authors have contributed to the ideas of the paper. D.J.S.'s contribution was developing the methods, interpretation of the results, and drafting the article. B.S.C. prepared the data and investigated the previous studies. B.H.S.K. provided core advice, revising it critically for important contents, English revision, and final preparation for the manuscript. The views expressed in this paper are those of the authors and should not be interpreted as those of the National Assembly Budget Office. All authors have read and agreed to the published version of the manuscript.

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