Comparative Analysis of Transportation Sustainability in OECD Countries

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Abstract: The Korean government prepared and published sustainable transport indicators in April 2010, and with these indicators, evaluated the transportation sustainability in each of 84 Korean cities. The purpose of this study is to measure and evaluate the transportation sustainability in OECD countries with the same indicators as were used in Korea, allowing the comparison between the present position of Korean transportation sustainability and economic scale with other nations. According to the evaluation based on 2007 data, European countries such as Norway and Sweden received a favorable evaluation, while Korea was in grade 4; Canada, the USA, Australia, and New Zealand scored even lower. There is not enough data to explain the relationship between economic scale and transportation sustainability, because the results could be different if other economic indicators are applied. This study can be meaningful in examining the present position of Korea relative to other nations helping to establish and enforce future sustainable transportation policy.

Key Words: transportation sustainability, sustainable transport indicator, z-score, evaluation

1. INTRODUCTION

1.1 Background and Purpose
The Korean government enacted the Sustainable Transportation and Logistics Development Law in December 2009 to cope with changes in the fields of transportation and logistics related to climatic change, the energy crisis, and others. According to this law, it is a requirement to periodically investigate and evaluate the sustainability of the transportation system. According to the evaluation, some regions are to be designated as special areas for green transportation improvements in compliance with this law.

For this, the Korean government prepared and published sustainable transport indicators in April 2010, and with these indicators, evaluated the transportation sustainability in each of 84 Korean cities.

The purpose of this study is to measure and evaluate the transportation sustainability in Organization for Economic Cooperation and Development (OECD) countries with the same indicators as were used in Korea, allowing the comparison between the present position of Korean transportation sustainability and economic scale with other nations.
1.2 Method and Scope
Chapter 2 presents the transportation sustainability evaluation system. For this, the method and target of evaluation are established. Chapter 3 calculates the grade of transportation sustainability in OECD countries. Also, a time series comparison is performed to examine progress. Chapter 4 performs the comparative analysis and evaluation of the balance level in each indicator area. Additionally, it compares the service levels on the evaluation coordinate space. Chapter 5 performs the analysis of the relation between economic scale and transportation sustainability using GDP per capita. Finally, Chapter 6 includes conclusions and suggestions for future research.

This study was performed for 29 OECD countries with data from 2000 through 2007. In order to collect valid data and compare those nations with similar economy, it is only limited to OECD countries.

2. TRANSPORTATION SUSTAINABILITY EVALUATION SYSTEM

2.1 Evaluation Indicators
The Korean government has prescribed the investigation and evaluation of transportation and logistics sustainability through Article 15 of the Sustainable Transportation and Logistics Development Law, and established the indicators for the measurement, evaluation, and management of transportation sustainability as is shown in Table 1 (Notification No. 2010-206 of the Korean Ministry of Land, Transport, and Maritime Affairs).

<table>
<thead>
<tr>
<th>Indicators Group</th>
<th>Indicators</th>
<th>Unit</th>
<th>International comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental</td>
<td>Annual greenhouse gas emissions</td>
<td>tCO₂-eq</td>
<td>O</td>
</tr>
<tr>
<td>Indicators Group</td>
<td>Greenhouse gas emissions per capita</td>
<td>tCO₂-eq/person</td>
<td>O</td>
</tr>
<tr>
<td></td>
<td>Greenhouse gas emissions per area</td>
<td>tCO₂-eq/km²</td>
<td>O</td>
</tr>
<tr>
<td></td>
<td>Air pollutant emissions per capita</td>
<td>kg/person</td>
<td>O</td>
</tr>
<tr>
<td>Social</td>
<td>Number of traffic fatalities per 100,000 persons</td>
<td>number of persons</td>
<td>O</td>
</tr>
<tr>
<td>Indicators Group</td>
<td>Number of traffic fatalities per 10,000 cars</td>
<td>number of persons</td>
<td>O</td>
</tr>
<tr>
<td>Economic</td>
<td>Public transportation mode share</td>
<td>%</td>
<td>O</td>
</tr>
<tr>
<td>Indicators Group</td>
<td>Green transportation mode share</td>
<td>%</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Traffic congestion cost per capita</td>
<td>Korean Won/person</td>
<td>X</td>
</tr>
</tbody>
</table>

From among these, the green transportation (non-motorized transportation modes such as bicycle, walking, and electric cars) mode share and the traffic congestion cost per capita were excluded from the evaluation indicators owing to the limits of obtaining data. Additionally, for the greenhouse gases, only CO₂ was reflected because there is a limit of obtaining data, and CO₂ accounts for most of the greenhouse gases emitted.

This study evaluates transportation sustainability with the seven indicators above.

2.2 Evaluation Method
The unit, maximum value, or minimum value of statistical data is different for each indicator, so it is necessary to unify them with a single scale. That is, it is necessary to change
incomparable values such as population, area, and greenhouse gas emissions into an identical scale, and to express individual indicator values as one value. In this study, a standardized scoring method known as the “Z-score” was used for the standardization of individual indicators.

The original indicator values from investigation or measurement have different mean values, standard deviations, and measurement units, so it is impossible to compare these values or simply add or subtract them. The standardized score has been used for several existing evaluation systems to complement the gap between multiple indicator values.

There are several kinds of standardization scoring methods, such as the Z-score, T-score, H-score, and stanine score; the Z-score, which has been widely used in previous studies, was used in this study. The expression to calculate a Z-score is as follows:

$$Z_{ij} = \frac{X_{ij} - \bar{X}_j}{\sigma} \quad (Where, \ mean=0, \ s.d=1)$$

If the original indicator values are changed to Z-scores, the values can be classified into grades as shown in Table 2. This grade section can be randomly classified; a five-grade system is used in this study considering the number of target countries, and it is formed into the distribution shown in Figure 1. Grade 1 is considered the highest scoring grade.

Table 2 Grade classification

<table>
<thead>
<tr>
<th>Grade</th>
<th>Number in Grades</th>
<th>Distribution Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
<td>Upper 10%</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>10 - 30%</td>
</tr>
<tr>
<td>3</td>
<td>12</td>
<td>30 - 70%</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>70 - 90%</td>
</tr>
<tr>
<td>5</td>
<td>3</td>
<td>Under 90%</td>
</tr>
</tbody>
</table>

Figure 1 Diagram of standard normal distribution and grade
In the event that an individual indicator value has a negative (-) expected effect (for example, it is desirable to have decreased greenhouse gas emissions or number of traffic fatalities), the calculation was performed with the opposite sign of the original standardized value.

2.3 Evaluation Target and Basic Statistics
The evaluation target in this study is 29 OECD countries for which data can be collected.

Table 3 Target OECD countries for sustainability evaluation

<table>
<thead>
<tr>
<th>Classification</th>
<th>Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>North America</td>
<td>Canada, USA</td>
</tr>
<tr>
<td>Asia-Pacific</td>
<td>Australia, Japan, Korea, New Zealand</td>
</tr>
<tr>
<td>Europe</td>
<td>Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Poland, Portugal, Slovakia, Spain, Sweden, Switzerland, Turkey, UK</td>
</tr>
</tbody>
</table>

The data source of each statistic value used in this study is as shown in Table 4.

Table 4 Data source of each statistic value

<table>
<thead>
<tr>
<th>Classification</th>
<th>Indicators</th>
<th>Data</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area</td>
<td>Korea Statistical Information Service (in Korean) (<a href="http://kosis.kr/nsportal/abroad/abroad_04List.jsp">http://kosis.kr/nsportal/abroad/abroad_04List.jsp</a>)</td>
<td>1000m²</td>
<td></td>
</tr>
<tr>
<td>GDP per capita</td>
<td>OECD</td>
<td>USD, current Prices and PPPs</td>
<td></td>
</tr>
<tr>
<td>CO₂ emission on road</td>
<td>IEA, CO₂ emissions from fuel combustion, Annual Report</td>
<td>tCO₂</td>
<td></td>
</tr>
<tr>
<td>Air pollutant emissions on roads</td>
<td>OECD (<a href="http://www.oecd.org/document/49/0,3343,en_2649_34283_39011377_1_1_1,00.html">http://www.oecd.org/document/49/0,3343,en_2649_34283_39011377_1_1_1,00.html</a>)</td>
<td>kg</td>
<td></td>
</tr>
<tr>
<td>Evaluation Indicator</td>
<td>Number of traffic fatalities</td>
<td>Road Traffic Authority (in Korean) (<a href="http://taas.rota.or.kr/report7.jsp">http://taas.rota.or.kr/report7.jsp</a>)</td>
<td>persons</td>
</tr>
</tbody>
</table>
### 3. CALCULATION AND COMPARISON OF TRANSPORTATION SUSTAINABILITY

#### 3.1 Evaluation Indicator Values

The value of each evaluation indicator based on 2007 data is as shown in Table 5.

<table>
<thead>
<tr>
<th>Country</th>
<th>Total CO₂ emissions 1)</th>
<th>CO₂ emissions per capita 2)</th>
<th>CO₂ emissions per km² 3)</th>
<th>Air pollutant emissions per capita 4)</th>
<th>Number of traffic fatalities per 100,000 persons 5)</th>
<th>Number of traffic fatalities per 10,000 cars 6)</th>
<th>Public transportation mode share 7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td>127.1</td>
<td>3.86</td>
<td>1.3</td>
<td>152.4</td>
<td>8.4</td>
<td>1.3</td>
<td>3.3</td>
</tr>
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<td>USA</td>
<td>1,523.6</td>
<td>5.06</td>
<td>15.8</td>
<td>180.0</td>
<td>13.7</td>
<td>1.6</td>
<td>5.3</td>
</tr>
<tr>
<td>Australia</td>
<td>67.0</td>
<td>3.18</td>
<td>0.9</td>
<td>116.2</td>
<td>7.6</td>
<td>1.1</td>
<td>10.8</td>
</tr>
<tr>
<td>Japan</td>
<td>214.7</td>
<td>1.68</td>
<td>56.8</td>
<td>11.9</td>
<td>5.2</td>
<td>0.8</td>
<td>36.5</td>
</tr>
<tr>
<td>Korea</td>
<td>81.0</td>
<td>1.67</td>
<td>81.2</td>
<td>23.7</td>
<td>12.7</td>
<td>3.1</td>
<td>44.2</td>
</tr>
<tr>
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<td>13.4</td>
<td>3.17</td>
<td>5.0</td>
<td>175.3</td>
<td>10.0</td>
<td>1.3</td>
<td>2.9</td>
</tr>
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<td>Austria</td>
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<td>2.73</td>
<td>27.0</td>
<td>36.4</td>
<td>8.3</td>
<td>1.3</td>
<td>20.9</td>
</tr>
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<td>Belgium</td>
<td>24.3</td>
<td>2.28</td>
<td>0.7</td>
<td>28.7</td>
<td>10.1</td>
<td>1.7</td>
<td>19.9</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>17.7</td>
<td>1.71</td>
<td>22.4</td>
<td>34.4</td>
<td>11.9</td>
<td>2.3</td>
<td>24.3</td>
</tr>
<tr>
<td>Denmark</td>
<td>13.0</td>
<td>2.38</td>
<td>30.2</td>
<td>45.9</td>
<td>7.4</td>
<td>1.5</td>
<td>20.5</td>
</tr>
<tr>
<td>Finland</td>
<td>12.3</td>
<td>2.33</td>
<td>3.6</td>
<td>55.5</td>
<td>7.2</td>
<td>1.2</td>
<td>15.0</td>
</tr>
<tr>
<td>France</td>
<td>121.3</td>
<td>1.96</td>
<td>22.1</td>
<td>32.9</td>
<td>7.5</td>
<td>1.2</td>
<td>15.1</td>
</tr>
<tr>
<td>Germany</td>
<td>140.8</td>
<td>1.71</td>
<td>39.4</td>
<td>24.0</td>
<td>6.0</td>
<td>0.9</td>
<td>14.5</td>
</tr>
<tr>
<td>Greece</td>
<td>19.4</td>
<td>1.73</td>
<td>14.7</td>
<td>77.7</td>
<td>14.4</td>
<td>2.2</td>
<td>20.1</td>
</tr>
<tr>
<td>Hungary</td>
<td>12.7</td>
<td>1.26</td>
<td>13.6</td>
<td>61.5</td>
<td>12.2</td>
<td>3.5</td>
<td>38.3</td>
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<tr>
<td>Iceland</td>
<td>0.9</td>
<td>2.75</td>
<td>0.8</td>
<td>70.1</td>
<td>4.9</td>
<td>0.6</td>
<td>11.4</td>
</tr>
<tr>
<td>Ireland</td>
<td>13.8</td>
<td>3.17</td>
<td>19.6</td>
<td>44.2</td>
<td>7.8</td>
<td>1.4</td>
<td>16.4</td>
</tr>
<tr>
<td>Italy</td>
<td>115.6</td>
<td>1.96</td>
<td>38.4</td>
<td>41.7</td>
<td>8.7</td>
<td>1.2</td>
<td>16.7</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>6.4</td>
<td>13.42</td>
<td>2.5</td>
<td>69.3</td>
<td>9.0</td>
<td>1.1</td>
<td>15.2</td>
</tr>
<tr>
<td>Netherlands</td>
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<td>2.06</td>
<td>81.3</td>
<td>28.1</td>
<td>4.3</td>
<td>0.8</td>
<td>13.3</td>
</tr>
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<td>10.8</td>
<td>2.29</td>
<td>3.3</td>
<td>46.5</td>
<td>5.0</td>
<td>0.7</td>
<td>11.9</td>
</tr>
<tr>
<td>Poland</td>
<td>40.7</td>
<td>1.07</td>
<td>13.0</td>
<td>23.5</td>
<td>14.6</td>
<td>2.9</td>
<td>16.4</td>
</tr>
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<td>Portugal</td>
<td>18.1</td>
<td>1.70</td>
<td>19.6</td>
<td>30.6</td>
<td>9.2</td>
<td>2.2</td>
<td>14.6</td>
</tr>
<tr>
<td>Slovakia</td>
<td>5.5</td>
<td>1.01</td>
<td>11.2</td>
<td>29.6</td>
<td>11.6</td>
<td>3.5</td>
<td>27.6</td>
</tr>
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<td>Spain</td>
<td>100.6</td>
<td>2.24</td>
<td>19.9</td>
<td>34.9</td>
<td>8.6</td>
<td>1.3</td>
<td>19.0</td>
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<td>Sweden</td>
<td>21.0</td>
<td>2.30</td>
<td>4.7</td>
<td>33.7</td>
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<td>0.9</td>
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</tr>
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<td>16.6</td>
<td>2.20</td>
<td>40.3</td>
<td>32.2</td>
<td>5.1</td>
<td>0.7</td>
<td>20.2</td>
</tr>
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<td>41.6</td>
<td>0.56</td>
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<td>3.8</td>
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<td>UK</td>
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<td>1.96</td>
<td>49.1</td>
<td>25.9</td>
<td>5.0</td>
<td>0.9</td>
<td>12.7</td>
</tr>
</tbody>
</table>

Units: 1) million tCO₂, 2) tCO₂ / capita, 3) 1000 tCO₂ / 1000m², 4) kg / capita, 5), 6) person, 7) %

#### 3.2 Calculation of Transportation Sustainability Grade

The evaluation was then performed for 29 OECD countries from 2000 to 2007, considering the continuity of data. And, a weight for each of indicator group and individual indicator was not applied.
The transportation sustainability evaluation grade in each country and indicator based on 2007 data is as shown in Table 6.

Table 6 Transportation sustainability evaluation grade for each indicator (based on 2007 data)

<table>
<thead>
<tr>
<th>Country</th>
<th>Total CO₂ emissions</th>
<th>CO₂ emissions per capita</th>
<th>CO₂ emissions per km²</th>
<th>Air pollutant emissions per capita</th>
<th>Number of traffic fatalities per 100,000 persons</th>
<th>Number of traffic fatalities per 10,000 cars</th>
<th>Public transportation mode share</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td>4</td>
<td>5</td>
<td>2</td>
<td>5</td>
<td>3</td>
<td>3</td>
<td>5</td>
<td>4</td>
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<tr>
<td>USA</td>
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</tr>
<tr>
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<td>1</td>
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</tbody>
</table>

The distribution in each grade among continents is shown in Table 7.

Table 7 Distribution of countries and continents for each grade (based on 2007 data)

<table>
<thead>
<tr>
<th>Grade</th>
<th>N. America</th>
<th>Asia-Pacific</th>
<th>Europe</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-</td>
<td>-</td>
<td>Norway, Sweden, Turkey</td>
</tr>
<tr>
<td>2</td>
<td>-</td>
<td>Japan</td>
<td>Belgium, Finland, Germany, Iceland, Switzerland</td>
</tr>
<tr>
<td>3</td>
<td>-</td>
<td>-</td>
<td>Austria, Czech Republic, Denmark, France, Ireland, Italy, Netherlands, Portugal, Slovakia, Spain, UK</td>
</tr>
<tr>
<td>4</td>
<td>Canada</td>
<td>Australia, Korea</td>
<td>Greece, Hungary, Poland</td>
</tr>
<tr>
<td>5</td>
<td>USA</td>
<td>New Zealand</td>
<td>Luxembourg</td>
</tr>
</tbody>
</table>

Note: The order of nations in each grade does not indicate rank within a grade.
As a result of the evaluation, Norway, Sweden, and Turkey rank within the first grade; USA, New Zealand, and Luxembourg are in the fifth grade. In the Asia-Pacific area, Japan is in the second grade. Korea is in grade 4, because Korea scored poorly for most indicators, except the public transportation mode share, CO₂ emissions per capita, and air pollutant emissions per capita. Most European countries, scored satisfactorily.

The results of the transportation sustainability evaluation for each year and country are shown in Table 8.

Table 8 Results of transportation sustainability evaluation for each year and country

<table>
<thead>
<tr>
<th></th>
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</tbody>
</table>

As a result of the time series evaluation, Sweden and Turkey appear in grade 1 since 2000, and Norway has been in the same grade since 2001. Japan, Finland, and Switzerland have been in the second grade continuously, and Ireland, Spain, and the UK have been in the third grade continuously. On the contrary, the USA and Luxembourg have been in the fifth grade continuously.

On the other hand, as shown in Figure 2 below, Hungary, Poland, and Slovakia have worsened from grade 2 down to 4, grade 3 down to 4, and grade 1 down to 3, respectively.
This suggests that it is important to make constant efforts to keep at a country’s present level, since it requires much time effort to return to the average.

Figure 2 Case of worsened transportation sustainability

Table 9 shows the change of evaluation grade in 2007 as compared with 2000.

<table>
<thead>
<tr>
<th>Classification</th>
<th>Change</th>
<th>Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved Sustainability</td>
<td>Grade 1</td>
<td>Korea, Belgium, France, Germany, Iceland, Norway, Portugal</td>
</tr>
<tr>
<td>Worsened Sustainability</td>
<td>Grade 1</td>
<td>New Zealand, Austria, Poland</td>
</tr>
<tr>
<td></td>
<td>Grade 2</td>
<td>Hungary, Slovakia</td>
</tr>
</tbody>
</table>

4. COMPARATIVE EVALUATION OF EACH INDICATOR GROUP AREA

4.1 Comparison of Balance Level
The balanced development of transportation sustainability plays a very important role in constructing the proper level of national transportation sustainability. In this chapter, the balance level was examined using a comparison of the relation between three indicator groups—environmental, social, and economic—based on 2007 data.

In type 1, the three indicator groups are balanced and higher than the average (it is 50, expressed with a heavy dotted line in Figure 3). Austria, Denmark, and Switzerland, which have been developed in a balanced way, are in type 1. In type 2, two indicator groups are balanced, but the other one is not. Japan, Belgium, Czech Republic, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Norway, Slovakia, Spain, Sweden, and Turkey are in type 2.
Type 3 includes Canada, Australia, Korea, Italy, Luxembourg, Netherlands, Poland, Portugal, and the UK, which need improvement in two indicator groups Figure 4. Type 4 includes the USA and New Zealand, which need balanced improvement in all of the three indicator groups.
4.2 Comparison of Service Level on the Evaluation Coordinate

Sometimes it is necessary to compare the level of more than two indicator groups and perform an integrated analysis to maintain and develop the national sustainability in a balanced way, thereby establishing the proper policy. A pair wise comparison between two indicator groups can be performed using a two-dimensional graph, plotting each indicator on one axis.

4.2.1 Comparison Between Environmental Indicator Group and Social Indicator Group

According to the comparison between the environmental indicator group and social indicator group shown in Figure 5, there are 11 countries including Austria, Denmark, and Finland.
which have superior indicator values in both of these two indicator groups, all of which are in Europe Table 10. Most of the cities in these countries are distributed around the mean value. On the other hand, it is necessary for the USA and Korea to improve in both of the two indicator groups.

![Figure 5 Distribution of countries according to the relation between indicator groups (Environmental indicator group vs. social indicator group)](image)

Table 10 Analysis of characteristics of indicator group service level (Environmental indicator group vs. social indicator group)

<table>
<thead>
<tr>
<th>Quadrant</th>
<th>Environmental indicator</th>
<th>Social indicator</th>
<th>Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>+</td>
<td>+</td>
<td>Austria, Denmark, Finland, France, Germany, Iceland, Ireland, Norway, Spain, Sweden, Switzerland</td>
</tr>
<tr>
<td>2</td>
<td>—</td>
<td>+</td>
<td>Canada, Australia, Japan, Italy, Luxembourg, Netherlands, UK</td>
</tr>
<tr>
<td>4</td>
<td>+</td>
<td>—</td>
<td>Belgium, Czech Republic, Greece, Hungary, Poland, Portugal, Portugal, Turkey</td>
</tr>
<tr>
<td>3</td>
<td>—</td>
<td>—</td>
<td>USA, Korea, New Zealand</td>
</tr>
</tbody>
</table>

4.2.2 Comparison Between Environmental Indicator Group and Economic Indicator Group

According to the comparison between the environmental indicator group and the economic indicator group shown in Figure 6, there are nine countries including Austria and Belgium which have superior indicator values in both of these two indicator groups, all of which are in Europe Table 11. On the other hand, there are eight countries which have inferior indicators in both the environmental indicator group and economic indicator group.
Table 11 Analysis of characteristics of indicator group service level (Environmental indicator group vs. economic indicator group)

<table>
<thead>
<tr>
<th>Quadrant</th>
<th>Environmental indicator</th>
<th>Economic indicator</th>
<th>Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>+</td>
<td>+</td>
<td>Austria, Belgium, Czech Republic, Denmark, Greece, Hungary, Slovakia, Switzerland, Turkey</td>
</tr>
<tr>
<td>2</td>
<td>—</td>
<td>+</td>
<td>Japan, Korea</td>
</tr>
<tr>
<td>4</td>
<td>+</td>
<td>—</td>
<td>Finland, France, Germany, Iceland, Ireland, Norway, Poland, Portugal, Spain, Sweden</td>
</tr>
<tr>
<td>3</td>
<td>—</td>
<td>—</td>
<td>Canada, USA, Australia, New Zealand, Italy, Luxembourg, Netherlands, UK</td>
</tr>
</tbody>
</table>

4.2.3 Comparison Between Social Indicator Group and Economic Indicator Group

According to the comparison between the social indicator group and the economic indicator group shown in Figure 7, there are four countries including Japan and Austria which have superior indicator values in both of these two indicator groups Table 12. On the other hand, there are three countries including the USA and Poland which have inferior indicators in both of these two indicator groups.
5. COMPARISON BETWEEN ECONOMIC SCALE AND TRANSPORTATION SUSTAINABILITY

5.1 Assumptions
GDP per capita has been widely used as an indicator to measure national economic scale. But it is necessary to examine whether there is a positive relation between economic scale and transportation sustainability. That is, it is necessary to examine whether transportation sustainability is improved as the economy grows.

5.2 Comparison Between Economic Scale and Transportation Sustainability
The relation between rank in GDP per capita (current prices and purchasing power parity) and transportation sustainability grade was compared for the countries evaluated in the sections above. The assumption among the authors was that there would a positive relationship.
However, according to this comparison, there was no definite positive relationship between transportation sustainability and economic scale. Each country was ranked according to the z-scale into five grades, similar to the sustainability indicators. The mean transportation sustainability grade of countries which have higher GDP per capita within the first grade is 3.7, but the mean transportation sustainability grade of countries in the third grade for economic scale is 2.4. In the case of Luxembourg, the USA, and Turkey, there was a negative relationship between economic scale and sustainability.

Table 13 Rank in GDP per capita and transportation sustainability grade

<table>
<thead>
<tr>
<th>Countries</th>
<th>GDP per capita (USD, based on=2007)</th>
<th>Grade of economic scale</th>
<th>Grade of Transportation Sustainability</th>
<th>Mean grade of Transportation Sustainability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Luxembourg</td>
<td>79,793</td>
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<td></td>
</tr>
<tr>
<td>Norway</td>
<td>53,477</td>
<td>1</td>
<td>1</td>
<td>3.7</td>
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<tr>
<td>USA</td>
<td>45,489</td>
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<tr>
<td>Ireland</td>
<td>45,027</td>
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<td>3</td>
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<td>Switzerland</td>
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<td>3.2</td>
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<td>Canada</td>
<td>38,500</td>
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<td>37,565</td>
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<tr>
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<td>Denmark</td>
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<td>34,391</td>
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<tr>
<td>Japan</td>
<td>33,626</td>
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<tr>
<td>France</td>
<td>32,686</td>
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<td>New Zealand</td>
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<tr>
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</tr>
<tr>
<td>Turkey</td>
<td>12,993</td>
<td></td>
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<td>1</td>
</tr>
</tbody>
</table>
Even if the values of countries which have a negative relationship between economic scale and sustainability are excluded, it is still insufficient to show a positive relation between economy and sustainability. In this analysis, a sustainability index with a mean value of 50 was used instead of the sustainability grade Figure 8.

\[ y = 0.0002x + 45.509 \]
\[ R^2 = 0.2651 \]

Figure 8 Relation between economy and sustainability

6. CONCLUSION AND FUTURE RESEARCH

6.1 Main Results
This study evaluated the sustainability in 29 OECD countries using the sustainable transport indicators outlined in the Korean Sustainable Transportation and Logistics Development Law. According to the evaluation based on 2007 data, European countries such as Norway and Sweden received a favorable evaluation, while Korea was in grade 4; Canada, the USA, Australia, and New Zealand scored even lower.

According to the annual analysis, Norway, Sweden, and Turkey have been stably and continuously in the first grade, but the transportation sustainability in some Eastern European countries have been getting progressively worse.

As a result of comparing the balance levels among the indicators for each country, there are more countries with good transportation sustainability than there are countries which need to be improved, and in particular, some countries which are seriously unbalanced in transportation sustainability need to make more concerted efforts to improve.

According to these results, there is not enough data to explain the relationship between economic scale and transportation sustainability, because the results could be different if other economic indicators are applied.
This study can be meaningful in examining the present position of Korea relative to other nations helping to establish and enforce future sustainable transportation policy.
6.2 Limitations and Future Research
There are some suggestions in this study, and also there are some limitations. First, the sustainable transport indicators applied in this study have been developed in Korea, so they may be insufficient for explaining transportation sustainability in each country, though it is useful to compare and understand the present position of OECD countries with identical indicators. It is necessary to perform mutual comparisons with international standards or other standards.

Second, weights were not applied for each indicator group. The purpose of this was to better evaluate balanced development, but if weights were applied, the results could be different.

Third, for the economic indicator group, only the public transportation mode share was used owing to the limit of obtaining data, and this cannot represent all of the economic indicator group. It is necessary to complement this with the green transportation mode share or other substitutive indicators.

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