An Appraisal of National Public and Private Road Transportation Sustainability: A Global Comparison

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Abstract

This paper is an endeavor to identify and characterize national public and private transport sustainability. Using a pioneer measure for sustainable development (SD), based on the conformity of the growths of all sectors with the transport aspects, the selected countries are comparatively studied. The proposed measure, elasticity, is the indicator of "harmonic development" reflecting sustainability. Using individual elasticities, composite sustainability indices were suggested. Then, for comparative appraisal, country groupings were developed. The results of the paper are used to find show-cases for countries with respect to public and private SD. The methodology may be applied to any other time and geographic scope for addressing pertinent issues for balancing and SD of transport systems.

Key words: Road transport, sustainable development, transport policy, public transport, private transport, comparative analysis.

Introduction

Despite its key role in economic and social development, transport has many spill-over effects such as congestion, safety, pollution and non-renewable resource depletion. Generally, the prevailing concern during last forty years has been undesirable socio-environmental impacts of population, urbanization and economic growths (1-2). The concept of sustainable transport is derived from these concerns that imply movement of people and goods in ways that are environmentally, socially and economically sustainable (3-6).

For motorized urban passenger transport, two groups of private and public transport are often distinguishable as categorized by the types of operation and usage *(7)*. Private transport reflects privately owned vehicles operated by owners for their own use. In this group, private auto is the most common mode. Public transport reflects for-hire and common carrier transport. For-hire transport, often designated as paratransit, is provided by an operator, is available to users who meet the conditions of a contract for carriage, and is adjustable in various degrees to passenger's trip and desire. Due to lack of centralized data, they were not included in public or private transport modes in the study reported herein.

In order to address some of pertinent sustainability issues, as a preliminary step, a comparative macroscopic assessment of private and public road transport systems at the national level was conducted from economic, environmental and social perspectives (EES). The study objective is to

quantify and to address public and private road transport sustainability through an international comparative assessment. Therefore, the paper aims to uncover the extent of growth consistency between private and public road transport, and EES for selected countries. The methodology is to obtain a set of indices which assigns each country an ordinal value which specifies the situation of that country among the others. Furthermore, according to their performance, countries are categorized in order to identify the countries with similar trends in their harmonic development.

As other transport modes also may be classified as public or private, they could have been considered in the study reported herein. Nevertheless, the study focused on road transport due to lack of relevant data for other modes. Of particular interest was the rail transport that plays significant role in urban transport in large cities. Study of rail transport was excluded, because the time-series data were scarce and the mode was only available in large cities for intra-city trips. Furthermore, for intercity trips, consideration of rail transport would have required consideration of other modes such as air transport.

FIGURE 1 shows the framework based on which the study was performed. It is an attempt to achieve a unique sustainability index from raw data reported annually for the countries. These indices which include highly aggregated indicators, top an information pyramid, whose base is primary data derived from monitoring and data analysis *(8)*. The main idea behind these steps is to find benchmarks for public and private SD. The paper attempts to uncover some patterns of the overall development of countries, in order to point to some "good" countries as showcases, on one hand, and categorize the countries based on their similarity in trends of development.

The paper is organized as follows: first, discussion about the application of elasticity to measure sustainability is presented. Second, using elasticity as a measure of sustainability is discussed. Then, the database and its statistical analysis are described. Then the elasticity analysis and the integration of single indicators to composite indices are presented and taxonomy of countries is proposed. At the end, the study conclusions and reference are presented.

Elasticity As A Measure of Sustainability

Although there is no unified definition and interpretation of sustainability, most studies have the common feature of quantifying it by the indicators that are related to the three key dimensions of EES (9-17). In order to perform a comparative macroscopic assessment of public and private transport at the national level from the EES perspectives, one way is redefining the popular term "sustainable development" (SD) as "harmonic development", because consistency among the changes of all these three aspects as well as public and private transport would naturally cause SD. In other words, when a country grows in economic sector only, and diminishes in the other dimensions such as environment, it is not on a sustainable way, but when it flourishes in all aspects simultaneously and harmonically, it could be considered as a country with SD. The current paper proposes elasticity as a measure of sustainability based on this special viewpoint. The preferred measure of the relationship is the proportional or percent change in the variables that is also dimensionless. Generally elasticities greater than 1 indicate an elastic relationship and those less than one reflect an inelastic relationship

(6). In the current paper, which comparatively studies the relationship between EES variables; and public and private transport variables, the ordinal values of elasticity among countries are important and are used to assess sustainable transport of the countries. Elasticity has limitations and strengths. It is often used for large systems studies with enormous variables when the cause and effect relations are complex and vague. It gives simple and interpretable results for any type of data, irrespective of dimensionality and/or causality. It measures EES changes with respect to transport change and therefore is a trend variable (18). This characteristic also implies that elasticity reflects the relative dynamic behavior of the variables. The term “relative” herein means that elasticity shows the trends of variables but does not reflect their state.

Database and Variable Selection

In order to perform the previously mentioned assessment, relevant time-series transport, social, environmental and economic information was gathered and analysed. The main encountered problems encountered were the availability and accessibility to comparable relevant transport data on demand, supply, utilization and impacts at the national level. Few past studies have attempted such a comparative assessment, but mostly have addressed the issues qualitatively (19). After evaluation of the centralized and accessible time-series databases and their completeness, the limited study resources confined the selected countries to around one third across the globe. Due to incompleteness of data, two variables have been selected to reflect the public and private aspects of road transport. They are acceptable approximates and surrogate national transport supply measures available for different countries in a time-series context.

Preliminary evaluation of the accessible centralized databases covered the three decades covering years of 1970 to 2000 for more than 190 countries. The initially collected relevant national data included more than 450 variables encompassing categories of transport, demographic, economic, social, environmental, geographical and political *(20-22)*.

Due to many missing data, it was necessary to find a subset of variables presenting key dimensions of sustainability. The process of data refinement and reduction included several stages of univariate and multivariate statistical analyses. By using factor analysis and a cut-off rule for minimum number of non-missing data, the number of variables in each group was significantly reduced. The process of data reduction is lengthy and thus is not reported in details herein. The reliability of database was checked as much as possible when the respective governments had reported the data to international agencies. The selected variables were neither standard nor unique and far from ideal; nevertheless, they reflected the major required dimensions.

The final study database was confined to 20 variables for 67 countries. Two variables have been selected to represent the public and private aspects of transport. An acceptable surrogate of private road transport was the total number of passenger cars in usage, although a small portion of

automobiles might have been used for public transport, such as in paratransit. An acceptable surrogate of public transport was the total number of buses in usage, although a small portion of buses might have been used for private transport. Availability of other relevant national road transport data such as information on utilization, cost, benefit, energy consumption, safety and environmental impact could have greatly enhanced the study results.

The selected 67 countries covered all five continents and met minimum data requirements. They were: 24 in Europe, 19 in Asia, 11 in America, 9 in Africa and 4 in Oceania, respectively. TABLE1 has tabulated the selected countries and their continents.

To reflect transport relationships and impacts on non-transport variables, ideally, those that were most influenced by transport should have been selected. For some of the selected variables, such as energy consumption in the environmental group, the relationships are intuitive. After evaluation of more than 450 variables in the initial database, it was decided that social, environmental and economic groups should be presented in order to reflect the three key dimensions of sustainability. Harmonization of development in any of the key dimensions with respect to transport development is desirable and hints towards sustainable development, even if the direct relationship is perceived fuzzy or questionable.

The final database comprised of three variables in transport group and three variables for each of the three groups of economy, social aspect, and environment. The time scope of detail assessment covered the period of 1980-1995, when due to many missing data other periods of 1970-1980 and 1995-2000 were excluded for further analysis. TABLE 2 shows the final study database structure and variables. The variable names are consisted of four characters. The first character reflects the group membership; the remaining three characters reflect the variable description. Two transport variables were: TPUB reflecting number of buses and coaches in thousand and presenting public transport, and TPRV reflecting number of passenger cars in thousand and presenting private transport, respectively.

Availability of more relevant comparative national data on public and private transport demand, supply and utilization, and their more direct economic, social and environmental impacts could have greatly enhanced the study results. Nevertheless, due to the limited resources of the study reported herein, the database was confined to abovementioned variables. As a consequence, the study results would be of more methodological interest, and their direct national policy implications render caution.

Primary Statistical Analyses

The univariate statistical analysis of the database shed light on the database cross-sectional and time-series variability. For both 1980 and 1995, the mean values of TPRV were around hundred times of TPUB. Furthermore, for both 1980 and 1995, the coefficients of variation in descending order belonged to environmental, transport, economic and social variables, respectively. For 1980, the

average coefficients of variation for transport, social, environmental and economic variables were 2.97, 0.84, 3.06 and 1.57, respectively. The analyses showed that the mean values of TPUB and TPRV have increased during period 1980-1995. Nonetheless, TPRV, number of cars in usage, on the average has increased around hundred times of TPUB, number of buses in usage. These unparallel growths are not aligned with advocacy for increasing role for public transport, and raise concerns about sustainable development of transport. During the study period, all social variables did not show promising growths. Increase of mean value for SUPN, urban population as a percent of total, were not in support of sustainable development. Some of the environmental variables showed less promising trends such as growths in mean values of energy variables ETEU and ETEP, and CO2 emissions ECO2. The economic variables, nevertheless, showed favorable growths in the context of sustainability except CTCN, total consumption.

For 1995, the average coefficients of variation for transport, social, environmental and economic variables were 2.67, 0.76, 2.77 and 1.67, respectively. Their average annual changes for the period of 1980 to 1995 were not always favorable with respect to sustainable development.

TABLE 3 shows key statistics for the changes during the period of 1980-1995. Changes of transport variables, ΔTPUB and ΔTPRV, showed high coefficients of variation. Based on the reported data, few countries showed negative growths. The database had reduction of TPUB for Australia, Belgium, Iceland, Japan, Malawi, Papua New Guinea, South Africa, Suriname, United Kingdom and Venezuela. Furthermore, the database had reduction of TPRV for Honduras, Iran, Madagascar, Malawi and Tanzania. Based on average coefficients of variation of changes, in descending order economic, environmental, transport and social variables showed the highest variability, respectively. TABLE 3 shows that the variables had significant variations in their changes from year 1980 to 1995. The study database univariate analysis showed significant cross-sectional and time-series variability. Nevertheless, the changes were not always in support of sustainable development.

Furthermore, to develop an understanding of the interrelationship among the database variables, as a first step, pair-wise correlation analysis for both years of 1980 and 1995 was performed. The size of two 20x20 correlation matrices prevented their display herein. The resulted matrices revealed a number of interesting patterns and were found useful in elasticity analysis phase of the study. Many pairs of variables were found correlated at a level of significance 0.05. For years 1980 and 1995, TPUB was positively and significantly correlated with STLF, ECO2, ETEP, CGDP, CTCN and TPRV. For years 1980 and 1995, TPRV was positively and significantly correlated with STLF, ECO2, ETEP, CGDP, CTCN, and TPUB.

Elasticity Analysis

Elasticity is a concept, often used in economics, which reflects the relationship of changes for one variable with respect to another variable. The preferred measure of the relationship is the proportional

or percent change in the variables that is also dimensionless. It is often used for large systems studies with enormous variables when the cause and effect relations are complex and vague. Elasticity gives simple and interpretable results for any type of data, irrespective of dimensionality and/or causality. As a preliminary exploration into public and private road transport sustainability and balancing, two types of elasticity were developed. The first type reflected the elasticity of public transport with respect to private transport. The arc elasticity E of a variable Y with respect to a variable X for the period t1-t2 reflects the percent variable Y changes with respect to one percent change of the variable X as is shown by Equation 1:

$$E_{Y/X,t1-t2} = [(Y_{t2} - Y_{t1})/(Y_{t2} + Y_{t1})] / [(X_{t2} - X_{t1})/(X_{t2} + X_{t1})] \quad (1)$$

Where $E_{Y/X,t1-t2}$ is the arc elasticity of variable Y with respect to variable X during the period t1 to t2. As the period of t1-t2 gets smaller and converges to zero, the arc elasticity converges to point elasticity. For the period of 1980 to 1995, $E_{TPUB/TPRV}$, the arc elasticity of public transport TPUB with respect to private transport TPRV was computed and the values are summarized in TABLE 4. Thirteen countries with either reduction of TPUB or TPRV showed negative elasticities. Malawi with reduction of both TPUB and TPRV showed a positive elasticity. Fifty-three countries with growths in both TPUB and TPRV showed positive elasticities. Forty countries showed elasticity values less than one, confirming growths in the number of buses but not with the same pace as of the growth for the number of cars. The average value of elasticity was 0.466, when only around one fifth of the countries showed elasticities greater than one. The average elasticity of smaller than one raises some concerns in the context of public and private transport balancing if higher public transport growth is advocated and desirable.

To further assess sustainability, elasticities of non-transport variables with respect to transport variables were computed. The second type reflected the elasticity of the social, environmental and economic variables with respect to public and private road transport variables. In the absence of any perceived and intuitive causal relationships between transport and social, environmental and economic variables, sustainability is deemed to be characterized by a manifold growth or diminishment, depending on the nature of variables, in harmony and consistency with transport growth. In this part, elasticity of 3 social variables, SLEX to SUPN, 3 environmental variables, ETEU to ETEP, and 3 economic variables, CGDP to CTCN, with respect to the two transport variables TPUB and TPRV were studied. In the absence of intuitive relation, elasticity still was found proper to reflect harmony or disharmony between two variables over a period of time.

For each country, based on non-missing values, a maximum of 18 elasticities for the period of 1980-1995 were computed. For Equation 1, Y's were SLEX to SUPN, ETEU to ETEP, and CGDP to CTCN, and X's were TPUB and TPRV. Study of individual elasticities revealed a number of interesting patterns. Each country was characterized by a profile consisting of 36 measures hinting on different dimensions for sustainable development with respect to the 2 transport variables. To support

sustainability, reductions of non-transport variables ETEU, ECO2, and CTCN were found more desirable, irrespective of transport variables lessening or growth. The developed arc elasticities provided dimensionless and acceptable measures to assess changes for pairs of non-transport and transport variables during the period 1980 to 1995. They encompassed key sustainable development dimensions of social, environmental and economic variables with corresponding transport variables. Each of the developed elasticities represented a unique facet hinting on sustainable development, harmony and balancing. They were found acceptable indicators for sustainability appraisal addressing specific subjects pertinent to the involved pairs of variables. The developed elasticities offered a profile for each country consisting of 36 indicators. Nevertheless, space limitation prohibited their display herein.

Aggregating Individual Elasticities

Each indicator is a single dimension addressing a particular aspect of the system sustainability. Having measured individual indicators, their aggregation has been suggested to reflect the overall system status. The developed composite indices often are not very intuitive to interpret; nevertheless, they reflect all-inclusive measures. They are needed for overall comparative appraisal and benchmarking.

Development of 36 elasticities made available a base to develop composite sustainability indices. The idea behind the concept of sustainability, as discussed earlier, emphasizes on multi-dimensionality of issues and balanced focus on changes of key dimensions. Consequently, the individual elasticities were aggregated for a single overall measure that contained information from all dimensions. The developed aggregate measures of elasticities with respect to either public or private transport reflected the extent to which all aspects comparatively have changed with respect to changes in public or private transport. The developed composite index for each transport variable reflected how harmonized the country has overall grown with respect to public or private transport. There are many suggestions to combine different sustainability indicators to develop a single measure to present the approximate overall status *(23-24).* As social, environmental and economic are the major dimensions of sustainability, for each group an aggregate measure was developed. To make elasticities comparable, Z scores were computed by the following equation:

$$ZE_{Y/X} = [E_{Y/X} - M(E_{Y/X})] / S(E_{Y/X}) \quad (2)$$

where $ZE_{Y/X}$ is the Z score of the $E_{Y/X}$ as computed by Equation 1, and M and S are functions that provide the mean and the standard deviation of their arguments, respectively. The composite index CI for each of the social, environmental and economic groups, was computed using the Z scores:

$$CI_{G/X} = (\Sigma\, \alpha_Y\, ZE_{Y/X}) \;/\; \Sigma\, |\alpha_Y| \quad (3)$$

where $CI_{G/X}$ is the composite index of group G, either social, S group, environmental, E group, or economic, C group, with respect to transport variable X, T group, either TPUB or TPRV, α_Y's are

coefficients that are +1 for elasticities with desirable positive sign and -1 for those with desirable negative sign, when Y variable is ETEU, ECO2, and CTCN, and $|\alpha_Y|$ is the absolute value of α_Y. To develop an overall sustainability index, social, environmental and economic composite indices were again aggregated as weighted combination:

$$SI_X = (\beta_S CI_{S/X} + \beta_E CI_{E/X} + \beta_C CI_{C/X}) / (\beta_S + \beta_E + \beta_C) \quad (4)$$

where SI_X is the sustainability index of transport variable X, β_S, β_E and β_C are the weighting factors of social, environmental and economic dimensions, respectively. TABLE 4 also shows the results of the above-mentioned computations, using equal weighting factors, $\beta_S = \beta_E = \beta_C$. Based on Z score computation and usages, as reflected by Equation 2, the negative values for sustainability index should be interpreted in the context of comparative assessment.

In the context of sustainable development, the larger composite index values reflected comparatively preferred overall social, economic and environmental developments with respect to transport development. The composite indices reflected the overall harmony and uniformity between non-transport groups on the one hand, and each transport variable on the other hand. In this respect, TABLE 4 shed some light on the overall comparative sustainability situation of countries. Countries with higher indices are comparatively more sustainable. Although each country is unique due to its inherent characteristics, history and background, it can learn about sustainability from others. Countries with high scores can be used as showcases for good practice and experience sharing. For sustainability indices with respect to public transport, SI_{TPUB}, and with respect to private transport, SI_{TPRV}, 45 and 36 countries showed negative values, respectively. Thirty-two countries showed negative values for both SI_{TPUB} and SI_{TPRV}. The highest SI values from the public and private transport were for Netherlands and Papua New Guinea, respectively. The lowest SI values from the public and private transport were for Tanzania and Hong Kong, respectively. As expected, the mean values of SI_{TPUB} and SI_{TPRV} were close to zero.

Taxonomy of the Countries

Based on $E_{TPUB/TPRV}$, SI_{TPUB} and SI_{TPRV} for a comparative sustainability assessment, taxonomy of the countries was developed and is presented in FIGURE 2. Several classifications were developed, using different combinations of the developed elasticities and indices. The taxonomy reported herein was found superior as it reflected all the involved elasticities in a hierarchical order. The taxonomy of countries put forward an acceptable ranking for comparative analysis and show-casing. The classification can be used in learned lessons and experience sharing among and between groups. In modelling process, as an example, information of peer countries may be used, as a compliment or instead of including all countries. Each country is unique due to its multi-facet backgrounds on social, political, economic, geographical, demographic, environmental, climate and transport characteristics. The policies for sustainable development should be tailored and customized to nation's unique

circumstance, setting and eminence. Nevertheless, peer comparison would be conducive to policy enhancement.

The 67 countries were distributed among 13 groups. Three kinds of criteria were considered: The first one relates to elasticity $E_{TPUB/TPRV.}$ For this elasticity three criteria were considered: Negative elasticities show reverse change of public and private transport and thus inconsistent development. Elasticities between 0 and 1 reflect a kind of relationship in which public transport has changed in the direction of private transport change but slower than it. Conversely, Elasticities greater than 1 show changes of public transport faster than that of private transport. The second type of criteria (ΔTPUB and ΔTPRV) is utilized to consider special cases in which transport variables have declined, and hence have affected on elasticity values. The third type of criteria is obtained by considering the sign of composite indices, in order to reflect the consistency or inconsistency of development with respect to each transport aspect.

The first 6 groups with 14 countries had negative values for ΔTPUB and/or ΔTPRV, reflecting rather less probable situations of decrease in either or both of the transport fleets. These could have been due to possible recording errors in any of the involved stages of database development. Nevertheless, they presented possibilities that reflected especial situations. For these 14 countries, interpretations of SI_{TPUB} and SI_{TPRV} were complex and needed detailed evaluation of each of the 36 original elasticities. The next 7 groups with 53 countries reflected countries with positive values for ΔTPUB and ΔTPRV. Among these, the last group, consisting of 3 countries, was in better harmonization, balancing and sustainability status than the rest. They demonstrated more relative growths for public transport and superior sustainability indices. These three European countries of Bulgaria, Demark and Ireland may offer information on their good practices and development experiences.

FIGURE 2 facilitates interpretation of TABLE 4 with respect to $E_{TPUB/TPRV}$, SI_{TPUB} and SI_{TPRV} for each country. Interpretation for the 53 countries with positive values for ΔTPUB and ΔTPRV such as Denmark is intuitive. It has $E_{TPUB/TPRV}$ equal to 2.561, reflecting that percentage public transport fleet growth exceeded percentage private transport fleet growth, SI_{TPUB} equal to 0.001 and near zero, reflecting average standing among the selected countries with respect to SI_{TPUB} , and SI_{TPRV} of 0.604, reflecting above average standing with respect to SI_{TPRV}. Interpretation of SI_{TPUB} and SI_{TPRV} for 14 countries with negative values for ΔTPUB and/or ΔTPRV was not spontaneous, and further detailed evaluation of each of the 36 original elasticities was required. Consequently, they were not deployed in further investigation and peer comparisons reported herein.

For the 53 countries that showed growths both in TPUB and TPRV, two other groupings were developed. The results of their statistical analyses are summarized in TABLE 5. The table shows the group averages and coefficients of variation with respect to $E_{TPUB/TPRV}$, SI_{TPUB} and SI_{TPRV}. The first grouping is based on 5 continent memberships. The second grouping is based on categorical

membership of developed and developing countries. The database developed and developing countries are identified in TABLE 1.

As coefficients of variation show, significant variability existed within member countries of each group. Between groups differences, based on average values of $E_{TPUB/TPRV}$, were also significant. In the contrary, between groups differences, based on average values of SI_{TPUB} and SI_T, were not significant. This suggested that irrespective of continent membership or developing versus developed status, there were countries with relative superior standings. Learned lessons, experience and good practice information sharing could enhance public and private transport balancing and sustainable development among and between peer nations. Countries in Europe and Oceania showed larger variability for $E_{TPUB/TPRV}$, America and Europe for SI_{TPUB}, and America and Africa for SI_{TPRV}, respectively. Based on lower values of $E_{TPUB/TPRV}$, SI_{TPUB} and SI_T, developing countries were in less desirable status than developed nations.

The elasticity analysis raised concerns about balancing and sustainability of national public and private transport during period 1980 to 1995. The taxonomy presented a logical framework for comparative analysis and peer group appraisal. It facilitates good practices, learned lessons and experiences information sharing. Nevertheless, the study results were directly influenced by the selected variables when they were far from ideal. Relevant data on public and private transport demand, supply and utilization, and their direct economic, social and environmental impacts, are needed to improve national transport policy. Comparative assessment could be a compliment to other types of analyses to enhance national policies to support sustainable development.

Summary and Conclusions

The study objective is to quantify and to address public and private road transport sustainability through an international comparative assessment. Therefore, the paper aims to uncover the extent of growth consistency between private and public road transport, and EES for selected countries. The methodology is to obtain a set of indices which assigns each country an ordinal value which specifies the situation of that country among the others. Furthermore, according to their performance, countries are categorized in order to identify the countries with similar trends in their harmonic development.

The study database was consisted of 20 national variables for 67 countries. The variables were 2 for transport, and 18 for 3 categories of social, economic, and environmental. The selected variables and the period of 1980 to 1995 were suitable in the context information availability, reliability and completeness. Availability of more relevant comparative national data on public and private transport demand, supply and utilization, and their more direct economic, social and environmental impact could have greatly enhanced the study results. As a consequence, the study results would be of more methodological interest, and their direct national policy implications render caution. Nevertheless, the applied comparative assessment methodology could be used as a compliment to any other types of

assessment to enhance national policies to support sustainable transport development. The study also revealed relevant data scarcity when appraisal of national transport sustainable development is significantly hampered. For the selected countries, the database primary statistical analysis showed significant cross-sectional and time-series variations. The observed trends however were not always in favour of sustainable development.

As a preliminary exploration into public and private road transport sustainability, for each country, two types of arc elasticity were developed. The first type reflected the elasticity between the 2 transport variables, addressing more the balancing issues. The average elasticity of public transport with respective to private transport was 0.466, when only around one fifth of the countries showed elasticises greater than one. This conclusion raises concerns if higher relative public transport growth is advocated in the context of modal balancing and sustainable development. The second type reflected the elasticity of the social, environmental and economic variables with respect to transport variables, addressing more the sustainable development and harmonization issues. Using individual elasticises, composite sustainability index for public and private transport were suggested.

Because of the difficulties in measuring broad concepts such as sustainability and environment most of the time (and in this paper too) the study results in indices which reflect the relative situation of alternatives (countries). Furthermore, what is important in this paper, is the “trend” of variables rather than their current situation or “stock”. Therefore, countries with different economic situations may behave similarly in making conformity among their different sectors. The computed figures are indices which relatively assign each country a number that shows its comparative situation with respect to the others.

Based on elasticity and composite indices, for comparative sustainability assessment, taxonomy of the countries was developed. The taxonomy resulted in 13 groups with one outstanding group. It facilitated comparative appraisal among and between the identified peer groups. The outstanding group reflected countries with superior values for elasticity and composite indices. They could be used for show casing, experience and good practice information sharing. Further groupings were based on continent membership, and developed versus developing countries. They suggested that irrespective of continent membership or developing versus developed status, there were countries with relative superior standings. The study confirmed the significance of public and private transport balancing and sustainable development challenges, especially for the developing countries.

Acknowledgement

The authors wish to thank the Sharif University of Technology for providing partial funding for this study.

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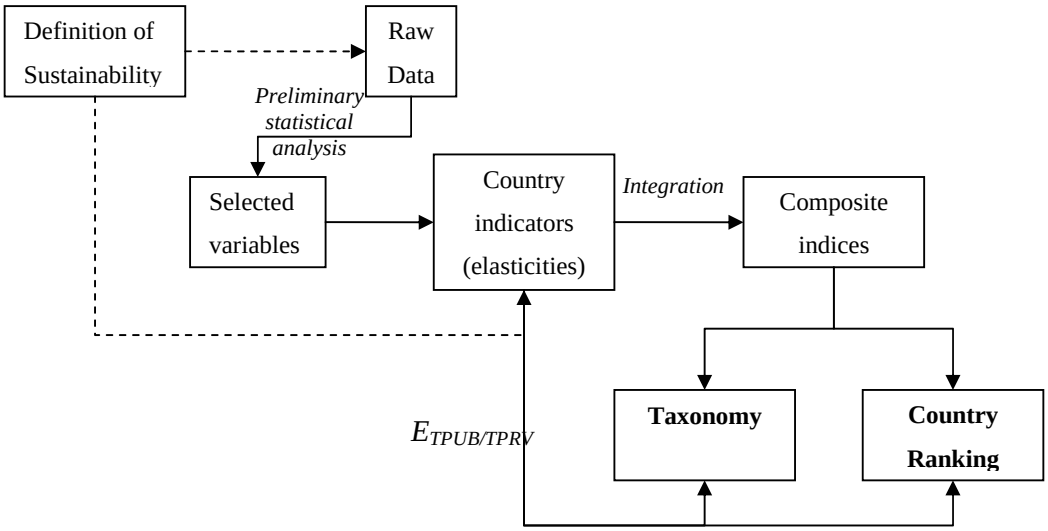

FIGURE 1 The Framework of the study.

TABLE 1 The Selected Countries and Their Continents

Continent	Selected Countries	
	Developing	**Developed**
Europe	Bulgaria, Cyprus, Czech Republic, Poland	Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom
Asia	Bahrain, Bangladesh, Brunei, Burma, Hong Kong-China, India, Indonesia, Iran, Jordan, South Korea, Kuwait, Malaysia, Pakistan, Philippines, Saudi Arabia, Singapore, Sri Lanka	Israel, Japan
America	Argentina, Bolivia, Chile, Ecuador, Honduras, Panama, Suriname, Venezuela	Canada, Mexico, United States
Africa	Botswana, Egypt, Madagascar, Malawi, Mauritius, Morocco, Senegal, Tanzania	South Africa
Oceania	Fiji, Papua New Guinea	Australia, New Zealand

TABLE 2 Description and Structure of the Database Variables

Variable	Category	Description	Dimension
TPUB	Public transport	Buses and coaches	Thousand vehicles
TPRV	Private	Passenger cars	Thousand vehicles
SLEX	Social	Life expectancy	Years
STLF	Social	Total labour force	Thousand persons
SUPN	Social	Urban population	% total population
ETEU	Environmental	Total energy use	Thousand tons
ECO2	Environmental	CO2 emissions	Thousand tons
ETEP	Environmental	Total energy	Thousand tons
CGDP	Economic	GDP	Million US$
CIPM	Economic	Interest payments	% total expenditure
CTCN	Economic	Total consumption	Million US$

TABLE 3 Descriptive analysis of the database changes during 1980 to 1995

Variable	Number of cases	Minimum	Maximum	Mean	Standard deviation	Coefficient of variation
ΔTPUB	67	-40.24	501.61	31.14	88.71	2.85
ΔTPRV	67	-599.40	38950.40	2479.60	5929.76	2.39
ΔSLEX	66	-6.52	9.47	4.31	2.69	0.62
ΔSTLF	67	-331.72	102000.00	4852.65	13325.06	2.75
ΔSUPN	67	-1.90	44.90	6.25	7.28	1.16
ΔETEU	64	-27506.00	448241.00	23143.78	61926.46	2.68
ΔECO2	65	-38921.00	174909.00	11573.17	32332.53	2.79
ΔETEP	57	-49556.00	255884.00	27052.23	51783.41	1.91
ΔCGDP	61	-180.00	1610000.00	84400.20	250376.99	2.97
ΔCIPM	43	-10.81	29.98	5.21	7.05	1.35
ΔCTCN	53	-230.00	1410000.00	73971.36	216967.24	2.93

TABLE 4 Public/private elasticity and sustainability indices

No.	Country	$E_{TPUB/TPRV}$	SI_{TPUB}	SI_{TPRV}	No.	Country	$E_{TPUB/TPRV}$	SI_{TPUB}	SI_{TPRV}
1	Argentina	0.554	0.073	0.337	35	South Korea	0.647	-0.013	-0.081
2	Australia	-1.047	-0.066	-0.045	36	Kuwait	1.170	-0.063	-0.084
3	Austria	0.108	0.040	0.055	37	Luxembourg	0.324	0.192	0.091
4	Bahrain	0.074	0.021	-0.112	38	Madagascar	-0.666	-0.032	-0.178
5	Bangladesh	0.844	-0.071	-0.220	39	Malawi	0.608	-0.009	-0.070
6	Belgium	-0.803	-0.147	0.340	40	Malaysia	0.370	-0.056	-0.174
7	Bolivia	0.178	-0.079	-0.249	41	Malta	0.030	-0.082	-0.150
8	Botswana	1.478	-0.158	-0.467	42	Mauritius	1.153	-0.008	0.028
9	Brunei	0.352	-0.109	-0.216	43	Mexico	0.901	-0.039	-0.015
10	Bulgaria	2.262	0.026	0.161	44	Morocco	0.597	0.033	0.089
11	Burma	0.292	0.075	-0.049	45	Netherlands	0.039	1.234	0.287
12	Canada	1.498	-0.010	0.276	46	New Zealand	2.550	-0.039	-0.001
13	Chile	1.027	-0.030	0.041	47	Norway	0.659	0.042	0.033
14	Cyprus	1.182	-0.097	-0.087	48	Pakistan	0.372	-0.033	-0.138
15	Czech Republic	0.525	0.122	0.360	49	Panama	0.880	-0.030	-0.051
16	Denmark	2.561	0.001	0.604	50	Papua New Guinea	-8.349	-0.114	0.913
17	Ecuador	0.028	0.246	-0.114	51	Philippines	1.278	-0.075	-0.056
18	Egypt	0.430	-0.106	-0.135	52	Poland	0.070	0.125	0.031
19	Fiji	0.397	0.143	0.156	53	Portugal	0.657	-0.106	-0.216
20	Finland	0.228	-0.028	0.011	54	Saudi Arabia	0.533	-0.134	-0.304
21	France	0.579	0.120	0.317	55	Senegal	2.469	-0.006	0.160
22	Germany	0.667	-0.023	0.024	56	Singapore	0.324	-0.176	-0.186
23	Greece	0.365	-0.035	-0.071	57	South Africa	-0.525	-0.109	0.030
24	Honduras	-1.290	-0.042	-0.192	58	Spain	0.482	-0.051	-0.041
25	Hong Kong	0.793	-0.156	-0.717	59	Sri Lanka	0.837	-0.010	0.012
26	Iceland	-0.349	-0.010	0.002	60	Suriname	-0.283	-0.395	0.019
27	India	0.480	-0.082	-0.209	61	Sweden	0.346	0.017	0.061
28	Indonesia	1.171	-0.074	-0.145	62	Switzerland	4.116	-0.038	-0.045
29	Iran	-0.373	0.257	-0.243	63	Tanzania	-0.157	-0.212	-0.339
30	Ireland	5.716	0.018	0.215	64	Turkey	0.739	-0.071	-0.083
31	Israel	0.200	0.070	0.026	65	United Kingdom	-0.813	0.039	-0.058
32	Italy	0.092	0.158	0.024	66	United States	0.778	0.012	0.074
33	Japan	-0.233	-0.135	-0.022	67	Venezuela	-1.852	-0.078	0.264
34	Jordan	0.952	-0.053	0.000		Average	0.466	-0.006	-0.008

TABLE 5 Peer group comparison

Group	Countries	$E_{TPUB/TPRV}$		SI_{TPUB}		SI_{TPRV}	
		Average	Coefficient of variation	Average	Coefficient of variation	Average	Coefficient of variation
Africa	5	1.225	0.66	-0.049	-1.62	-0.065	-3.84
America	8	0.730	0.65	0.018	5.69	0.037	5.21
Asia	17	0.629	0.59	-0.055	-1.27	-0.156	-1.10
Europe	21	1.036	1.42	0.075	3.74	0.075	2.56
Oceania	2	1.474	1.03	0.052	2.49	0.077	1.43
Developed	22	1.074	1.34	0.063	4.33	0.067	2.68
Developing	31	0.765	0.75	-0.024	-3.96	-0.078	-2.71

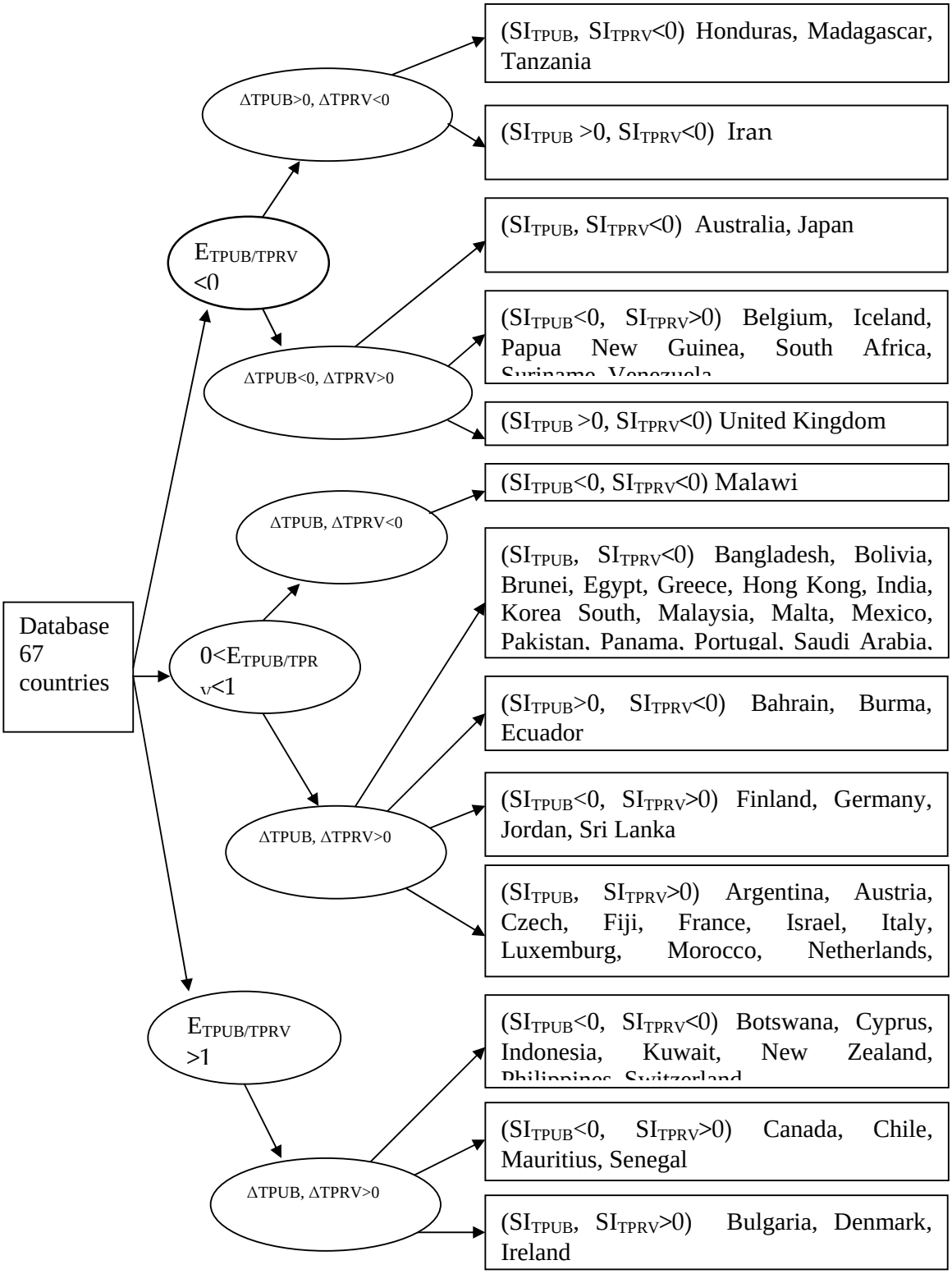

FIGURE 2 Taxonomy of the countries.