Transport energy consumption achievement based on indicator analysis

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Abstract. In order to evaluate the transport sustainability level for regions, the concept of achievement efficiency in transport energy consumption is initially suggested in this paper. The research object is not only for the energy consumption by transport operation but also the whole life of the transport procedure, which is the thought of life cycle assessment. And then, on the quantitative analysis to calculate the transport energy achievement efficiency of the regions, the indicators that can represent the achievement of transport energy consumption are convincingly found out by indicator theory. Next, concentration is focused on the transport related indicators and proper indicators are picked up from the candidate indicators, which were the affecting factors to this issue. After that, using the selected indicators, we introduce the method of data envelopment analysis to do quantitative analysis, which helps to get the achievement efficiency of transport energy among cities all over the world. The analysis result shows the efficient regions and the inefficient regions respectively. Furthermore, the detailed efficiency value of each region is also laid out clearly. For the improvement, the inadequate output or input variables of the inefficient regions were listed compared with the efficient regions so that corresponding transport policy implications can be resulted for the inefficient regions to reach high level sustainability.

1 Introduction

Energy issue is one of the crucial problems in the corresponding research of sustainability. The incident of twice world oil crisis showed that energy is indispensable. However, most of the energy being consumed is non-renewable; furthermore, the consumption of energy all over the word is increasing year by year, and is estimated to keep on increasing in the near future. Nowadays, the rapid growth of the economic in the world is driving the energy consumption grew up rapidly. So especially because of the existence of developing regions which are at a high speed of economic growth, if this pace continues, many types of energy will exhaust in decades.

In this case, before we find out the resource of new energy, it is more practical to improve the efficiency of energy consumption, which will contribute much to the sustainability development of the world. There are many literatures that involved in the issue for transport sustainability. The consumption of energy and the emission of carbon dioxide in transport sector are usually considered to be the representative of the transport sustainability [1,2]. As there are some potential relationship between the consumption of energy and the emission of carbon dioxide for positive correlation, we focus on the energy consumption issue. It is no doubt that the transport sector consumes more and more energy which is not so ideal. But on the other hand, such transport energy consumption brings in more and more transport achievement as well when we can find it is more convenient and comfortable or people to travel and the logistics is far more improved to contribute to the modernized society. Therefore, we
cannot predicate the increasing of transport energy consumption should be restricted toughly. The
great achievement caused by the consumption should also be taken into consideration. The fact is that
the great quantity of energy consumption brings in more achievement of transport activity which con-
tributes to the economic development, but it’s hard to evaluate whether this achievement deserves such
amount of consumption. In other words, we expect to make simultaneous improvement both at the
achievement of transport activity which leads to economic growth and the transport energy consump-
tion. Here a variable is proposed for the concept which calls achievement efficiency to measure this
balance between transport energy consumption and its achievement.

Before we define the formula on calculating achievement efficiency, we should make it clear what
efficiency is in advance. Efficiency in general describes the extent to which time or effort is well used
for the intended task or purpose. Here we use input variable to represent the time or effort and output
variable to represent the intended task or purpose. Therefore, efficiency can be expressed by the quotation
of the amount of the output variable and the input variable to represent the extent how the output
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2 The introduction of transport energy efficiency
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Efficiency= output variable/ input variable

Here, efficiency refers to the achievement efficiency in transport energy consumption, it is the vari-
able we want to calculate, and the denominator input variable apparently refers to the transport energy
consumption it is a definite amount which can be got easily from data sources. In order to improve the
amount of the efficiency, we should find out proper way to analyze this item to minimize it as much as
possible. On the other hand, we should try to maximize the numerator output variable; however, it
seems unclear how to make the achievement countable.

The remained problem is what variables can represent the output variable in this issue-the transport
energy consumption achievement. To solve this problem, we should scan over the literatures to find a
proper way to determine the indicators to represent the output variable. After the indicators that can
indicate appropriately the output variable are determined, we are supposed to find a proper way using
selected indicators for calculating the achievement efficiency in various regions to see whether the
achievement efficiency of some specific region is good. Next, if the achievement efficiency is not as
good as other regions, we want to analyze the reason that leads to the low efficiency quantitatively for
the relatively inefficiency region and give corresponding suggestion for improvement.

The core issue of indicator related researches is how to identify appropriate indicators or choose
well among possible candidates. The way to select specific indicators using criteria is important when
applying indicators to practical use. There are various contributions by many researchers and organiza-
tions on this problem, which are more deserving for this research to reference. These literatures showed
different numbers and names of categories and criteria to their own field of studies, and of course some of criteria in different literatures are more or less the same. In this research, we are making
contempt to find an appropriate system of criteria to evaluate whether a variable should be an indicator
for the achievement efficiency of transport energy consumption.

For practical application, [3] applied this methodology on energy efficiency evaluation among ob-
ject regions based on the contribution by [4]. This innovation solves many difficulties on the incon-
venience of other methodology. Besides, [5,6] also did similar efficiency evaluations to get results.
What's more, [7-10] revealed such accomplishment in the area of environmental, sustainability assessment from different points of view, which are more deserving for this research to reference. However, in these previous researches listed above, some problem remains unsolved. On the hypothesis of the affecting factors that result in energy consumption efficiency, no convincing evidence is shown for the reason of the variables selection. In the data envelopment analysis done for environmental efficiency analysis, the input and output variables are chosen subjectively by the researchers in spite of the fact that huge differ probably occurs in the analysis result based on a different choice of variables. Moreover, at least whether the selected variables can indicate the evaluation object also has not been solved. As a result, the credibility of the quantitative result based on variables be selected at will is hard to say. This research intends to decide the variables for evaluation based on indicator criteria to ensure the correctness of this selection. There are some other improvements on the application of the methodology as well due to some reality in the transport sector, detailed illustration are intended to be shown in the chapters afterwards.

This research initially proposes the concept of “achievement efficiency” by transport energy consumption which will pay attention to the result on how well the energy converts into the achievement of transport activity, and perform quantitative analysis on the evaluation of the efficiency. Owing to the quantitative evaluation result, a standard will reveal on evaluating whether a region perform well on the converting from consumed energy in transport related field into the achievement of transport activity. Regions fit this standard well will be an example for the other regions. We will also observe the reason and way of improvement in this point of view.

3 Indicator selection for transport energy consumption achievement

There are many literatures involving the issue for environmental, sustainable transport or other fields which connected with the issue of transport energy consumption. The variables usually mentioned in the literatures, which are the classical statistics, should be emphasized for investigated on whether they are proper to be the output of transport energy consumption. As the input variable, which is represented by total energy consumption in transport sector, is not divided by capita, the output variable will also be represented by the variables which are not divided by capita, but the total amount.

These variables of statistics are always expressed by passenger transport and freight transport respectively, for they behave differently on the phenomenon of transport. At the same time, the data of private transport and public transport in a city are also collected respectively, for they undertake different responsibilities of urban transport. Besides, for the very issue being discussed in this research, private transport contributes more to the energy consumption because vehicles supporting private transport are more possible to be high energy consuming vehicles than that of public transport. These facts should also be taken into consideration for indicator selection.

Output variables for transport energy consumption achievement can be divided into two groups: direct output variables and indirect output variables. They are listed and stated as follows.

3.1 Direct variables indicate the output of transport energy consumption achievement

Direct variables for the output of transport energy consumption achievement refer to the variables which can directly express the achievement in the transport activity while consuming energy. Main statistics variables can be listed as follows:

V.K.T.: Abbreviation of Vehicle Kilometers Travelled. This variable reports is the total in kilometers travelled by motor vehicles on any particular road systems during a given period of time. V.K.T is a widely used international proxy for the pressures of road transport on the environment, and also can be used to measure the phenomenon of transport safety and human health from another point of view sometimes. It is a variable focuses on the issue of road transport both for passengers and cargos.

Passenger kilometers in public transport: It is calculated by dividing total distance travelled, in kilometers, in a given period, by the number of passengers in public system of transportation. It is also a basic unit used by transport department for calculating profit levels etc. Public transport system plays
an important role on carrying a large number of passengers to destinations, sharing responsibilities of the burden by road vehicles. Passenger kilometers is also an important variable to evaluate the transportation capacity and achievement.

Average trip length: It represents the average distance each trip travels. It can reveal the achievement of consumed energy to a certain extent because it is affected by the number of trips. This variable is always used to measure the mode of transport in one region for it can reveal the distance of travel number for passengers.

Average speed of vehicle: This variable measures the velocity and fluency for the vehicles in the region. High velocity of vehicles can be considered to be a symbol of convenient region of communication. Furthermore, the energy consumption has something to do with the speed of vehicle. In the same distance, the energy consumption can be much different due to different speeds of the same vehicle. It is not clear whether absolutely better if the speed is high on the issue of energy consumption.

3.2 Indirect variables indicate the output of transport energy consumption achievement
Indirect variables for the output of transport energy consumption achievement are not variables represent clearly for the achievement of transport activity, but efficiency can be connected between indirect output variables and input variables from other points of view. The relationship will be explained separately.

Road network length: It means the total length of road network in a region and shows the degree of road development for the region. Highly developed road network can promote and stimulate the use of vehicles, which leads to energy consumption. Region with highly developed road network and common transport energy consumption can be explained as a model for encouraging public or environmental transport, which can be interpreted for a special way of high efficiency. It is also considered as one the more the better variable for this research.

Number of vehicles on register: It is a common statistics variable for many transport literatures which means the number of vehicles registered in a region. With the same nature of the former variable, high ownership of vehicles can promote and stimulate the use of vehicles and leads to energy consumption. Besides, big number of vehicles on road also brings in traffic jam, which consumes extra energy. Therefore, as to the same transport energy consumption, large number of vehicles on register can be considered a way of high efficiency more or less.

Area of parking places: It is a statistics in the capacity of a city for its convenience of car using. Insufficient area of parking places is a restriction for people using vehicles for trip. Large area of parking place promotes and stimulates the use of vehicles and leads to energy consumption as well.

GDP: It is the abbreviation of Gross Domestic Product. It is widely accepted as the most comprehensive measure of the size of an economy. Transport activity, as a component of the economy, naturally is often measured against GDP. In popular press as well as in policy discussions, measures of transport in relation to GDP are often cited to illustrate the importance or contribution of transport activity to the economy.

However, there is a problem that the relationship between transport activity and the economy is a complicated one and measures of transport in relation to GDP are not always based on a conceptual framework that explicitly and accurately reflects the underlying relationship. This has resulted in both incorrect measures and incorrect interpretations of correct measures. Consequently, although GDP contributed by transport activity is one the more the better achievement by consumed energy, the accurate relationship for their direct relationship remains unclear.

Employment rate: It is also an economic statistics and seems have not such direct relationship with transport energy. It is taken into consideration because transport circumstance is always bad at rush hours in many regions, when much extra energy is consumed. Therefore some kind of relationship can be concluded to connect with the employment rate. It is treated as an affecting variable for efficiency of energy consumption tentatively.
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