PUBLIC TRANSPORTATION AND SUSTAINABILITY: EFFICIENCY AND SAFETY ISSUES IN HARYANA-INDIA

Nitisha Sehrawat
Doctoral student, Department of Economics, Indira Gandhi University, Meerpur- Rewari, Haryana, India.
Email: nitishakhardwal352@gmail.com

Devinder Singh Hooda
Ph.D, Faculty in Economics, Indira Gandhi University, Meerpur- Rewari, Haryana, India.
Email: dshooda.igu@gmail.com; dshooda@igu.ac.in
ORCID: 0000-0002-1026-2122

Corresponding author: Devinder Singh Hooda,Ph.D, Faculty in Economics, Indira Gandhi University, Meerpur- Rewari, Haryana, India.
Email:dshooda.igu@gmail.com

Abstract
The primary aim of the paper is try to examines the efficiency of the depots in the state of Haryana during the period of 2015-16 to 2020-21. The depots of the state roadways are considered as decision making units. For evaluating the efficiency scores of decision-making units (DMUs), the paper used the Data Envelopment Analysis (DEA) technique with specific inputs and outputs. Three types of inputs i.e., fleet size, total staff and bus utilization have been taken and for the output, daily passengers carried out and effective kilometers have considered. Further, along with the efficiency measurement, a total number of accidents of each depot have been collected for the measurement of safety. From efficiency scores it is clearly observed that during the study period the average efficiency score is .89 which indicates that these DMUs worked 89 percent efficiently and near about 11 percent scope for reduction in its output. The score of efficiency is based on output oriented which means that inputs will be constant for attaining the full efficiency and there is scope in reduction of its output. On the other hand, Haryana roadways is also good in terms of safety indicators. It is also witnessed that Haryana roadways performed well because the accidents rate declined over the time period.

Keywords: Sustainability, Public transport, Efficiency, safety, decision making units.

Introduction
The sustainable development and public transport both are linked with each other and there is a deep connection between them. The main focus of this paper is to delineate the relationship between sustainability and transport sector. The first thing which everyone should get to know is the concept of sustainability. It is a very broader term in itself. Every region face different kinds of difficulties in attaining the sustainability (Ozili, 2022). It is just avoidance of wastage of all natural resources. For sustainability the government has also made many policies such as renewable energy transition, fossil fuel emission and green economy. These all create a positive impact on the climate which leads towards sustainability (Aven, 2020). The Brundtland commission report came into existence and published in 1987 which was focused on sustainable development. Through this report, an attempt was made to explain that the development process should be made in such a way that the necessities of the present-day generation shall be satisfied without negotiating the wants of upcoming generation

3380

(D. J. Greenland, 1997; Grant, 2010). Sustainable development is the most crucial for economic and social development (Szymańska, 2021). In the main economic branch, the first thing which taught to everyone is deal with scare resources. The scare resources can be better utilized with the help of sustainable model of development. There are three major points which can explain the concept of sustainability in a better way. These points are as: economy, society and environment. To deal with the scare resources, the concept of sustainability is developed in the field of economy. There is no doubt that every country has limited resources, unlimited wants and concerning upon the better utilization of these resources, the resources should be efficiently utilized in the production process. Sustainable development has an important role in the field of economics. It is just about to satisfy current needs of people without compromising the future needs. Both generation should get satisfy, present as well as future. So, with the help of sustainable development, possibility of better utilization of resources will be increased. For society side, the matter of concern is to distribution of resources equitably. Alike with economy, in society also, the resources should be distributed in such a way that they are sufficient for present generation and also satisfied the need of future generation. All resources should be allocated at certain level. Allocation of resources is for the people and by the people (Szymańska, 2021). In most of developing countries, the need of power is fulfilled with help of thermal and hydro power. Both of these have negative impact on environment. The key feature of the sustainable development is to promote such type of development which helps in minimizing the damage to environment and optimize the use of natural resources. More use of private vehicles leads to congestion and pollution as well. So, the transport needs should be satisfying with public transport, this is good for environment and it leads to reduce traffic congestion and condense pollution level.

When the discussion comes to the sustainable transport, it is a broad subject itself. It has many terms which define the concept of sustainable transport such as safety, efficiency, minimum damage to the environment, focus on climate changes and accessibility. These are the main objectives of the sustainable transport. After independence, all the sectors have grown speedy and many changes have been brought in it. At the same time, the need of the efficient transport system in India has been realized. Looking at the increasing activities of transport, it can be estimated that the resources are getting reduced and on account of scare resources future generation may suffer a lot. Transport sector play a crucial role in social and economic development of any country. But the matter of concern is that due increasing activities of transport there are many problems arises like congestion, road accidents, damage to environment, climate changes and pollution. Along with these problems the wastage of time is also a part of it. Broadly speaking, transport sector plays a dual role, on the one hand, it taking towards the development and the other hand, it is dangerous for the society and environment also.

This paper makes an attempt to focus on two objectives of sustainable transport which are safety and efficiency of public transport in Haryana. Haryana is a progressive state and it is the state of north India which is only ranked 22nd in terms of area but the road network is quite good. Road infrastructure is of great importance in a progressive state like Haryana. In the state, 13 out of 22 districts fall under the national capital region. In order to increase the economic activities of NCR and for the economic development, growth of road and highways in Haryana is also on a large scale. Before November 1, 1966, Haryana used to be part of Punjab but after the recognition of Haryana as a separate state on November 1, 1966, the construction of roads and highways is going on continuously. Haryana roadways which is a government unit, its main motive is to connect people within the state and its neighboring states. The state public transport has made a notable development during the recent years and doing much better in terms of safety indicators. But the number of staff/ employees have been reduced instead of increasing. Currently, it has a fleet of about 4250 buses being operated by 24 depots (Hooda and Sehrawat, 2021).

The rest of the paper is structured in to six sections. The second section consist of existing literature review. Section III highlights the statement of problem, research gap and objectives of the study. Section IV details out the research methodology employed and section V talks about results and findings. The last section concludes the paper.

Literature Review

Looking at the importance of sustainability, the scholars are taking profound interest in assessing the significance of state transport undertakings. Recently a good number of researchers have been inclined towards sustainable development. Researchers have contributed their efforts in the area of transport and sustainability. Several authors have written to explain the notion of sustainability and transport undertakings in detail such (Aven, 2020; D. J. Greenland, 1997; Grant, 2010; Ozili, 2022; Szymańska, 2021). Further, a list of researchers has done a good work in the field of public transportation and tried to connect sustainability with the energy and transport sector (Abhyankar et al., 2017; Shivi Agarwal et al., 2010; Chakrabartty & Gupta, 2015; Ramanathan & Parikh, 1999; Singh, 2017; Tiwari & Kharola, 2008).

The literature shows that the sustainability is a notion and approach which directs the usage of existing assets and resources in a better way to make sure that the resources are accessible and sufficient to cater current needs and for the future generation also. Sustainability is also stated as the capacity of making decisions for the appropriate provision of funds to economic and non-economic activities (Grant, 2010). Many researchers also demarcated its various aspect such as product sustainability (Dyllick & Rost, 2017), urban sustainability (James et al., 2014), business sustainability (Bansal & DesJardine, 2014), career sustainability (Tordera et al., 2020) and fiscal sustainability (Byrne et al., 2011).

Statement of the problem and objectives of the paper

The field of the transport is very vital for the development of any economy. But somewhere this may be harmful for the environment. Nowadays, transport is become the major reason for an air pollution. Due to excessive usage of private vehicles there are many problems arises like congestion, road accidents, damage to environment, climate changes and pollution. To deal with these problems there should be appropriate facilities of public transport. Along with the private vehicles, the use of public transport should be enlarged which will prove to be good for environment and society as well. This paper primarily is an emphasis on the transport and sustainability. It tries to explain that how public transport leads towards sustainability. For this purpose, the two indicators which are necessary for the sustainability, one is efficiency and another is safety. So, the key objective of this study is to examine the efficacy of state transport undertakings in Haryana and also analyses the status of safety indicators for the public transport sector at depot level.

Methodology and data base

Through this paper, two major indicators have been selected which will be workout for assessing whether the public transport of the state is sustainable or not. Define the concept of sustainable transport such as safety, efficiency, minimum damage to the environment, focus on climate changes and accessibility.

So, there are two indicators, the first one is safety and another is efficiency have been taken. For safety indicator, the numbers of accidents and some inputs are used and output for measuring the efficiency score of public transport in Haryana have been taken.

The data for measuring the efficiency are being collected by secondary sources involving official documents, reports etc. of the state government during the period 2015-2020. Currently, 24 depots and 13 sub depots are effective in the state and operated by the department of Haryana roadways. The study considers only 24 depots for the efficiency estimation of the transport undertakings.

For justify the objectives of this paper, the most popular non parametric Data Envelopment Analysis (DEA) technique has employed. The important feature of this model is that it is applied to the homogenous units (S. Agarwal, 2016) and there is no need for the functional form. The models Charnes, Cooper and Rhodes (CCR) was introduced in 1978 and Banker, Charnes and Cooper (BCC) developed in 1984. These models of DEA have used to evaluate the total technical effectiveness, pure technical and scale efficiency for the state transport undertakings (Aneja & Sehrawat, 2022).

Selection of inputs and output for Data Envelopment Analysis

As discussed, DEA has used as DMUs are homogenous, the results have been extracted by selecting homogenous units. The total fleet uses input and output for these DMUs. The total fleet size refers to

3382

total number of buses operated in the state that denotes its capital input. The total number of staff indicated the labour input of DMUs and fuel consumption has been taken as material input. The fuel consumption is the ratio of total effective kilometer and fuel average. For output, total passengers carried and effective kilometer have been taken for the assessment of efficiency. The input variables such as total fleet size (capital input), total staff (labour input) and fuel consumption (material input) have also been used for the efficiency estimation.

Data Envelopment Analysis
This technique is very popular for quantifying the efficacy score of selected decision-making units. Basically, this is the non-parametric method and which has no need of any distribution and functional form. It is distribution free technique. Here, units should be homogenous which will be selected for the efficiency evaluation.
For the efficiency evaluation:

Max $E_k = \frac{\sum_{r=1}^{s} u_{rn} y_{rn}}{\sum_{i=1}^{m} v_{in} x_{in}}$

The DEA models, estimates n number of DMUs. For every DMUs p different inputs have been considered for producing the q outputs. The efficiency score of each DMUs cannot be more than one. Furthermore, one essential thing is that the weights for all inputs and outputs ought to be greater than 0 i.e $\lambda_a + \lambda_b + \lambda_c + \ldots \ldots \lambda_n \geq 0$. For the specification of model, homogeneous n DMUs units have been employed (DMU$_j$ j=1,2,3……….n).

For safety indicator, accidents by all depot in a year are considered. The negative and positive growth rate for all the number of accidents indicates that the rate of the total number of accidents during the study period has been reduced or increased, as a safety indicator. This is highly important in the reduction of total number of accidents by state transport undertakings for their best utilization.

There are two key models included in DEA the one is CCR and another is BCC model. By using these models, total technical efficiency, pure and scale technical efficiency have been examined. This paper tries to measure the total technical efficiency which has been extracted by using the CCR model. This model was developed in 1978, which assumes constant return to scale. For this purpose, there is need of some input and output variables which has explained in next section.

Results and Findings
There are 24 decision making units and these units have different efficiency scores. On the basis of these efficiency scores, it has been found that depots which worked efficiently and which are not. Here, the measurement of efficiency has been done by collecting the data for the study period. The mean value also calculated under CCR model and overall efficiency of selected decision making units captured in the table 1 below.

Table 1: Overall technical efficiency scores

DMUs	2015	2016	2017	2018	2019	2020	Mean value
Ambala	0.90	0.92	1.00	0.94	0.98	1.00	0.96
Bhiwani	0.95	1.00	0.88	0.86	0.90	0.84	0.90
Charkhi Dadri	0.79	0.88	0.84	0.81	0.86	0.83	0.84
Faridabad	0.80	0.78	0.86	0.62	0.79	0.77	0.77
Fatehabad	0.93	0.88	0.93	0.95	0.90	0.91	0.92
Gurugram	1.00	1.00	0.88	1.00	0.72	0.74	0.89
Hisar	0.95	0.91	1.00	1.00	1.00	1.00	0.98
Jhajjar	0.76	0.82	0.87	0.88	0.88	0.87	0.85

Jind	0.87	0.93	0.84	0.90	0.87	0.93	0.89
Kaithal	0.86	0.92	0.86	0.85	0.80	0.70	0.83
Karnal	0.89	0.91	0.91	0.90	0.85	0.67	0.86
Kurukshetra	0.93	0.96	0.95	0.88	0.96	0.86	0.92
Nuh	0.88	0.86	1.00	0.88	0.81	0.98	0.90
Panchkula	0.88	0.78	0.65	0.65	0.76	0.90	0.77
Palwal	0.88	0.82	0.86	0.75	0.89	0.96	0.86
Panipat	0.88	0.84	0.80	0.87	0.82	0.70	0.82
Rewari	0.88	0.89	0.93	0.94	0.92	0.83	0.90
Rohtak	0.90	0.88	0.95	0.99	0.96	0.87	0.92
Sirsa	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Sonipat	0.87	0.88	1.00	0.94	0.85	0.69	0.87
Yamuna Nagar	0.89	0.90	0.90	0.85	0.82	1.00	0.89
Chandigarh	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Delhi	1.00	1.00	1.00	0.96	1.00	0.90	0.98
Narnaul	0.91	0.95	0.95	0.92	1.00	0.95	0.95
Yearly mean value	0.90	0.90	0.91	0.89	0.88	0.87	0.89

Source: Author's own calculation

Input and output efficiency scores have been calculated for the estimation of technical efficiency of public road transport of selected states. The range of efficiency score is 0 to 1 which simply indicates that the DMUs which having efficiency score one worked efficiently, the inputs are fully employed and there is no need to reduction in inputs. Table 1 indicates the efficiency score of various DMUs for the year 2015 to 2020. From these efficiency scores it is crystal clear that from 2015-20, the average efficiency score is 0.89 which shows that these DMUs worked 89 percent efficiently and near about 11 percent scope for reduction in its outputs. For calculating the efficiency scores of DMUs, CCR output model have been used. Under this model overall technical efficiency of these DMUs have been extracted through CCR output oriented model which means that here inputs are assumed to be constant and inefficient unit need to increase its output with existing level of inputs. It is found that the efficiency score of selected DMUs during the study period is around 90 percent worked efficiently. There is no very large variation among various DMUs efficiency score. All having good efficiency scores and doing worked with an efficient manner.

The total number of accidents for each depot have been collected for working out of safety analysis. In the state, there is Haryana roadways which fulfill the needs of public transport. In table 2 the concerned data on accidents have been collected for all depots and along with that data CAGR also have been calculated.

Percentage and compound annual growth rate methods have been employed for the quantification of growth rate of safety indicators.

Compound annual growth rate (percentage) = [logest (Ya1+Ya2+Ya3+……….Yan)-1]*100

Here, Y= variables used for analysis

3384

a= time (1, 2, 3…………………………. n) for each period

The status of safety indicators has been measured with the help of CAGR and presented in figure 1 given below. If we talk about sustainable transport it should be safe transport. If a smaller number of accidents are registered, it indicates that transport is fulfilling one of its objectives of sustainability.
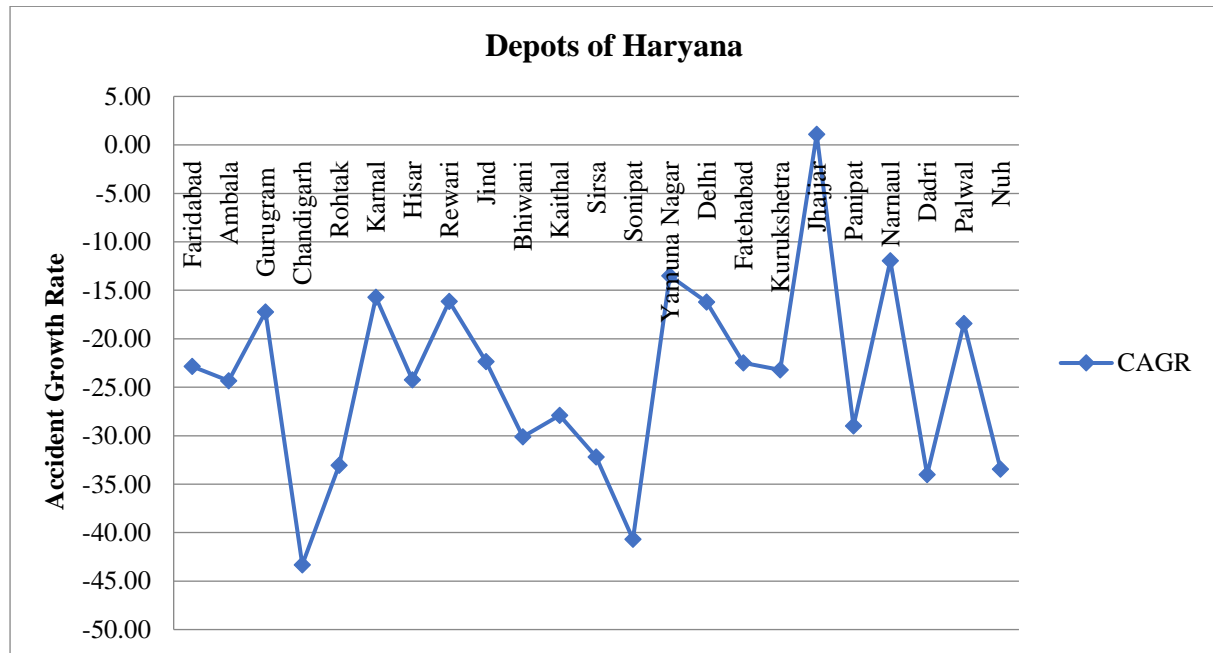

Figure 1: Representation of safety indicators

Source: Author's own calculation

Table 2: Depot wise number of accidents and CAGR

Depots	2015	2016	2017	2018	2019	2020	CAGR
Faridabad	13	13	8	6	8	3	-22.84
Ambala	14	16	8	8	5	4	-24.32
Gurugram	15	8	9	7	14	3	-17.23
Chandigarh	5	7	3	1	0	3	-43.31
Rohtak	23	29	14	14	8	3	-33.06
Karnal	9	9	11	17	13	2	-15.71
Hisar	22	34	22	19	24	4	-24.24
Rewari	9	11	12	10	4	5	-16.13
Jind	17	16	6	10	4	6	-22.35
Bhiwani	13	13	15	11	5	2	-30.10
Kaithal	22	15	13	10	10	3	-27.88
Sirsa	11	15	13	12	9	1	-32.20
Sonipat	10	24	17	10	3	1	-40.69

3385

Yamuna Nagar	13	6	9	6	9	4	-13.52
Delhi	13	10	10	8	6	0	-16.22
Fatehabad	12	10	9	13	9	2	-22.47
Kurukshetra	12	19	13	2	4	7	-23.21
Jhajjar	7	2	16	9	7	4	1.11
Panipat	8	12	13	9	8	1	-28.99
Narnaul	5	6	14	16	6	2	-11.93
Charkhi Dadri	0	0	4	1	1	1	-34.03
Palwal	5	4	2	5	4	1	-18.43
Nuh	8	10	6	2	4	1	-33.44

Source: Haryana statistical abstract and author's calculation

Table 2 and figure 1 represents the CAGR of bus accidents during the time period 2015 -2020. It shows the negative growth rate of accidents in all depots except Jhajjar depot. The Sonipat depot of Haryana roadways having highest negative growth rate -40.69. The negative accidents rate shows a good sign for state transport sector. During the study period, it has also found that the public transport of Haryana is safe for public. There is only one depot i.e. Jhajjar which display positive accidents growth. Except Jhajjar, all other depots showing negative growth rate of accidents. With the help of above safety indicators, it has been overall concluded that from the above graphic representation that the Haryana roadways performed well because of the accidents rate declined over the time period.

Conclusion

There are two important aspects of sustainable transport discussed in this paper are safety and efficiency. If the transport is safe and efficient then it leads towards sustainability. This paper focused on public road transport in Haryana. In this paper, the efficiency score of all depots of Haryana roadways has been calculated. From efficiency scores it has been noticed that over the study period, the average efficiency score is 0.89 which indicates that these DMUs worked 89 percent efficiently and nearly about 11 percent scope for reduction in its output. The score of efficiency is based on output oriented which means that inputs will be constant for attaining the full efficiency and there is scope in reduction of its output. On the other hand, Haryana roadways is also good in terms of safety indicators. It   clearly observed that Haryana roadways performed well because the accident rate declined over the time period. This paper concludes that public transport should be promoted for sustainable transport. If the uses of public transport increased, then there is decrease in use of private vehicles. Nowadays due to increase in private vehicles there is various problems arises which leads to environment degradation. Therefore, in order to deal with these   problems efficiently and for sustainable transport, the use of public transport should be enlarged and improved.

Although safety and efficiency are two important parameters for sustainable transport but there are some other parameters also which affect the sustainable transport. So, it can be said that for the rapid movement towards sustainability it is necessary that other factors should also be considered. With the help of efficiency results, efficient DMUs are set as benchmark for the inefficient units. The results and findings of the paper reflects that the performance of Haryana roadways is largely virtuous. Therefore, public transport in the state should be promoted so that it may leads to reduce the congestion on roads and pathway towards sustainability. In order to enhance the productivity, it is necessary to put new buses on road and recruit the further staff. The infrastructure is also performing critical role in the efficiency like good condition of road is reducing the number of accidents, saving time, moreover, it will enhance the fuel efficiency. These all factors are indicating that policy should

3386

be work on specific areas such as construction of roads, create the new job opportunities in public transport sector and introduce new capital in the form of fleet.

References

1.   Abhyankar, N., Gopal, A., Sheppard, C., Park, W. Y., & Phadke, A. (2017). *Techno-Economic Assessment of Deep Electrification of Passenger Vehicles in India* (Issue May). https://vehicle-grid.lbl.gov/sites/default/files/lbnl-1007121_report_1.pdf

2.   Agarwal, S. (2016). Evaluation of Efficiency and Effectiveness of Public Transport Sector of India Using DEA Approach. *A. Emrouznejad, R. Bankar, H. Ahn, & M. Afsharian (Ed.), Proceedings of the 13th International Conference on Data Envelopment Analysis, Braunschwieg*.

3.   Agarwal, Shivi, Yadav, S. P., & Singh, S. P. (2010). DEA based estimation of the technical efficiency of state transport undertakings in India. *Opsearch*, *47*(3), 216–230. https://doi.org/10.1007/s12597-011-0035-4.

4.   Aneja, R., & Sehrawat, N. (2022). Depot-Wise Efficiency of Haryana Roadways: A Data Envelopment Analysis. *Arthaniti: Journal of Economic Theory and Practice*, *21*(1). https://doi.org/10.1177/0976747920954973.

5.   Aven, T. (2020). Climate change risk–what is it and how should it be expressed? *Journal of Risk Research*, *23*(11), 1387–1404. https://doi.org/10.1080/13669877.2019.1687578.

6.   Bansal, P., & DesJardine, M. (2014). Business sustainability: It is about time. *Strategic Organization*, *12*(1). https://doi.org/10.1177/1476127013520265.

7.   Byrne, J. P., Fiess, N., & MacDonald, R. (2011). The global dimension to fiscal sustainability. *Journal of Macroeconomics*, *33*(2). https://doi.org/10.1016/j.jmacro.2011.01.002.

8.   Chakrabartty, A., & Gupta, S. (2015). Technical Efficiency of Urban Public Transport Undertakings in India: A Study with Special Reference to CSTC. *Arthshastra : Indian Journal of Economics & Research*, *4*(3). https://doi.org/10.17010/aijer/2015/v4i3/71377.

9.   D. J. Greenland. (1997). *The Sustainability of Rice Farming*. CAB International, Manill, The Phillipines.

10.   Dyllick, T., & Rost, Z. (2017). Towards true product sustainability. In *Journal of Cleaner Production* (Vol. 162). https://doi.org/10.1016/j.jclepro.2017.05.189.

11.   Grant, L. K. (2010). Sustainability: From Excess to Aesthetics. *Behavior and Social Issues*, *19*(1). https://doi.org/10.5210/bsi.v19i0.2789.

12.   Hooda DS and Sehrawat. (2021). Performance Analysis of State Transport Undertaking: A Study of Haryana. *International Journal of Research in Social Sciences*, *11*(03), 135–142.

13.   James, P., Magee, L., Scerri, A., & Steger, M. (2014). Urban sustainability in theory and practice: Circles of sustainability. In *Urban Sustainability in Theory and Practice: Circles of sustainability*. https://doi.org/10.4324/9781315765747.

14.   Ozili, P. K. (2022). Sustainability and Sustainable Development Research around the World. *Managing Global Transitions*, *20*(3), 259–293. https://doi.org/10.26493/1854-6935.20.259-293.

15.   Ramanathan, R., & Parikh, J. K. (1999). Transport sector in India: An analysis in the context of sustainable development. *Transport Policy*, *6*(1). https://doi.org/10.1016/S0967-070X(98)00030-4.

16.   Singh, S. K. (2017). State Transport Undertakings in India: Status and Issues. *International Journal of Applied Business and Economic Research*, *15*.

17.   Szymańska, A. (2021). Article reducing socioeconomic inequalities in the european union in the context of the 2030 agenda for sustainable development. *Sustainability (Switzerland)*, *13*(13). https://doi.org/10.3390/su13137409.

18.   Tiwari, G., & Kharola, P. S. (2008). Urban Public Transport Systems: Are the Taxation Policies Congenial for Their Survival and Growth? *Economic and Political Weekly*.

19.   Tordera, N., Peiró, J. M., Ayala, Y., Villajos, E., & Truxillo, D. (2020). The lagged influence of organizations' human resources practices on employees' career sustainability: The moderating role of age. *Journal of Vocational Behavior*, *120*. https://doi.org/10.1016/j.jvb.2020.103444.