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Original Article

Development of a Balanced Scorecard Framework for Passenger Road Transport Companies

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Abstract *- Performance measurement of manufacturing or service organizations is an important instrument to support decision-making in respect of strategic plans to improve existing business. The balanced scorecard (BSC) approach is one of the performance measurement frameworks which makes doubtless links among various dimensions of performance for measurement of the overall performance of transport organizations. BSC is concerned with balanced attention towards financial and non-financial measures that managers need to pay. The BSC approach has been satisfactorily implemented across a large number of organizations in various geographical locations. This article aims to find the weight structure for BSC design for performance computation of passenger road transport companies. An MCDM model that integrates DEMATEL, ANP, and AHM based is proposed for arriving at the criteria weights under balanced scorecard perspectives.*

Keywords *- ANP, Balanced Score Card, DEMATEL, Hybrid MCDM.*

1. Introduction

Today's passenger transport industry has stricter requirements for businesses that offer transport services. The fundamental principles of transport, which include travel time, cost, security & convenience, as well as growing consumer expectations in the areas of infrastructures which are already occupied, such as railway stations, bus stops, vehicles and parking spaces etc., have extra support such as wireless support, electronic ticketing structure are forcing transport companies to focus on organisational efficiency.

The larger transportation organizations are compelled to alter their strategy and the means by which their strategic goals are implemented at an operational performance level due to the increased passenger preferences. Using various strategies at once is conceivable for monitoring the performance level of transportation networks. BSC usage is an alternative strategy suggested by academics Robert Kaplan and David Norton in 1992.

The BSC's key challenge is to connect business strategy with daily business operations. This is accomplished by employing measurements that show both the extent to which the organization's strategy has been implemented and the connection between operational actions and corporate objectives.

2. Literature Review

To select the best RER, Gülçin Büyüközkan and Sezin Güleryüz (2016) used various decision-making tools which are used today in Turkey from an investor point of view. For the purpose of evaluating potential locations for solar farms, Chao-Rong Chen et al. (2014) developed an MCDM model which is Hybrid in nature. Sajjad Rostamzadeh et al. (2022) Used DEMATEL along with ANP to find the problems and their effects on falls in the construction sector. Perry CY Liu et al. (2020) evaluated green building systems using DEMATEL, BWM & ANP processes. Jiann Liang Yang and Gwo-Hshiung Tzeng (2011) used MCDM & DEMATEL to find the relative weights of various criteria. The BSC method can bring a lot of effectiveness in decision-making in a balanced and consistent way; this was stated by Grochowski (2013). If properly used and adapted, BSC can provide extraordinary results, Deem, et al., (2010). Tubis et al.'s (2017) paper is one of the earliest works that uses the BSC technique to analyse the performance of transport companies. The author suggested using a BSC card and specified the evaluation metrics for each of the three major areas for him to quantify the effectiveness and efficiency of public transport systems. The author concentrated on outlining the steps necessary to create and apply the BSC technique for public transport providers. Buganova and Luskova (2009) informed that the BSC process could influence transport services at the same

time reducing business risk. Rajesh et al. (2012) used a model for 3 PL logistic services using BSc implementation. Żarski et al. (2014) implemented BSC in a freight transport company. The possibility of computer software was discussed here. The BSC technique was presented by Janczewski (2013) by using strategy maps in an international goods transit company using a strategic scorecard.

Simultaneously, various studies were made for implementing BSC methodologies by G. Frederico and Cavanaghi (2008), Mir Ali et al. (2013), seaport management companies, Habelman et al. (2013), Ossowski et al. (2013) and air transport services providers, Nusraningrum et al., (2014). All these research papers focused on how BSC improvised the organization's efficiency. Tubis and Sylwia (2017) discussed various methods of BSC to improve the requirements of companies handling passenger traffic in Poland. David Staš et al. (2015) applied an MCDM for supply chains. Olszańska, et al., (2021) implemented a strategic score card for a transport company in Podckarpakie and Voivodship. Macián et al. (2019) thoroughly studied various methods to bring out a new model under the reduced management balanced scorecard methods. Habibur Rahman and Hoong Chor Chin (2013) developed a framework with integrated nature for evaluating strategic performance for sustainable urban transport (SUT) based on the Balanced ScoreCard.

Xuqin Song (2022) used an analytic hierarchy process to evaluate the performance of the enterprise and proposed corresponding safeguards for smooth system functioning according to his results. Mohammed Sayed Abdel Hamied and Ayman Elabagoury (2022) provided a framework for implementing the BSC model to evaluate performance. O.E.akinbowale et al. (2022) have employed the four perspectives of BSC for the scrutiny of cyber fraud in the banking sector in South Africa. Anna Saniuk(2022) developed a strategy that supports applying the Logistics 4.0 concept for the transport sector in small and medium industries. Chieh Y L et al. (2023) have explored the application of BSC to measure the performance of industries in the medical sector using the AHP and DEMATEL. E B Leksono et al. (2023) have developed performance measures that indicate the role of service that is sustainable in nature for supply chain management using the DEMATEL approach. Zhe Huang and Mickaël Gardoni (2023), using BSC and DEMATEL methods, have developed product concepts for measuring the System.

3. Proposed Hybrid DEMATEL and ANP Methodology

In the present work, the relative weights of Balanced Scorecard factors are obtained from the aggregated responses from stakeholders. Hybrid Decision Making Trial and Evaluation Laboratory (DEMATEL) method and ANP are applied to evaluate the relative weights of factors from aggregated responses of stakeholders of transport organizations. The DEMATEL-ANP procedure is discussed as shown below.

Step 1: Develop a direct-influence matrix (Z).

The direct-influence matrix is developed depending on the degrees of relative impacts evaluated from comparisons which are pairwise using a 1 to 5 Likert scale to indicate the rate of impact between the enablers. The element Zij of the matrix Z defines the rate of impacts of the i-th dimension on the j-th dimension.

$$Z = \begin{bmatrix} Z_{11} & Z_{12} & \cdots & Z_{1n} \\ Z_{21} & Z_{22} & \cdots & Z_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ Z_{n1} & Z_{n2} & \cdots & Z_{nm} \end{bmatrix}$$

Step 2: Develop the normalized direct-influence matrix (X)

A normalized direct-influence matrix is developed by the relation shown below.

$$X = S * Z$$

$$S = min\left[\frac{1}{\max_i \sum_{j=1}^{n} |z_{ij}|}, \frac{1}{\max_j \sum_{j=1}^{n} |z_{ij}|}\right],$$

$i, j = 1, 2, \ldots, n.$

Step 3: Derive the total-influence matrix (*T*).

Total-influence matrix T is an $n \times n$ matrix Total-influence matrix T is an $n \times n$ matrix and is shown below

$$T = X + X^2 + X^3 + \ldots + X^m = X(I - X)$$

where 'I' represents the identity matrix.

Step 4: Normalized Total relation matrix.

$$(z_i)_{normalized} = \frac{z_{ij}}{\sum_{j=1}^{n} z_{ij}}$$

Step 5: Compute transpose of the normalized total relation matrix.

Step 6: Compute prominence (d_i) and relation (r_j).

Prominence and relation matrices are developed by the following relation.

d_i = Total of elements in every row in '*T*';
i = 1,2,...,*n*
r_j = Total of elements of every column in '*T*';
j = 1,2,...,*n*
$d_i + r_i$ = Prominence
$d_i - r_i$ = relation

The positive relationship puts the enabler in the case group, and the negative relationship puts the enabler in the effect group.

Step 7: Develop a supermatrix which is unweighted.

The unweighted supermatrix can be calculated using the group's interdependent relationship to the transposed normalized total relation matrix.

Step 8: Obtain supermatrix, which is weighted.

The supermatrix is obtained by normalizing the total

relation matrix, which is normalized and transposed.

Step 9: Obtain a stable matrix.

The weighted supermatrix is multiplied by itself a number of times until the occurrence of the stable matrix to get a limit supermatrix from which the priority of the factors can be taken.

4. Data and Parameters Used in the Methodology

The perception of the factors of a balanced scorecard of passenger transport organization is evaluated based on 20 parameters. The degree of perception of influence among the factors is collected through discussion among the stakeholders quantified by using a 5-point scale: Very High-5, High-4; Medium-3; Low-2 and Very Low-1. The following Balanced scorecard perspective and 5 factors under each perspective are considered after a review of the literature.

4.1. Learning and Growth Perspective

This dimension is verified by the following characteristics.
DD1: Staff Productivity;
DD2: Staff Bus ratio;
DD3: Staff Cost/Revenue Earning KMs;
DD4: Fleet Utilization;
DD5: Expenditure on IT Strategies.

4.2. Internal Business Perspective

This dimension is verified by the following characteristics.
DD6: Fuel efficiency;
DD7: Vehicle Productivity (KMs/Bus/Day);
DD8: Income from Advertisements;
DD9: Total cost per Revenue Earnings;
DD10: Income from other provisions

4.3. Financial Perspective

This perspective has the following factors.
DD11: Revenue/KM;
DD12: Revenue/Bus/Day;
DD13: Cost/KM;
DD14: Cost/Bus/day;
DD15: Profit or Loss/KM.

4.4. Customer Perspective

The dimension is verified by the following characteristics.
DD16: Occupancy ratio;
DD17: Passenger KM Performed;
DD18: Number of Accidents /Lakh Effective KMs;
DD19: Average age of Fleet;
DD20: Number of Fatal accidents/Lakh effective KMs.

4.5. Initial Direct Relation Matrix

The initial direct relation matrix is derived as discussed in Step 1 is presented in Table 1.

Table 1. Initial direct relation matrix

	DD1	DD2	DD3	DD4	DD5	DD6	DD7	DD8	DD9	DD10	DD11	DD12	DD13	DD14	DD15	DD16	DD17	DD18	DD19	DD20
DD1	0.0000	2.0000	2.4667	2.0000	3.0000	2.6000	2.5333	2.0667	3.4667	3.4667	3.1333	2.7333	3.3333	3.2000	3.0667	3.1333	3.3333	2.5333	2.6000	2.9333
DD2	2.0000	0.0000	2.6000	2.5333	2.5333	2.0667	3.0000	2.0667	3.5333	3.0667	2.6000	3.4000	3.2000	1.8667	2.7333	3.4667	3.6000	2.8000	2.6000	2.2000
DD3	2.0000	2.6000	0.0000	2.0667	2.5333	2.0667	2.5333	2.5333	3.5333	3.5333	3.2000	3.2667	3.0667	2.4667	3.0667	2.8667	3.2000	2.9333	3.0667	2.8000
DD4	2.4667	2.5333	2.5333	0.0000	2.5333	2.5333	3.0000	3.0000	3.5333	2.6000	3.4000	2.9333	2.9333	2.5333	3.0667	3.2667	2.8667	2.1333	3.0667	2.7333
DD5	2.5333	2.5333	2.5333	3.0000	0.0000	2.5333	3.0000	2.5333	3.5333	3.0667	2.8000	3.0000	2.9333	2.4000	3.2667	3.3333	3.2000	2.8667	2.6667	2.8000
DD6	2.6000	2.0667	2.5333	2.5333	2.5333	0.0000	3.0000	3.0000	2.5333	2.5333	2.5333	2.5333	3.0000	2.7333	3.0000	2.8667	2.6000	3.0000	2.6667	2.7333
DD7	3.0000	2.5333	2.0667	3.0000	3.0000	2.5333	0.0000	2.5333	3.0000	3.5333	2.3333	2.6667	3.3333	3.0667	2.8000	3.2667	2.9333	3.5333	4.1333	3.4000
DD8	2.0667	2.0667	2.0667	2.0667	2.5333	2.5333	2.5333	0.0000	2.5333	2.5333	2.8667	3.3333	3.0000	3.0667	3.5333	2.7333	3.2000	3.2000	3.0667	3.2000
DD9	3.0000	3.0667	3.0667	3.5333	2.5333	2.5333	2.5333	2.5333	0.0000	4.0000	2.8667	2.8000	2.6667	3.2667	2.5333	3.1333	3.7333	3.6667	3.2000	3.4000
DD10	3.4667	3.5333	3.5333	3.0667	2.5333	2.0667	3.0667	2.0667	4.0000	0.0000	3.0667	2.7333	2.9333	3.3333	3.3333	3.6667	2.8000	3.0667	3.4667	2.7333
DD11	2.7333	2.6000	3.1333	2.6667	2.8000	3.0667	2.7333	3.2667	3.2667	2.9333	0.0000	3.3333	3.2667	2.8667	3.3333	2.5333	3.0000	3.1333	2.7333	3.5333
DD12	2.7333	2.6000	3.1333	2.6667	2.8000	3.0667	2.7333	3.2667	3.2667	2.9333	3.3333	0.0000	3.2667	2.8667	3.3333	2.5333	3.0000	3.1333	2.7333	3.5333
DD13	2.7333	2.6000	3.1333	2.6667	2.8000	3.0667	2.7333	3.2667	3.2667	2.9333	3.3333	3.2667	0.0000	2.8667	3.3333	2.5333	3.0000	3.1333	2.7333	3.5333
DD14	2.9333	2.6000	3.6000	3.0000	2.7333	3.2667	3.9333	3.0000	3.1333	2.8667	2.8000	2.6667	3.1333	0.0000	3.0667	2.5333	3.2000	3.2000	2.7333	3.0000
DD15	3.4000	2.2000	3.7333	3.1333	2.7333	3.0000	3.4000	2.9333	3.6667	2.2667	2.8000	2.7333	2.5333	3.2000	0.0000	2.5333	2.8667	3.5333	3.3333	3.1333
DD16	3.0667	3.4000	3.2000	3.2000	2.7333	2.8000	3.0000	3.1333	2.9333	3.0000	3.5333	3.0667	3.2000	3.4000	3.2000	0.0000	3.6667	3.8667	3.2667	2.6667
DD17	3.1333	2.8667	2.5333	3.4000	2.6000	2.6667	2.4667	2.6667	2.3333	2.8000	2.9333	3.6000	3.0000	2.6667	3.1333	3.0667	0.0000	2.1333	2.4667	3.1333
DD18	3.0000	3.0667	3.7333	2.9333	3.2667	3.0000	2.6000	3.1333	2.4667	3.0000	3.0000	2.8667	2.9333	2.1333	3.4000	2.6000	3.0667	0.0000	2.8667	3.4000
DD19	2.9333	3.3333	3.2000	3.1333	3.0667	2.4667	3.4667	3.1333	2.7333	2.6667	2.8000	3.7333	3.2000	3.3333	2.6000	2.8667	3.6667	2.8667	0.0000	3.4667
DD20	2.6667	2.8000	3.4000	3.2000	3.2000	2.8000	3.1333	3.4667	3.1333	2.4000	2.4667	3.0000	2.8000	3.7333	2.5333	2.5333	3.4667	4.0667	3.0000	0.0000

4.5.1. Generalized Relation Matrix

Generalized Relation Matrix is obtained as discussed in step 2 and is shown in Table 2 below.

Table 2. Generalized relation matrix

	DD1	DD2	DD3	DD4	DD5	DD6	DD7	DD8	DD9	DD10	DD11	DD12	DD13	DD14	DD15	DD16	DD17	DD18	DD19	DD20
DD1	0.0000	0.0331	0.0408	0.0331	0.0497	0.0430	0.0419	0.0342	0.0574	0.0574	0.0519	0.0453	0.0552	0.0530	0.0508	0.0519	0.0552	0.0419	0.0430	0.0486
DD2	0.0331	0.0000	0.0430	0.0419	0.0419	0.0342	0.0497	0.0342	0.0585	0.0508	0.0430	0.0563	0.0530	0.0309	0.0453	0.0574	0.0596	0.0464	0.0430	0.0364
DD3	0.0331	0.0430	0.0000	0.0342	0.0419	0.0342	0.0419	0.0419	0.0585	0.0585	0.0530	0.0541	0.0508	0.0408	0.0508	0.0475	0.0530	0.0486	0.0508	0.0464
DD4	0.0408	0.0419	0.0419	0.0000	0.0419	0.0419	0.0497	0.0497	0.0585	0.0430	0.0563	0.0486	0.0486	0.0419	0.0508	0.0541	0.0475	0.0353	0.0508	0.0453
DD5	0.0419	0.0419	0.0419	0.0497	0.0000	0.0419	0.0497	0.0419	0.0585	0.0508	0.0464	0.0497	0.0486	0.0397	0.0541	0.0552	0.0530	0.0475	0.0442	0.0464
DD6	0.0430	0.0342	0.0419	0.0419	0.0419	0.0000	0.0497	0.0497	0.0419	0.0419	0.0419	0.0419	0.0497	0.0453	0.0497	0.0475	0.0430	0.0497	0.0442	0.0453
DD7	0.0497	0.0419	0.0342	0.0497	0.0497	0.0419	0.0000	0.0419	0.0497	0.0585	0.0386	0.0442	0.0552	0.0508	0.0464	0.0541	0.0486	0.0585	0.0684	0.0563
DD8	0.0342	0.0342	0.0342	0.0342	0.0419	0.0419	0.0419	0.0000	0.0419	0.0419	0.0475	0.0552	0.0497	0.0508	0.0585	0.0453	0.0530	0.0530	0.0508	0.0530
DD9	0.0497	0.0508	0.0508	0.0585	0.0419	0.0419	0.0419	0.0419	0.0000	0.0662	0.0475	0.0464	0.0442	0.0541	0.0419	0.0519	0.0618	0.0607	0.0530	0.0563
DD10	0.0574	0.0585	0.0585	0.0508	0.0419	0.0342	0.0508	0.0342	0.0662	0.0000	0.0508	0.0453	0.0486	0.0552	0.0552	0.0607	0.0464	0.0508	0.0574	0.0453
DD11	0.0453	0.0430	0.0519	0.0442	0.0464	0.0508	0.0453	0.0541	0.0541	0.0486	0.0000	0.0552	0.0541	0.0475	0.0552	0.0419	0.0497	0.0519	0.0453	0.0585
DD12	0.0453	0.0430	0.0519	0.0442	0.0464	0.0508	0.0453	0.0541	0.0541	0.0486	0.0552	0.0000	0.0541	0.0475	0.0552	0.0419	0.0497	0.0519	0.0453	0.0585
DD13	0.0453	0.0430	0.0519	0.0442	0.0464	0.0508	0.0453	0.0541	0.0541	0.0486	0.0552	0.0541	0.0000	0.0475	0.0552	0.0419	0.0497	0.0519	0.0453	0.0585
DD14	0.0486	0.0430	0.0596	0.0497	0.0453	0.0541	0.0651	0.0497	0.0519	0.0475	0.0464	0.0442	0.0519	0.0000	0.0508	0.0419	0.0530	0.0530	0.0453	0.0497
DD15	0.0563	0.0364	0.0618	0.0519	0.0453	0.0497	0.0563	0.0486	0.0607	0.0375	0.0464	0.0453	0.0419	0.0530	0.0000	0.0419	0.0475	0.0585	0.0552	0.0519
DD16	0.0508	0.0563	0.0530	0.0530	0.0453	0.0464	0.0497	0.0519	0.0486	0.0497	0.0585	0.0508	0.0530	0.0563	0.0530	0.0000	0.0607	0.0640	0.0541	0.0442
DD17	0.0519	0.0475	0.0419	0.0563	0.0430	0.0442	0.0408	0.0442	0.0386	0.0464	0.0486	0.0596	0.0497	0.0442	0.0519	0.0508	0.0000	0.0353	0.0408	0.0519
DD18	0.0497	0.0508	0.0618	0.0486	0.0541	0.0497	0.0430	0.0519	0.0408	0.0497	0.0497	0.0475	0.0486	0.0353	0.0563	0.0430	0.0508	0.0000	0.0475	0.0563
DD19	0.0486	0.0552	0.0530	0.0519	0.0508	0.0408	0.0574	0.0519	0.0453	0.0442	0.0464	0.0618	0.0530	0.0552	0.0430	0.0475	0.0607	0.0475	0.0000	0.0574
DD20	0.0442	0.0464	0.0563	0.0530	0.0530	0.0464	0.0519	0.0574	0.0519	0.0397	0.0408	0.0497	0.0464	0.0618	0.0419	0.0419	0.0574	0.0673	0.0497	0.0000

4.5.2. Total Influence Matrix

The DEMATEL technique is applied to explore the issues of interdependence and feedback among 20 criteria. The total Influence Matrix is obtained as discussed in step 3 and is shown in Table 3.

Table 3. Total influence matrix

	DD1	DD2	DD3	DD4	DD5	DD6	DD7	DD8	DD9	DD10	DD11	DD12	DD13	DD14	DD15	DD16	DD17	DD18	DD19	DD20
DD1	0.5188	0.5367	0.5935	0.5637	0.5644	0.5420	0.5839	0.5617	0.6396	0.6057	0.5976	0.6089	0.6175	0.5922	0.6197	0.5929	0.6434	0.6174	0.5952	0.6198
DD2	0.5344	0.4889	0.5776	0.5550	0.5409	0.5178	0.5734	0.5449	0.6220	0.5824	0.5725	0.6014	0.5977	0.5545	0.5966	0.5810	0.6288	0.6030	0.5779	0.5906
DD3	0.5483	0.5437	0.5516	0.5621	0.5548	0.5313	0.5812	0.5662	0.6378	0.6040	0.5961	0.6146	0.6107	0.5783	0.6169	0.5863	0.6387	0.6207	0.5997	0.6152
DD4	0.5574	0.5443	0.5937	0.5310	0.5570	0.5406	0.5906	0.5756	0.6402	0.5922	0.6014	0.6119	0.6112	0.5818	0.6193	0.5946	0.6362	0.6111	0.6021	0.6165
DD5	0.5666	0.5523	0.6024	0.5867	0.5248	0.5483	0.5990	0.5766	0.6493	0.6079	0.6009	0.6215	0.6199	0.5880	0.6312	0.6042	0.6503	0.6310	0.6047	0.6263
DD6	0.5342	0.5126	0.5669	0.5452	0.5320	0.4761	0.5643	0.5500	0.5965	0.5642	0.5616	0.5782	0.5848	0.5583	0.5907	0.5621	0.6032	0.5961	0.5692	0.5886
DD7	0.5942	0.5725	0.6175	0.6077	0.5928	0.5680	0.5735	0.5976	0.6642	0.6363	0.6154	0.6389	0.6483	0.6196	0.6466	0.6246	0.6697	0.6637	0.6485	0.6580
DD8	0.5379	0.5239	0.5726	0.5503	0.5436	0.5277	0.5694	0.5147	0.6093	0.5761	0.5787	0.6029	0.5972	0.5754	0.6114	0.5718	0.6254	0.6120	0.5872	0.6086
DD9	0.6055	0.5917	0.6448	0.6273	0.5970	0.5789	0.6256	0.6091	0.6300	0.6557	0.6357	0.6535	0.6508	0.6342	0.6554	0.6348	0.6947	0.6781	0.6466	0.6704
DD10	0.6171	0.6031	0.6568	0.6249	0.6015	0.5763	0.6385	0.6065	0.6979	0.5988	0.6436	0.6574	0.6599	0.6401	0.6722	0.6476	0.6863	0.6746	0.6558	0.6655
DD11	0.5902	0.5733	0.6339	0.6027	0.5900	0.5767	0.6169	0.6092	0.6689	0.6279	0.5786	0.6494	0.6477	0.6169	0.6553	0.6138	0.6710	0.6584	0.6279	0.6606
DD12	0.5902	0.5733	0.6339	0.6027	0.5900	0.5767	0.6169	0.6092	0.6689	0.6279	0.6309	0.5971	0.6477	0.6169	0.6553	0.6138	0.6710	0.6584	0.6279	0.6606
DD13	0.5902	0.5733	0.6339	0.6027	0.5900	0.5767	0.6169	0.6092	0.6689	0.6279	0.6309	0.6484	0.5964	0.6169	0.6553	0.6138	0.6710	0.6584	0.6279	0.6606
DD14	0.5969	0.5769	0.6445	0.6115	0.5927	0.5831	0.6388	0.6087	0.6710	0.6311	0.6267	0.6433	0.6499	0.5753	0.6553	0.6179	0.6782	0.6633	0.6321	0.6566
DD15	0.6019	0.5689	0.6445	0.6114	0.5908	0.5772	0.6287	0.6058	0.6766	0.6201	0.6246	0.6421	0.6387	0.6236	0.6047	0.6157	0.6711	0.6660	0.6389	0.6565
DD16	0.6262	0.6156	0.6678	0.6424	0.6198	0.6024	0.6534	0.6385	0.6986	0.6618	0.6667	0.6793	0.6806	0.6567	0.6875	0.6061	0.7163	0.7032	0.6688	0.6816
DD17	0.5656	0.5475	0.5919	0.5823	0.5564	0.5410	0.5809	0.5689	0.6206	0.5931	0.5927	0.6200	0.6105	0.5819	0.6186	0.5899	0.5888	0.6089	0.5910	0.6204
DD18	0.5886	0.5751	0.6369	0.6010	0.5917	0.5701	0.6092	0.6015	0.6510	0.6231	0.6203	0.6367	0.6369	0.6000	0.6505	0.6094	0.6659	0.6027	0.6241	0.6523
DD19	0.6086	0.5996	0.6511	0.6257	0.6096	0.5825	0.6443	0.6230	0.6784	0.6406	0.6394	0.6726	0.6640	0.6399	0.6614	0.6354	0.6990	0.6713	0.6012	0.6767
DD20	0.5961	0.5833	0.6453	0.6180	0.6032	0.5795	0.6305	0.6194	0.6745	0.6276	0.6254	0.6522	0.6486	0.6369	0.6512	0.6214	0.6863	0.6799	0.6394	0.6130

4.5.3. Normalized Total Relation Matrix

Normalized Total Relation Matrix is obtained as discussed in step 4 and is shown in Table 4.

Table 4. Normalized total relation matrix

	DD1	DD2	DD3	DD4	DD5	DD6	DD7	DD8	DD9	DD10	DD11	DD12	DD13	DD14	DD15	DD16	DD17	DD18	DD19	DD20
DD1	0.0439	0.0454	0.0502	0.0477	0.0478	0.0459	0.0494	0.0475	0.0541	0.0513	0.0506	0.0515	0.0523	0.0501	0.0524	0.0502	0.0545	0.0523	0.0504	0.0525
DD2	0.0467	0.0427	0.0505	0.0485	0.0473	0.0453	0.0501	0.0476	0.0544	0.0509	0.0500	0.0526	0.0522	0.0485	0.0521	0.0508	0.0550	0.0527	0.0505	0.0516
DD3	0.0466	0.0462	0.0469	0.0478	0.0472	0.0452	0.0494	0.0482	0.0542	0.0514	0.0507	0.0523	0.0519	0.0492	0.0525	0.0499	0.0543	0.0528	0.0510	0.0523
DD4	0.0472	0.0461	0.0503	0.0450	0.0472	0.0458	0.0500	0.0487	0.0542	0.0502	0.0509	0.0518	0.0518	0.0493	0.0524	0.0504	0.0539	0.0518	0.0510	0.0522
DD5	0.0472	0.0461	0.0502	0.0489	0.0438	0.0457	0.0499	0.0481	0.0541	0.0507	0.0501	0.0518	0.0517	0.0490	0.0526	0.0504	0.0542	0.0526	0.0504	0.0522
DD6	0.0475	0.0456	0.0505	0.0485	0.0474	0.0424	0.0502	0.0490	0.0531	0.0502	0.0500	0.0515	0.0520	0.0497	0.0526	0.0500	0.0537	0.0531	0.0507	0.0524
DD7	0.0477	0.0460	0.0496	0.0488	0.0476	0.0456	0.0460	0.0480	0.0533	0.0511	0.0494	0.0513	0.0520	0.0497	0.0519	0.0501	0.0538	0.0533	0.0521	0.0528
DD8	0.0468	0.0456	0.0498	0.0479	0.0473	0.0459	0.0495	0.0448	0.0530	0.0501	0.0503	0.0524	0.0519	0.0501	0.0532	0.0497	0.0544	0.0532	0.0511	0.0529
DD9	0.0476	0.0465	0.0507	0.0493	0.0469	0.0455	0.0492	0.0479	0.0495	0.0516	0.0500	0.0514	0.0512	0.0499	0.0515	0.0499	0.0546	0.0533	0.0508	0.0527
DD10	0.0481	0.0470	0.0512	0.0487	0.0469	0.0449	0.0498	0.0473	0.0544	0.0467	0.0502	0.0513	0.0515	0.0499	0.0524	0.0505	0.0535	0.0526	0.0511	0.0519
DD11	0.0473	0.0460	0.0508	0.0483	0.0473	0.0462	0.0495	0.0489	0.0536	0.0504	0.0464	0.0521	0.0519	0.0495	0.0526	0.0492	0.0538	0.0528	0.0504	0.0530
DD12	0.0473	0.0460	0.0508	0.0483	0.0473	0.0462	0.0495	0.0489	0.0536	0.0504	0.0506	0.0479	0.0519	0.0495	0.0526	0.0492	0.0538	0.0528	0.0504	0.0530
DD13	0.0473	0.0460	0.0508	0.0483	0.0473	0.0462	0.0495	0.0489	0.0536	0.0504	0.0506	0.0520	0.0478	0.0495	0.0526	0.0492	0.0538	0.0528	0.0504	0.0530
DD14	0.0476	0.0460	0.0513	0.0487	0.0472	0.0464	0.0509	0.0485	0.0534	0.0503	0.0499	0.0512	0.0518	0.0458	0.0522	0.0492	0.0540	0.0528	0.0504	0.0523
DD15	0.0481	0.0455	0.0515	0.0489	0.0472	0.0461	0.0503	0.0484	0.0541	0.0496	0.0499	0.0513	0.0511	0.0499	0.0483	0.0492	0.0537	0.0533	0.0511	0.0525
DD16	0.0475	0.0467	0.0507	0.0488	0.0471	0.0457	0.0496	0.0485	0.0530	0.0502	0.0506	0.0516	0.0517	0.0499	0.0522	0.0460	0.0544	0.0534	0.0508	0.0517
DD17	0.0481	0.0465	0.0503	0.0495	0.0473	0.0460	0.0494	0.0483	0.0527	0.0504	0.0504	0.0527	0.0519	0.0494	0.0526	0.0501	0.0500	0.0517	0.0502	0.0527
DD18	0.0477	0.0466	0.0516	0.0487	0.0479	0.0462	0.0493	0.0487	0.0527	0.0505	0.0502	0.0516	0.0516	0.0486	0.0527	0.0494	0.0539	0.0488	0.0505	0.0528
DD19	0.0475	0.0468	0.0508	0.0488	0.0475	0.0454	0.0502	0.0486	0.0529	0.0500	0.0499	0.0524	0.0518	0.0499	0.0516	0.0495	0.0545	0.0523	0.0469	0.0528
DD20	0.0472	0.0462	0.0511	0.0489	0.0478	0.0459	0.0499	0.0490	0.0534	0.0497	0.0495	0.0516	0.0513	0.0504	0.0516	0.0492	0.0543	0.0538	0.0506	0.0485

4.5.4. Transpose Matrix

The transpose matrix is obtained by discussed in the methodology section and is presented in Table 5.

Table 5. Transpose matrix

	DD1	DD2	DD3	DD4	DD5	DD6	DD7	DD8	DD9	DD10	DD11	DD12	DD13	DD14	DD15	DD16	DD17	DD18	DD19	DD20
DD1	0.0439	0.0467	0.0466	0.0472	0.0472	0.0475	0.0477	0.0468	0.0476	0.0481	0.0473	0.0473	0.0473	0.0476	0.0481	0.0475	0.0481	0.0477	0.0475	0.0472
DD2	0.0454	0.0427	0.0462	0.0461	0.0461	0.0456	0.0460	0.0456	0.0465	0.0470	0.0460	0.0460	0.0460	0.0460	0.0455	0.0467	0.0465	0.0466	0.0468	0.0462
DD3	0.0502	0.0505	0.0469	0.0503	0.0502	0.0505	0.0496	0.0498	0.0507	0.0512	0.0508	0.0508	0.0508	0.0513	0.0515	0.0507	0.0503	0.0516	0.0508	0.0511
DD4	0.0477	0.0485	0.0478	0.0450	0.0489	0.0485	0.0488	0.0479	0.0493	0.0487	0.0483	0.0483	0.0483	0.0487	0.0489	0.0488	0.0495	0.0487	0.0488	0.0489
DD5	0.0478	0.0473	0.0472	0.0472	0.0438	0.0474	0.0476	0.0473	0.0469	0.0469	0.0473	0.0473	0.0473	0.0472	0.0472	0.0471	0.0473	0.0479	0.0475	0.0478
DD6	0.0459	0.0453	0.0452	0.0458	0.0457	0.0424	0.0456	0.0459	0.0455	0.0449	0.0462	0.0462	0.0462	0.0464	0.0461	0.0457	0.0460	0.0462	0.0454	0.0459
DD7	0.0494	0.0501	0.0494	0.0500	0.0499	0.0502	0.0460	0.0495	0.0492	0.0498	0.0495	0.0495	0.0495	0.0509	0.0503	0.0496	0.0494	0.0493	0.0502	0.0499
DD8	0.0475	0.0476	0.0482	0.0487	0.0481	0.0490	0.0480	0.0448	0.0479	0.0473	0.0489	0.0489	0.0489	0.0485	0.0484	0.0485	0.0483	0.0487	0.0486	0.0490
DD9	0.0541	0.0544	0.0542	0.0542	0.0541	0.0531	0.0533	0.0530	0.0495	0.0544	0.0536	0.0536	0.0536	0.0534	0.0541	0.0530	0.0527	0.0527	0.0529	0.0534
DD10	0.0513	0.0509	0.0514	0.0502	0.0507	0.0502	0.0511	0.0501	0.0516	0.0467	0.0504	0.0504	0.0504	0.0503	0.0496	0.0502	0.0504	0.0505	0.0500	0.0497
DD11	0.0506	0.0500	0.0507	0.0509	0.0501	0.0500	0.0494	0.0503	0.0500	0.0502	0.0464	0.0506	0.0506	0.0499	0.0499	0.0506	0.0504	0.0502	0.0499	0.0495
DD12	0.0515	0.0526	0.0523	0.0518	0.0518	0.0515	0.0513	0.0524	0.0514	0.0513	0.0521	0.0479	0.0520	0.0512	0.0513	0.0516	0.0527	0.0516	0.0524	0.0516
DD13	0.0523	0.0522	0.0519	0.0518	0.0517	0.0520	0.0520	0.0519	0.0512	0.0515	0.0519	0.0519	0.0478	0.0518	0.0511	0.0517	0.0519	0.0516	0.0518	0.0513
DD14	0.0501	0.0485	0.0492	0.0493	0.0490	0.0497	0.0497	0.0501	0.0499	0.0499	0.0495	0.0495	0.0495	0.0458	0.0499	0.0499	0.0494	0.0486	0.0499	0.0504
DD15	0.0524	0.0521	0.0525	0.0524	0.0526	0.0526	0.0519	0.0532	0.0515	0.0524	0.0526	0.0526	0.0526	0.0522	0.0483	0.0522	0.0526	0.0527	0.0516	0.0516
DD16	0.0502	0.0508	0.0499	0.0504	0.0504	0.0500	0.0501	0.0497	0.0499	0.0505	0.0492	0.0492	0.0492	0.0492	0.0492	0.0460	0.0501	0.0494	0.0495	0.0492
DD17	0.0545	0.0550	0.0543	0.0539	0.0542	0.0537	0.0538	0.0544	0.0546	0.0535	0.0538	0.0538	0.0538	0.0540	0.0537	0.0544	0.0500	0.0539	0.0545	0.0543
DD18	0.0523	0.0527	0.0528	0.0518	0.0526	0.0531	0.0533	0.0532	0.0533	0.0526	0.0528	0.0528	0.0528	0.0528	0.0533	0.0534	0.0517	0.0488	0.0523	0.0538
DD19	0.0504	0.0505	0.0510	0.0510	0.0504	0.0507	0.0521	0.0511	0.0508	0.0511	0.0504	0.0504	0.0504	0.0504	0.0511	0.0508	0.0502	0.0505	0.0469	0.0506
DD20	0.0525	0.0516	0.0523	0.0522	0.0522	0.0524	0.0528	0.0529	0.0527	0.0519	0.0530	0.0530	0.0530	0.0523	0.0525	0.0517	0.0527	0.0528	0.0528	0.0485

4.5.5. Degree of Influence

Prominence and Relation values are obtained as discussed in step 6 and are shown in Table 6.

Table 6. Prominence and relation values

Criteria	DD1	DD2	DD3	DD4	DD5	DD6	DD7	DD8	DD9	DD10	DD11	DD12	DD13	DD14	DD15	DD16	DD17	DD18	DD19	DD20
r	11.815	11.442	11.758	11.809	11.992	11.235	12.457	11.496	12.720	12.824	12.469	12.469	12.469	12.554	12.508	13.174	11.771	12.347	12.824	12.632
d	11.5690	11.2567	12.3612	11.8543	11.5431	11.1729	12.1360	11.7965	13.0642	12.3046	12.2395	12.6302	12.6190	12.0877	12.7552	12.1370	13.1954	12.8781	12.3662	12.7984
d + r	23.384	22.698	24.119	23.663	23.535	22.408	24.593	23.292	25.784	25.129	24.709	25.100	25.088	24.641	25.263	25.310	24.966	25.225	25.191	25.430
d – r	-0.246	-0.185	0.603	0.045	-0.449	-0.062	-0.321	0.300	0.344	-0.520	-0.230	0.161	0.150	-0.466	0.247	-1.037	1.425	0.531	-0.458	0.167

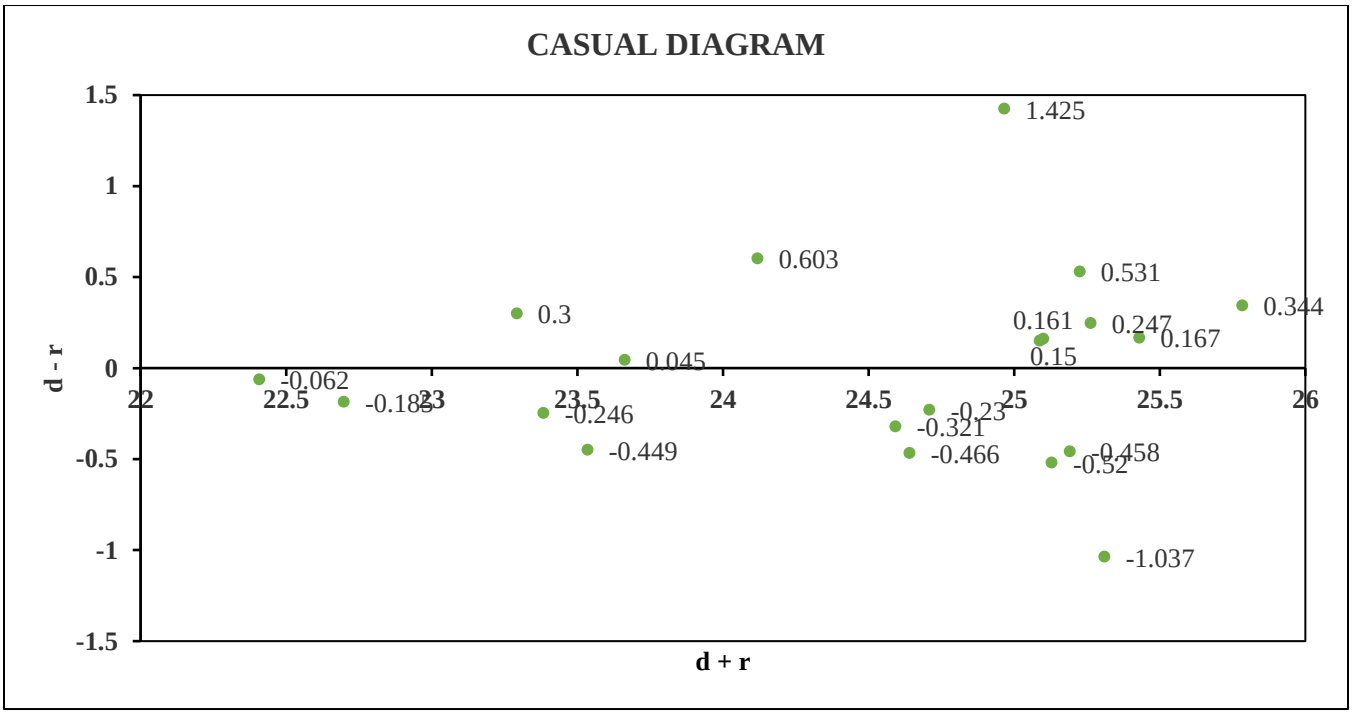

Fig. 1 Causal diagram

From the results, it is observed that DD8, DD9, DD12, DD13, DD15, DD17, DD18 and DD20 have positive relation values and hence may be considered a Cause group. The remaining factors are considered effect groups.

Cause and Effect Relation Figure

*The c*ause and effect relation figure was developed with the X axis considering the values of (d+r) and the Y axis considering the values of (d–r), which are taken from Table 6 and presented in Figure 1.

Relative Weight through Prominence and Relation Values

DEMATEL method can be extended to evaluate weights of the criteria which are relative in nature under consideration. Relative weights and normalized relative weights are determined from the following relations and are presented in Table 7.

$$\text{Relative weights of the Criteria (wi)} = w_i = \sqrt{(d_i = r_i)^2 + (d_i - r_j)^2}$$

$$\text{Normalized relative weight } (W_i) = W_i = \frac{w_i}{\Sigma w_i}$$

From the results, it is clear that the most important factor affecting the performance of road transport companies is the total cost per Revenue Earnings (DD9). It is followed by Number of Fatal accidents/Lakh effective KMs (DD20), Occupancy ratio (DD16), Profit or Loss/KM (DD15), Number of Accidents /Lakh Effective KMs (DD18), Average age of Fleet (DD19), Revenue/Bus/Day (DD10), Income from other provisions (DD12) and Cost/KM (DD13) respectively. Whereas Fuel efficiency (DD6) is the least important among those twenty criteria. In addition, the causal diagram also separates twenty criteria into two different groups as per their value of (Ri–Ci) is positive or negative. The cause group comprises of (DD3), (DD4), (DD8), (DD12), (DD13), (DD15), (DD17) (DD18) and (DD20), while the effect group comprises of (DD1), (DD2), (DD5), (DD6), (DD7), (DD10), (DD11), (DD14), (DD16), and (DD19)

Table 7. Relative weights of criteria

Criteria	DD1	DD2	DD3	DD4	DD5	DD6	DD7	DD8	DD9	DD10	DD11	DD12	DD13	DD14	DD15	DD16	DD17	DD18	DD19	DD20
Relative Weight	23.385	22.699	24.127	23.663	23.539	22.408	24.595	23.294	25.786	25.134	24.710	25.101	25.088	24.645	25.264	25.331	25.007	25.231	25.195	25.431
Normalized Relative Weight	0.0478	0.0464	0.0493	0.0483	0.0481	0.0458	0.0502	0.0476	0.0527	0.0513	0.0505	0.0513	0.0512	0.0503	0.0516	0.0517	0.0511	0.0515	0.0515	0.0519
Rank	17	19	14	15	16	20	13	18	1	7	11	8	9	12	4	3	10	5	6	2

DEMATEL-ANP: Hybrid method of DEMATEL and ANP is also implemented, as illustrated below, to evaluate the weights of the criteria, which are relative in nature

4.5.6. Super Matrix, which is Unweighted

Super Matrix, which is *Unweighted*, is derived as per methodology step 7 is provided in Table 8.

Table 8. Unweighted supermatrix

	DD1	DD2	DD3	DD4	DD5	DD6	DD7	DD8	DD9	DD10	DD11	DD12	DD13	DD14	DD15	DD16	DD17	DD18	DD19	DD20
DD1	0.1868	0.1982	0.1986	0.2002	0.2000	0.1985	0.1991	0.1971	0.1975	0.1988	0.1974	0.1974	0.1974	0.1975	0.1995	0.1974	0.1989	0.1967	0.1967	0.1957
DD2	0.1933	0.1813	0.1969	0.1956	0.1950	0.1905	0.1918	0.1920	0.1930	0.1943	0.1917	0.1917	0.1917	0.1909	0.1885	0.1941	0.1925	0.1921	0.1938	0.1915
DD3	0.2137	0.2142	0.1998	0.2133	0.2127	0.2107	0.2069	0.2099	0.2103	0.2116	0.2120	0.2120	0.2120	0.2132	0.2136	0.2106	0.2082	0.2128	0.2104	0.2118
DD4	0.2030	0.2058	0.2036	0.1908	0.2071	0.2026	0.2036	0.2017	0.2046	0.2014	0.2016	0.2016	0.2016	0.2023	0.2026	0.2025	0.2048	0.2008	0.2022	0.2029
DD5	0.2032	0.2006	0.2010	0.2001	0.1852	0.1977	0.1986	0.1992	0.1947	0.1938	0.1973	0.1973	0.1973	0.1961	0.1958	0.1954	0.1956	0.1977	0.1970	0.1980
DD6	0.1848	0.1823	0.1819	0.1839	0.1839	0.1731	0.1869	0.1887	0.1868	0.1848	0.1860	0.1860	0.1860	0.1861	0.1857	0.1851	0.1863	0.1866	0.1838	0.1850
DD7	0.1991	0.2019	0.1990	0.2009	0.2009	0.2051	0.1887	0.2036	0.2018	0.2048	0.1990	0.1990	0.1990	0.2039	0.2023	0.2007	0.2000	0.1994	0.2033	0.2013
DD8	0.1915	0.1918	0.1939	0.1958	0.1934	0.1999	0.1966	0.1840	0.1965	0.1945	0.1966	0.1966	0.1966	0.1943	0.1949	0.1962	0.1959	0.1969	0.1966	0.1978
DD9	0.2181	0.2190	0.2184	0.2178	0.2178	0.2168	0.2185	0.2178	0.2033	0.2238	0.2158	0.2158	0.2158	0.2142	0.2177	0.2146	0.2137	0.2131	0.2141	0.2154
DD10	0.2065	0.2050	0.2068	0.2015	0.2039	0.2051	0.2094	0.2060	0.2116	0.1920	0.2026	0.2026	0.2026	0.2015	0.1995	0.2033	0.2042	0.2040	0.2021	0.2004
DD11	0.1969	0.1959	0.1976	0.1988	0.1963	0.1954	0.1942	0.1951	0.1968	0.1966	0.1838	0.2004	0.2004	0.1989	0.1993	0.1978	0.1960	0.1973	0.1951	0.1946
DD12	0.2006	0.2058	0.2037	0.2022	0.2030	0.2012	0.2016	0.2033	0.2023	0.2009	0.2063	0.1897	0.2060	0.2042	0.2049	0.2015	0.2050	0.2025	0.2052	0.2029
DD13	0.2034	0.2045	0.2025	0.2020	0.2025	0.2035	0.2046	0.2014	0.2015	0.2016	0.2058	0.2058	0.1895	0.2063	0.2038	0.2019	0.2019	0.2026	0.2026	0.2018
DD14	0.1951	0.1897	0.1917	0.1923	0.1921	0.1943	0.1955	0.1940	0.1964	0.1956	0.1960	0.1960	0.1960	0.1826	0.1990	0.1948	0.1924	0.1908	0.1953	0.1981
DD15	0.2041	0.2041	0.2045	0.2047	0.2062	0.2056	0.2041	0.2062	0.2029	0.2054	0.2082	0.2082	0.2082	0.2080	0.1930	0.2040	0.2046	0.2069	0.2018	0.2026
DD16	0.1932	0.1949	0.1916	0.1943	0.1939	0.1925	0.1913	0.1903	0.1909	0.1945	0.1899	0.1899	0.1899	0.1902	0.1895	0.1795	0.1967	0.1932	0.1935	0.1918
DD17	0.2097	0.2109	0.2087	0.2079	0.2087	0.2066	0.2052	0.2081	0.2090	0.2061	0.2076	0.2076	0.2076	0.2088	0.2066	0.2122	0.1963	0.2111	0.2129	0.2118
DD18	0.2012	0.2023	0.2028	0.1997	0.2025	0.2042	0.2033	0.2037	0.2040	0.2026	0.2037	0.2037	0.2037	0.2042	0.2051	0.2083	0.2030	0.1911	0.2045	0.2098
DD19	0.1940	0.1938	0.1959	0.1967	0.1940	0.1950	0.1987	0.1954	0.1945	0.1969	0.1943	0.1943	0.1943	0.1946	0.1967	0.1981	0.1971	0.1978	0.1831	0.1974
DD20	0.2020	0.1981	0.2010	0.2014	0.2010	0.2016	0.2015	0.2025	0.2016	0.1999	0.2044	0.2044	0.2044	0.2021	0.2021	0.2019	0.2069	0.2068	0.2061	0.1892

4.5.7. Super Matrix: which is Weighted

Super Matrix, which is *Weighted, is* derived as discussed in step 8 and is presented in the following Table 9.

Table 9. Weighted supermatrix

	DD1	DD2	DD3	DD4	DD5	DD6	DD7	DD8	DD9	DD10	DD11	DD12	DD13	DD14	DD15	DD16	DD17	DD18	DD19	DD20
DD1	0.0439	0.0467	0.0466	0.0472	0.0472	0.0475	0.0477	0.0468	0.0476	0.0481	0.0473	0.0473	0.0473	0.0476	0.0481	0.0475	0.0481	0.0477	0.0475	0.0472
DD2	0.0454	0.0427	0.0462	0.0461	0.0461	0.0456	0.0460	0.0456	0.0465	0.0470	0.0460	0.0460	0.0460	0.0460	0.0455	0.0467	0.0465	0.0466	0.0468	0.0462
DD3	0.0502	0.0505	0.0469	0.0503	0.0502	0.0505	0.0496	0.0498	0.0507	0.0512	0.0508	0.0508	0.0508	0.0513	0.0515	0.0507	0.0503	0.0516	0.0508	0.0511
DD4	0.0477	0.0485	0.0478	0.0450	0.0489	0.0485	0.0488	0.0479	0.0493	0.0487	0.0483	0.0483	0.0483	0.0487	0.0489	0.0488	0.0495	0.0487	0.0488	0.0489
DD5	0.0478	0.0473	0.0472	0.0472	0.0438	0.0474	0.0476	0.0473	0.0469	0.0469	0.0473	0.0473	0.0473	0.0472	0.0472	0.0471	0.0473	0.0479	0.0475	0.0478
DD6	0.0459	0.0453	0.0452	0.0458	0.0457	0.0424	0.0456	0.0459	0.0455	0.0449	0.0462	0.0462	0.0462	0.0464	0.0461	0.0457	0.0460	0.0462	0.0454	0.0459
DD7	0.0494	0.0501	0.0494	0.0500	0.0499	0.0502	0.0460	0.0495	0.0492	0.0498	0.0495	0.0495	0.0495	0.0509	0.0503	0.0496	0.0494	0.0493	0.0502	0.0499
DD8	0.0475	0.0476	0.0482	0.0487	0.0481	0.0490	0.0480	0.0448	0.0479	0.0473	0.0489	0.0489	0.0489	0.0485	0.0484	0.0485	0.0483	0.0487	0.0486	0.0490
DD9	0.0541	0.0544	0.0542	0.0542	0.0541	0.0531	0.0533	0.0530	0.0495	0.0544	0.0536	0.0536	0.0536	0.0534	0.0541	0.0530	0.0527	0.0527	0.0529	0.0534
DD10	0.0513	0.0509	0.0514	0.0502	0.0507	0.0502	0.0511	0.0501	0.0516	0.0467	0.0504	0.0504	0.0504	0.0503	0.0496	0.0502	0.0504	0.0505	0.0500	0.0497
DD11	0.0506	0.0500	0.0507	0.0509	0.0501	0.0500	0.0494	0.0503	0.0500	0.0502	0.0464	0.0506	0.0506	0.0499	0.0499	0.0506	0.0504	0.0502	0.0499	0.0495
DD12	0.0515	0.0526	0.0523	0.0518	0.0518	0.0515	0.0513	0.0524	0.0514	0.0513	0.0521	0.0479	0.0520	0.0512	0.0513	0.0516	0.0527	0.0516	0.0524	0.0516
DD13	0.0523	0.0522	0.0519	0.0518	0.0517	0.0520	0.0520	0.0519	0.0512	0.0515	0.0519	0.0519	0.0478	0.0518	0.0511	0.0517	0.0519	0.0516	0.0518	0.0513
DD14	0.0501	0.0485	0.0492	0.0493	0.0490	0.0497	0.0497	0.0501	0.0499	0.0499	0.0495	0.0495	0.0495	0.0458	0.0499	0.0499	0.0494	0.0486	0.0499	0.0504
DD15	0.0524	0.0521	0.0525	0.0524	0.0526	0.0526	0.0519	0.0532	0.0515	0.0524	0.0526	0.0526	0.0526	0.0522	0.0483	0.0522	0.0526	0.0527	0.0516	0.0516
DD16	0.0502	0.0508	0.0499	0.0504	0.0504	0.0500	0.0501	0.0497	0.0499	0.0505	0.0492	0.0492	0.0492	0.0492	0.0492	0.0460	0.0501	0.0494	0.0495	0.0492
DD17	0.0545	0.0550	0.0543	0.0539	0.0542	0.0537	0.0538	0.0544	0.0546	0.0535	0.0538	0.0538	0.0538	0.0540	0.0537	0.0544	0.0500	0.0539	0.0545	0.0543
DD18	0.0523	0.0527	0.0528	0.0518	0.0526	0.0531	0.0533	0.0532	0.0533	0.0526	0.0528	0.0528	0.0528	0.0528	0.0533	0.0534	0.0517	0.0488	0.0523	0.0538
DD19	0.0504	0.0505	0.0510	0.0510	0.0504	0.0507	0.0521	0.0511	0.0508	0.0511	0.0504	0.0504	0.0504	0.0504	0.0511	0.0508	0.0502	0.0505	0.0469	0.0506
DD20	0.0525	0.0516	0.0523	0.0522	0.0522	0.0524	0.0528	0.0529	0.0527	0.0519	0.0530	0.0530	0.0530	0.0523	0.0525	0.0517	0.0527	0.0528	0.0528	0.0485

4.5.8. Stable Matrix

A stable matrix is obtained as discussed in step 9 and is shown in Table 10.

Table 10. Stable matrix

	DD1	DD2	DD3	DD4	DD5	DD6	DD7	DD8	DD9	DD10	DD11	DD12	DD13	DD14	DD15	DD16	DD17	DD18	DD19	DD20
DD1	0.0473	0.0473	0.0473	0.0473	0.0473	0.0473	0.0473	0.0473	0.0473	0.0473	0.0473	0.0473	0.0473	0.0473	0.0473	0.0473	0.0473	0.0473	0.0473	0.0473
DD2	0.0460	0.0460	0.0460	0.0460	0.0460	0.0460	0.0460	0.0460	0.0460	0.0460	0.0460	0.0460	0.0460	0.0460	0.0460	0.0460	0.0460	0.0460	0.0460	0.0460
DD3	0.0505	0.0505	0.0505	0.0505	0.0505	0.0505	0.0505	0.0505	0.0505	0.0505	0.0505	0.0505	0.0505	0.0505	0.0505	0.0505	0.0505	0.0505	0.0505	0.0505
DD4	0.0484	0.0484	0.0484	0.0484	0.0484	0.0484	0.0484	0.0484	0.0484	0.0484	0.0484	0.0484	0.0484	0.0484	0.0484	0.0484	0.0484	0.0484	0.0484	0.0484
DD5	0.0472	0.0472	0.0472	0.0472	0.0472	0.0472	0.0472	0.0472	0.0472	0.0472	0.0472	0.0472	0.0472	0.0472	0.0472	0.0472	0.0472	0.0472	0.0472	0.0472
DD6	0.0457	0.0457	0.0457	0.0457	0.0457	0.0457	0.0457	0.0457	0.0457	0.0457	0.0456	0.0456	0.0456	0.0456	0.0456	0.0457	0.0457	0.0456	0.0457	0.0457
DD7	0.0496	0.0496	0.0496	0.0496	0.0496	0.0496	0.0496	0.0496	0.0496	0.0496	0.0496	0.0496	0.0496	0.0496	0.0496	0.0496	0.0496	0.0496	0.0496	0.0496
DD8	0.0482	0.0482	0.0482	0.0482	0.0482	0.0482	0.0482	0.0482	0.0482	0.0482	0.0482	0.0482	0.0482	0.0482	0.0482	0.0482	0.0482	0.0482	0.0482	0.0482
DD9	0.0534	0.0534	0.0534	0.0534	0.0534	0.0534	0.0534	0.0534	0.0534	0.0534	0.0534	0.0534	0.0534	0.0534	0.0534	0.0534	0.0534	0.0534	0.0534	0.0534
DD10	0.0503	0.0503	0.0503	0.0503	0.0503	0.0503	0.0503	0.0503	0.0503	0.0503	0.0503	0.0503	0.0503	0.0503	0.0503	0.0503	0.0503	0.0503	0.0503	0.0503
DD11	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500
DD12	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516
DD13	0.0515	0.0515	0.0515	0.0516	0.0516	0.0515	0.0515	0.0515	0.0516	0.0516	0.0515	0.0515	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516
DD14	0.0494	0.0494	0.0494	0.0494	0.0494	0.0494	0.0494	0.0494	0.0494	0.0494	0.0494	0.0494	0.0494	0.0494	0.0494	0.0494	0.0494	0.0494	0.0494	0.0494
DD15	0.0521	0.0521	0.0521	0.0521	0.0521	0.0521	0.0521	0.0521	0.0521	0.0521	0.0521	0.0521	0.0521	0.0521	0.0521	0.0521	0.0521	0.0521	0.0521	0.0521
DD16	0.0496	0.0496	0.0496	0.0496	0.0496	0.0496	0.0496	0.0496	0.0496	0.0496	0.0496	0.0496	0.0496	0.0496	0.0496	0.0496	0.0496	0.0496	0.0496	0.0496
DD17	0.0539	0.0539	0.0539	0.0539	0.0539	0.0539	0.0539	0.0539	0.0539	0.0539	0.0539	0.0539	0.0539	0.0539	0.0539	0.0539	0.0539	0.0539	0.0539	0.0539
DD18	0.0526	0.0526	0.0526	0.0526	0.0526	0.0526	0.0526	0.0526	0.0526	0.0526	0.0526	0.0526	0.0526	0.0526	0.0526	0.0526	0.0526	0.0526	0.0526	0.0526
DD19	0.0505	0.0505	0.0505	0.0505	0.0505	0.0505	0.0505	0.0505	0.0505	0.0505	0.0505	0.0505	0.0505	0.0505	0.0505	0.0505	0.0505	0.0505	0.0505	0.0505
DD20	0.0523	0.0523	0.0523	0.0523	0.0523	0.0523	0.0523	0.0523	0.0523	0.0523	0.0523	0.0523	0.0523	0.0523	0.0523	0.0523	0.0523	0.0523	0.0523	0.0523

The Criteria Relative Weights: Values in the stable matrix represent the normalized Criteria Relative weights. These, along with ranking, are presented in the following Table 11:

DEMATEL-AHM

AHM is used because there are no eigenvector computations and consistency checks in AHM. The total influence matrix is derived in the DEMATEL method and is applied to compute criteria relative weights from the following relation.

Criteria Relative Weights

The relative attribute weight of the j^{th} criteria (W_{cj}) is calculated using the equation below.

$$w_i = \frac{2}{i*(i-1)} * \sum_{i=1}^{J} \mu_{ij} \qquad i = 1, 2....J$$

$$\mu_{ij} = Total\ Influence\ among\ the\ criteria$$

Normalized relative weight is calculated using the equation below.

$$W_i = \frac{w_i}{\sum_{i=1}^{j} w_i}$$

Table 11. Normalized relative weights of the criteria using DEMATEL-ANP

Criteria	DD1	DD2	DD3	DD4	DD5	DD6	DD7	DD8	DD9	DD10	DD11	DD12	DD13	DD14	DD15	DD16	DD17	DD18	DD19	DD20
Normalized Relative Weight	0.0473	0.046	0.0505	0.0484	0.0472	0.0457	0.0496	0.0482	0.0534	0.0503	0.05	0.0516	0.0515	0.0494	0.0521	0.0496	0.0539	0.0526	0.0505	0.0523
Rank	17	19	8	15	18	20	12	16	2	10	11	6	7	14	5	12	1	3	8	4

Table 12. Normalized relative weights of the criteria using DEMATEL-AHM

Criteria	DD1	DD2	DD3	DD4	DD5	DD6	DD7	DD8	DD9	DD10	DD11	DD12	DD13	DD14	DD15	DD16	DD17	DD18	DD19	DD20
Relative Weight	0.0622	0.0602	0.0619	0.0622	0.0631	0.0591	0.0656	0.0605	0.0669	0.0675	0.0656	0.0656	0.0656	0.0661	0.0658	0.0693	0.0620	0.0650	0.0675	0.0665
Normalized Relative Weight	0.0483	0.0467	0.0480	0.0482	0.0490	0.0459	0.0509	0.0470	0.0520	0.0524	0.0509	0.0509	0.0509	0.0513	0.0511	0.0538	0.0481	0.0504	0.0524	0.0516
Rank	14	19	17	15	13	20	11	18	4	2	8	8	10	6	7	1	16	12	3	5

5. Results

Normalized relative weights of the criteria are determined through DEMATEL and DEMATEL-AHM, and DEMATEL-ANP methods and are presented in Table 13.

Correlation between the proposed methods in respect of their ranking is computed using Minitab-16. It is observed that there is a high significant positive correlation (0.818) has existed between the DEMATEL and DEMATEL-ANP. Also, there exists a strong positive correlation between DEMATEL and DEMATEL-AHM. Since the p-value is equal to 0.00, there is sufficient evidence at $\alpha = 0.00$ that a significant correlation exists between DEMATEL with DEMATEL-ANP and DEMATEL-AHM. However, a moderate correlation exists (0.452) between DEMATEL-ANP and DEMATEL-AHM at a p-value of 0.045.

Aggregate Weights: In this work, an empirical methodology to evaluate aggregate numerical criteria weights using group ordinal ranks of multiple decision criteria is presented (Hesham K. Alfares and Salih.O. Duffuaa (2008).

Percentage weight factor

$w_{r,n} = 100 - s_n(r\text{-}1)$,

where, $s_n = 3.195 + \frac{37.758}{n}$, $1 \leq n$ 21, $1 \leq r \leq n$,

r and n are integer.

The hybrid method of DEMATEL-ANP is used in the study to obtain the level of influential weights of 20 Balanced scorecard criteria, which will be useful for the performance evaluation of passenger transport organizations. The results of the study indicate that the decision makers must pay more attention to the Customer Perspective (CP), Financial Perspective (FP), Internal Business Perspective (IBP) and Learning & Growth Perspective with relative weights of 0.3734, 0.2901, 0.2180 and 0.1186 respectively.

Total Costs per revenue Earning (DD9) is important with a relative weight of 0.0868, followed by Occupancy ratio (DD16), Number of Fatal accidents/Lakh effective KMs. (DD20). A similar rank is obtained for (DD10) Income from other provisions and Profit or Loss/KM (DD15)

Discussion of the results in respect of factors under four perspectives is useful to evaluate and monitor the factors in an order that will improve the performance of the passenger transportation organizations. The relative importance order of factors under four perspectives is presented below.

DD9>DD16>DD20>DD10,DD15>DD19>DD17>DD18>
DD12>DD13>DD11>DD14>DD7>DD3>DD4>DD5
>DD1>DD8>DD2>DD6

Table 13. Relative weights of the proposed methods

Criteria	DEMATEL		DEMATEL-ANP		DEMATEL-AHM	
	Weight	Rank	Weight	Rank	Weight	Rank
DD1	0.0478	17	0.0473	17	0.0483	14
DD2	0.0464	19	0.046	19	0.0467	19
DD3	0.0493	14	0.0505	8	0.048	17
DD4	0.0483	15	0.0484	15	0.0482	15
DD5	0.0481	16	0.0472	18	0.049	13
DD6	0.0458	20	0.0457	20	0.0459	20
DD7	0.0502	13	0.0496	12	0.0509	11
DD8	0.0476	18	0.0482	16	0.047	18
DD9	0.0527	1	0.0534	2	0.052	4
DD10	0.0513	7	0.0503	10	0.0524	2
DD11	0.0505	11	0.05	11	0.0509	8
DD12	0.0513	8	0.0516	6	0.0509	8
DD13	0.0512	9	0.0515	7	0.0509	10
DD14	0.0503	12	0.0494	14	0.0513	6
DD15	0.0516	4	0.0521	5	0.0511	7
DD16	0.0517	3	0.0496	12	0.0538	1
DD17	0.0511	10	0.0539	1	0.0481	16
DD18	0.0515	5	0.0526	3	0.0504	12
DD19	0.0515	6	0.0505	8	0.0524	3
DD20	0.0519	2	0.0523	4	0.0516	5

Table 14. Correlations between the methods

METHOD	DEMATEL	DEMATEL-ANP	DEMATEL-AHM
DEMATEL	1	0.818 (0.00)	0.830(0.00)
DEMATEL-ANP	0.818 (0.00)	1	0.452 (0.045)
DEMATEL-AHM	0.830(0.00)	0.452 (0.045)	1

Table 15. Aggregate weights of perspectives and the criteria

Perspective	Criteria	GM of Ranks	Relative weight	Aggregate weight	Aggregate Rank
LGP	DD1	15.93	24.09	0.0220	17
	DD2	19.00	8.51	0.0078	19
	DD3	12.39	42.08	0.0385	14
	DD4	15.00	28.84	0.0264	15
	DD5	15.53	26.16	0.0239	16
IBP	DD6	20.00	3.42	0.0031	20
	DD7	11.97	44.23	0.0404	13
	DD8	17.31	17.11	0.0156	18
	DD9	2.00	94.92	0.0868	1
	DD10	5.19	78.69	0.0720	4
FP	DD11	9.89	54.80	0.0501	11
	DD12	7.27	68.14	0.0623	9
	DD13	8.57	61.51	0.0562	10
	DD14	10.03	54.12	0.0495	12
	DD15	5.19	78.69	0.0720	4
CP	DD16	3.30	88.30	0.0807	2
	DD17	5.43	77.49	0.0709	7
	DD18	5.65	76.38	0.0698	8
	DD19	5.24	78.44	0.0717	6
	DD20	3.42	87.70	0.0802	3

6. Conclusion

The relative weights obtained through the proposed DEMATEL, DEMATEL–ANP and DEMATEL- AHP based on the balanced scorecard perspectives is useful for the decision-makers to compute the efficiency of passenger transport organizations. The present methodology developed a robust procedure to arrive at the aggregate weight and rank. However, they can be adjusted among the 20 factors per local conditions of regions to derive important data for decision-makers if they improve the efficiency of the Organizations. The study will give a potential base on the relative importance of the factors. This study explored the balanced scorecard perspectives and their factors. The proposed study will be more suitable if the opinions of the other stakeholders of passenger transport organizations.

Future Scope of Study

Combining the proposed subjective method with any objective methods like Entropy measurement, CRITIC etc., methods into consideration in future studies.

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