A Decision Support System for Performance Evaluation: A Combined D-ANP & ANN Approach

Gazi Murat Duman[1], Dr. Ahmed El-Sayed [2]
Advisor: Dr. Elif Kongar[1]
[1]Department of Technology Management, University of Bridgeport
[2] Department of Computer Science and Engineering, University of Bridgeport

Objective

Continuous performance evaluations utilizing both qualitative and quantitative information play an important role in sustaining efficient and effective business processes. Therefore, the literature offers a wide range of performance evaluation methodologies to assess the operational efficiency in various industries. Majority of these models however, focus solely on quantitative criteria avoiding the interrelations and dependencies between qualitative and quantitative measurements. Furthermore, these methodologies tend to utilize discrete and contemporary information eliminating historical performance data. With these motivations, this study proposes an integrated approach combining Decision-Making Trial and Evaluation Laboratory (DEMATEL), Analytic Network Process (ANP) and Artificial Neural Network (ANN) methodologies for performance evaluation. In the proposed model, DEMATEL and ANP methodologies are utilized to obtain priorities of the evaluation criteria. Following this, an ANN model is designed and trained with historical performance data collected from the organization and the results of the DEMATEL-ANP model. The outcomes included the relational data among the criteria and alternatives used in the model in addition to their relative rankings. A U.S.-based fast food restaurant company with seven franchise retail stores located in the northeast region is selected to demonstrate the steps of the proposed model.

Criteria Weights via DEMATEL-ANP (D-ANP) Method

The DANP is a novel method that combines the original DEMATEL and ANP methods to utilize total relation matrix for the criteria and the clusters, viz., the qualitative and quantitative perspectives in this study. The criteria, the linguistic scale for the assessments and the weights obtained via D-ANP are provided below.

Table 1. The Criteria

Influencing factors(D1)		Quantitative (D2)		Qualitative (D3)	
C11	Store territory	C21	Weekly sales	C31	Store Image
C12	Population Density	C22	Number of carry-out orders	C32	Service Quality
C13	Weekly expenses	C23	Number of delivery orders	C33	Product Quality
C14	Hours worked by in-store personnel	C24	Resource utilization ratio	C34	Food safety
C15	Hours worked by delivery personnel	C25	On-time delivery ratio	C35	Operational safety
		C26	Out to door time ratio		

Table 2. The linguistic scale for the assessments

Linguistic terms	Numbers
No influence (N)	0
Low influence (L)	1
Medium influence (M)	2
High influence (H)	3
Very high influence (V)	4

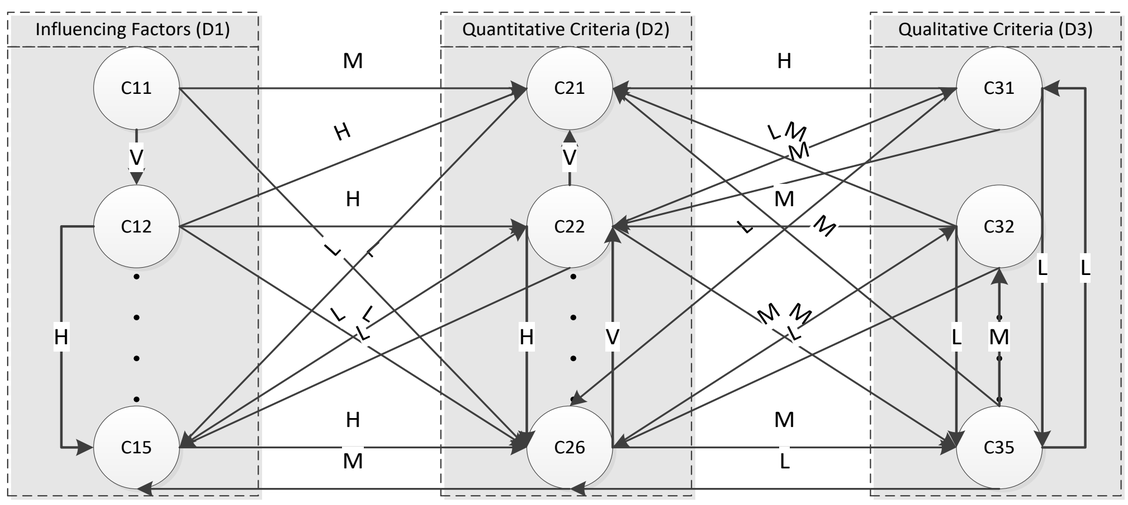

Figure 1: Partial representation of the assessments

Table 3. The weights of the dimensions and the criteria

Dimension	Local Weight	Ranking	Criteria	Local Weight	Global Weight	Ranking
D1	0.11	3	C11	0.0000	0.00000	15
			C12	0.0000	0.00000	16
			C13	0.4125	0.04626	12
			C14	0.2957	0.03316	13
			C15	0.2919	0.03273	14
D2	0.56	1	C21	0.1790	0.09990	1
			C22	0.1306	0.07285	7
			C23	0.1617	0.09024	5
			C24	0.1753	0.09782	4
			C25	0.1756	0.09800	3
			C26	0.1777	0.09916	2
D3	0.33	2	C31	0.2528	0.08338	6
			C32	0.1751	0.05777	10
			C33	0.1619	0.05340	11
			C34	0.2146	0.07079	8
			C35	0.1957	0.06454	9

Ranking via ANN

In order to obtain the store ranking, historical data from 2011 to 2017 for seven stores have been retrieved from the company's store management system. This historical data contains the numerical values for the evaluation criteria and the final performance score given by the external auditor for each period in a year. Furthermore, these numerical data for the evaluation criteria are weighted with the corresponding value obtained by D-ANP and a final weighted performance score is computed.

Table 4. The partial representation of the ANN data set

Store	Year	Period	C21	C22	.....	C34	C35	Auditor's Score	Weighted Score
Store1	2011	1	-0.08	1.86	.....	4	5	0.78	0.687
Store1	2011	2	7.82	5.94	.....	3	4	0.75	0.696
Store1	2011	3	2.17	2.03	.....	3	5	0.82	0.726
Store1	2011	4	-0.02	-3.23	.....	4	4	0.69	0.634
⋮	⋮	⋮	⋮	⋮	.....	⋮	⋮	⋮	⋮
Store7	2017	1	-3.46	-0.59	.....	2	4	0.57	0.526
Store7	2017	2	4.18	3.36	.....	5	5	0.89	0.793
Store7	2017	3	7.64	6.18	.....	2	5	0.69	0.621
Store7	2017	4	-3.23	3.36	.....	3	5	0.7	0.637

In the artificial neural network model, the evaluation criteria and both weighted scores and auditor's scores were embedded as inputs and outputs respectively. The designed model was executed in Matlab 2017b and run 7 times with the values of each store. Hence, 7 different networks were created. The configuration for the network is provided in Figure 2.

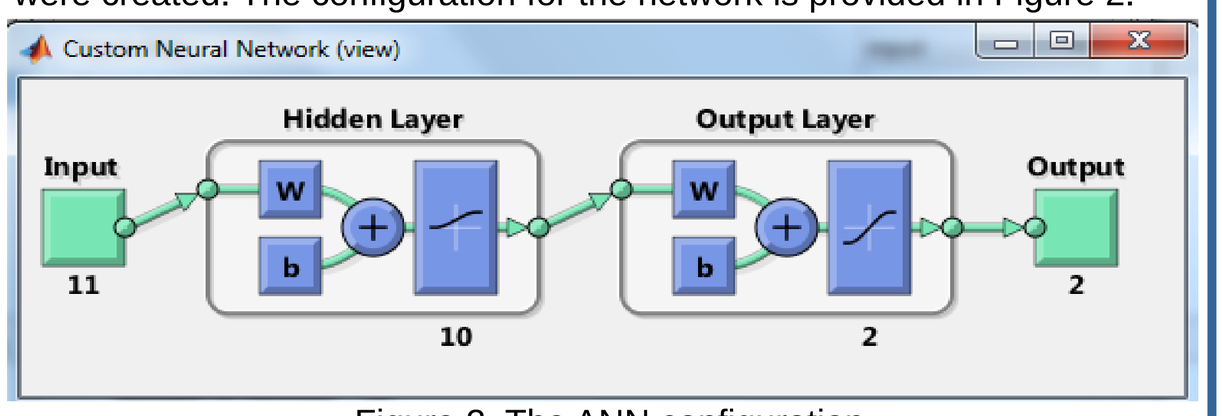

Figure 2. The ANN configuration

The highest normalized value for each criterion is determined as "1" so that the highest predicted performance value for each store is obtained by simulating the corresponding network. The results are provided in Table 5.

Table 5. ANN Results and Store Ranking

Store	Store 1	Store 2	Store 3	Store 4	Store 5	Store 6	Store 7
Performance	0.82480	0.68955	0.68015	0.77505	0.72950	0.75100	0.82485
Rank	2	6	7	3	5	4	1

Conclusions & Future Research

In this study, a novel performance evaluation approach combining DEMATEL, ANP and ANN methods is proposed. The influenced weights for the evaluation criteria are calculated by D-ANP and following this the final ranking of the stores is obtained by utilizing historical data in artificial neural networks.

In the future, a group decision making approach utilizing different perspectives from several decision makers could be added to the model. Moreover, instead of using crisp values, fuzzy numbers could be utilized to reflect the vagueness in this research.

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