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Simulating the profitability of state transport undertakings using artificial neural network

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ABSTRACT

State Transport Undertakings (STUs) are established with the major objective of providing economic, coordinated, efficient and adequate bus services to the society. The STUs are also bound to carry on their operations on business principles due to the recent Government policy of self sustain in the Public Sector Undertakings (PSUs). Due to this duality in its objectives the STUs are swinging on both sides (i.e.) social objectives on one side and the commercial objectives on the other side. In this process of conflicting goals the profitability and the public services were unsolved. In this paper an attempt has been made to simulate the profitability of STUs in terms of Total Cost/Bus (on Road)/Day and Total Revenue/Bus (Held)/Day using Artificial Neural Network (ANN). For this study as many as 29 performance indicators of 37 STUs with 11 years data were used to train the network. The results and statistical tests are very much encouraging. Therefore ANN is a better tool to map an unexplainable relationship between the input and the output variables. And this can also be used for future predictions and optimization.

Introduction

Forecasting the profitability of State Transport Undertakings (STUs) is an essential operation to the present state of Government polices. Due to the financial crisis in the Public Sector Undertakings (PSUs) which are started in the motive of industrial revolution in free India, Government of India is now slowly disinvesting her stack of shares and asked the remaining PSUs to become self sustain (i.e.) they are forced to improve their profit by improve their performances.

Now the PSUs and STUs are in a state of finding their ways and means to improve their performances. In their process they should be able to find what performances are to be improved to attain their goal. For this purpose they have to establish a reasonable relationship between the predicting and predictor parameters. There are two widely used methods viz. i) Time Series model and ii) Regression model. Of which Time Series model is simply an extrapolation of the past years data where as Regression model require complex modeling techniques and heavy computational time to produce reasonably accurate results. Also some times we have to eliminate few variables to satisfy statistical tests. In the recent years Artificial Neural Network (ANN) model was used to find the complex relationship between dependent and independent variables. In this paper an attempt has been made to build a model to forecast the profitability of STUs in terms of Total Revenue/Bus (Held)/Day and Total Cost/Bus (on Road)/Day with the use 29 performance parameters.

Overview of ann:

Recently a lot of interest has been focused on the application of ANNs for forecasting. The major advantage of ANN over statistical models lies in its ability to model a multivariate problem without making complex dependency assumptions among input variables. Further more the ANN extracts the implicit nonlinear relationship among the input by learning from training data.

Several ANN topologies have been developed for different applications, the most popular being the *Feed Forward Back Propagation Network.* It is a gradient descent error-correcting algorithm, which updates the weights in such a way that the network output error is minimized. The typical topology consists of one input layer, one or more hidden layers and one output layer. The operation of ANN consists of two stages namely i) Training and ii) Testing.

Training:

In the training stage the ANN is presented with pairs of several input and corresponding desired output data. The network is trained till the error between the actual and computed is minimized for all pattern pairs.

Testing:

In the testing stage, a new input pattern is presented and the output of the ANN is computed, which is when compared with the actual or target output, should provide an exact replica with minimum forecast error.

Neural network models:

The design of optimal Neural Network structures is till an art to determine the number of hidden layers and the number of neurons in each hidden layer. The purpose of the hidden layer in a neural network is to capture the inherent non-linearity in the input pattern in the form of multi-variable dependency information in the input. It also serves the purpose as a 'pattern matcher' for the input and output patterns to be learned by the neural network. With this principle, several hidden layers and nodes are considered in designing a neural network, the number of which is unknown in the initial stage. Till to date there exists no generalized rule for determining the number of hidden layers and neurons. Based on the neural network performance, the layers and neurons are heuristically assigned, on a trial and error basis, for reducing the error. In addition, the number of layers

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and neurons vary for different applications. Changes in input, in the form of addition of new information to existing training data, alters the topology of the neural network. In other words, the parameters of the neural network have to be tuned for efficient performance.

Input – output mapping with ann:

Most neural networks use sigmoidal activation functions, which make it possible for neural networks to perform a complicated input – output mapping through the Back Propagation procedure. In essence a neural network model is equivalent to a set of algebraic equations arranged in a hierarchical order to form an input – output mapping. Changing the structure of a neural network corresponds nothing more than changing the hierarchical order of the algebraic equations. Training the neural network is just another way to estimate the parameters in the complex input – output transformation function. The important stages to attain the solution are:

1. Data Presentation,
2. Data Normalization,
3. Training,
4. Testing.

Study network design:

Data Presentation:

Input:

The input parameters used to train the ANN consists of 29 neurons namely:

1. Staff per Bus,
2. Manpower Productivity,
3. Passenger Kilometer per Employee per Day,
4. Average Salary per Employee per Day,
5. Percentage of Fleet Utilisation,
6. Effective Bus Kilometer per Gross Bus Kilometer,
7. Passenger Kilometer per Effective Bus Kilometer,
8. Effective Bus Kilometer per Bus (Held) per Day,
9. Operating Revenue per Passenger Kilometer,
10. Operating Cost per Passenger Kilometer,
11. Operating Revenue per Effective Bus Kilometer,
12. Operating Cost per Effective Bus kilometer,
13. Total Revenue per Passenger Kilometer,
14. Total Cost per Passenger Kilometer,
15. Total Revenue per Gross Bus Kilometer,
16. Total Cost per Effective Bus Kilometer,
17. Operating Revenue per Operating Cost,
18. Total Revenue per Total Cost,
19. Breakdown per 1000 KM,
20. Accident per 10,000 Kilometers,
21. Kilometer per Litre of HSD,
22. Total Revenue per Capital Employed,
23. Total Revenue per Fixed Asset,
24. Total Revenue per Total Asset,
25. Total Revenue per Current Asset,
26. Current Asset per Current Liability,
27. Current Asset per Bus,
28. Total Revenue per Employee per Day,
29. Operating Ratio

Output:

The output parameters used to train the ANN consists of 2 neurons namely:

1. Total Revenue per Bus (Held) per Day,
2. Total Cost per Bus (on Road) per Day.

In Table A,Out of the 37 STUs data set, 35 sets were used for the network performance.

Data Normalization:

In the normalization stage, the input and output data are normalized between their minimum and maximum values to obtain values within the range from 0 to 1 using the following relationship:

$$Z_{norm} = \frac{Z - Z_{min}}{Z_{max} - Z_{min}}$$

Where Z_{norm}= Normalized data (range between 0 to1),
Z_{min} = Minimum value of the data range,
Z_{max} = Maximum value of the data range and
Z = Data value to be normalized.

Training:

In the training stage, the input and output patterns are presented to the neural network. The ANN is trained using the Feed Forward Back Propagation algorithm. The pattern pairs are presented to the network and trained in the batch mode, where all the patterns are recursively applied till the RMSE for all the patterns is less than the specified error value (0.001). Initially single hidden layer was considered and varied the neurons from 10 to 70 with an increment of 10 neurons. Then the second hidden layer was considered with neurons ranging from 10 to 60 with an increment of 10 neurons. The performances of the above networks were studied and the best networks were selected from the single and double hidden layer networks.

Testing:

In the testing stage the ANN was presented with an unknown input pattern (i.e.) 11 years data of 2 STUs namely JTC and ATC and the output of ANN prediction were compared with known output for its modeling efficiency. Table 1 shows the different network performances on test data set of JTC. The best network with minimum error was selected for forecasting and the same network architecture was used to forecast the second test data set (ATC) and the performance of the network was presented in the Table 2. Table 3 shows the actual and ANN predicted values of two dependent variables of single and double hidden layer networks of the test data sets.

Conclusion:

From the above results we can observe that the errors predicted by ANN model were well within the acceptable limit and the commonly adopted statistical test of 'goodness of fit' (χ^2) also accepts the results predicted by the ANN model. The 2 hidden layer ANN architecture has not fetched an improved result of all model efficiency parameters. Hence single hidden layer with 40 neurons ANN architecture may the best ANN model to predict the profitability of STUs.

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Table A: The data were collected for 11 years (1989-90 to 1999-2000) from the following 37 STUs:

1. Maharastra State Road Transport Corporation (MSRTC)
2. Andhra Pradesh State Road Transport Corporation (APSRTC)
3. Karnataka State Road Transport Corporation (KnSRTC)
4. Gujarat State Road Transport Corporation (GSRTC)
5. Uttar Pradesh State Road Transport Corporation (UPSRTC)
6. Rajasthan State Road Transport Corporation (RSRTC)
7. State Transport Haryana (STHAR)
8. Kerala State Road Transport Corporation (KSRTC)
9. Madhya Pradesh State Road Transport Corporation (MPSRTC)
10. Orissa State Road Transport Corporation (OSRTC)
11. Kadamba Transport Corporation Limited (KDTC)
12. Himachal Road Transport Corporation (HRTC)
13. Ahmedabad Municipal Transport Service (AMTS)
14. Pepsu Road Transport Corporation (PRTC)
15. Cheran Transport Corporation Limited (CTC)
16. Pandiyan Roadways Corporation Limited (PRC)
17. Dheeran Chinnamalai Transport Corporation Limited (DCTC)
18. Kattabomman Transport Corporation Limited (KTC)
19. Jeeva Transport Corporation Limited (JTC)
20. Anna Transport Corporation Limited (ATC)
21. Thiruvalluvar Transport Corporation Limited (TTC)
22. Thanthai Periyar Transport Corporation Limited (TPTC)
23. Pattukkotai Azagiri Transport Corporation Limited (PATC)
24. Cholan Roadways Corporation Limited (CRC)
25. Marudhu Pandiyar Transport Corporation Limited (MPTC)
26. Puratchi Thalaivar MGR Transport Corporation Limited (MGRTC)
27. Nesamony Transport Corporation Limited (NTC)
28. Rani Mangammal Transport Corporation Limited (RMTC)
29. Annai Sathya Transport Corporation Limited (ASTC)
30. Pallavan Transport Corporation Limited (PTC)
31. Dr. Ambedkar Transport Corporation Limited (DATC)
32. Mahakavi Bharathiyar Transport Corporation Limited (MBTC)
33. Bangalore Metropolitan Transport Corporation (BMTC)
34. North West Karnataka State Road Transport Corporation (NWKnSRTC)
35. State Express Transport Corporation (TN-II)
36. Tamil Nadu State Transport Corporation Limited (Kumbakonam Div. IV)
37. Tamil Nadu State Transport Corporation Limited (Madurai Div. V)

Out of the above 37 STUs data set, 35 sets were used for training and 2 sets namely JTC and ATC were used for testing the network performance

Table 1: Performance Comparison of Different Network Architecture of JTC

Single Hidden Layer Network

Hidden Neurons	10		20		30		*40*		50		60		70	
	TR	TC	TR	TC	TR	TC	*TR*	*TC*	TR	TC	TR	TC	TR	TC
MPE	-2.6407	0.247	-0.224	-1.942	-1.718	-1.467	*-0.132*	*-1.520*	-0.723	-1.860	0.149	-1.882	0.894	-3.499
ME	-57.738	10.575	-5.838	-46.854	-57.446	-39.740	*-14.258*	*-48.385*	-35.295	-62.921	1.312	-77.678	25.563	-101.07
RMSE	19.167	186.026	76.819	217.979	219.350	185.869	*118.862*	*125.289*	129.189	150.287	120.080	123.264	101.196	227.490
R	0.9742	0.9809	0.9959	0.9769	0.9733	0.9829	*0.9914*	*0.9942*	0.9913	0.9927	0.9985	0.9988	0.9932	0.9813
R^2	0.9959	0.9972	0.9994	0.9962	0.9949	0.9972	*0.9985*	*0.9987*	0.9982	0.9982	0.9900	0.9988	0.9989	0.9958

Double Hidden Layer Network

MPE	-4.566	-3.921	-2.263	-3.947	-1.352	-1.335	*-0.589*	*-0.884*	-3.856	-4.620	-2.998	-4.042	---	---
ME	-111.43	-146.88	-50.021	-143.53	-37.675	-33.889	*-23.508*	*-17.180*	-97.582	-148.37	-102.60	-116.19	---	---
RMSE	169.772	250.727	118.066	196.376	152.465	175.227	*87.464*	*198.603*	143.586	237.079	161.208	168.479	---	---
R	0.9884	0.9924	0.9925	0.9972	0.9850	0.9854	*0.9958*	*0.9792*	0.9922	0.9870	0.9934	0.9924	---	---
R^2	0.9970	0.9949	0.9985	0.9969	0.9976	0.9975	*0.9992*	*0.9968*	0.9978	0.9955	0.9973	0.9977	---	---

Table 2: Performance of Network Architecture of ATC

Single Hidden Layer Network		
	TR	TC
MPE	*0.5178*	*0.5264*
ME	*21.3532*	*13.3813*
RMSE	*131.3637*	*107.7475*
R	*0.9876*	*0.9946*
R^2	*0.9981*	*0.9991*
Double Hidden Layer Network		
MPE	*-0.1001*	*0.3247*
ME	*-0.3383*	*-9.5340*
RMSE	*103.3107*	*86.6060*
R	*0.9923*	*0.9980*
R^2	*0.9988*	*0.9994*

MPE – Mean Percentage Error
ME – Mean Error
RMSE – Root Mean Square Error
R – Coefficient of Correlation
R^2 – Coefficient of Efficiency

Table 3: Comparison of Actual and ANN Prediction of STUs

Year	**JTC**						**ATC**					
	Observed		**Predicted**				**Observed**		**Predicted**			
			Single Hidden Layer		**Double Hidden Layer**				**Single Hidden Layer**		**Double Hidden Layer**	
	TR	**TC**	**TR**	**TC**	**TR**	**TC**	**TR**	**TC**	**TR**	**TC**	**TR**	**TC**
1989-90	1616.810	1682.575	1609.250	1848.269	1667.703	1845.927	1587.539	1717.661	1754.919	1720.899	1549.915	1658.537
1990-91	1860.450	1923.862	1751.623	1943.192	1777.176	1955.142	1790.747	1953.799	1685.381	1903.581	1697.270	1837.499
1991-92	2029.744	2143.387	1943.499	2124.478	1985.576	2121.589	2013.473	2175.852	1951.631	2165.362	2059.273	2110.587
1992-93	2363.072	2539.087	2284.663	2432.363	2301.033	2482.471	2314.436	2506.343	2137.187	2403.733	2277.779	2424.772
1993-94	2617.116	2786.879	2813.614	2822.014	2761.419	2954.313	2533.820	2679.413	2528.944	2728.250	2666.669	2781.409
1994-95	2889.866	3025.406	2932.334	2985.046	2933.645	3114.466	2752.651	2918.719	2661.892	2827.453	2816.037	2981.817
1995-96	3045.796	2445.894	3314.029	3599.278	3183.477	3202.684	2886.564	3434.567	3142.666	3583.300	3098.937	3532.917
1996-97	3177.228	3602.638	3105.757	3489.982	3070.960	3404.240	3060.850	3889.417	3145.368	4011.264	3074.610	3848.228
1997-98	3760.675	3927.078	3673.215	4002.437	3763.588	3982.584	3696.304	4114.169	3634.461	4079.898	3650.796	4083.081
1998-99	3823.102	4348.034	3848.063	4422.218	3927.155	4095.886	3763.012	4480.298	3612.109	4232.803	3677.639	4600.720
1999-00	4392.489	4732.427	4457.136	5020.231	4463.200	5182.942	4303.966	4870.946	4211.921	4937.445	4138.160	4986.489
χ^2 calculated			5.129	4.792	2.754	10.629	X^2 calculated		6.948	3.121	3.672	2.558
χ^2 tabulated (0.05, 10) = 18.307												