Available online at www.sciencedirect.com

ScienceDirect

Transportation Research Procedia 00 (2018) 000–000

Transportation Research Procedia

www.elsevier.com/locate/procedia

World Conference on Transport Research - WCTR 2019 Mumbai 26-31 May 2019

TECHNIQUES FOR FORECASTING TRAFFIC GROWTH RATE

Shabana Thabassum[a], Kumar, M.[b]

[a] P.hd. Research Scholar, Department of Civil Engineering, Osmania University, Hyderabad, Telangana, India
[b]Professor, Department of Civil Engineering, Osmania University, Hyderabad, Telangana, India

Abstract

Road transport is the predominant mode of transport in India. To offer a better Level of Service (LOS) along the National Highways and to enhance their capacity, it is required to project the traffic in long term duration. Future calculation of traffic volume on each and every link with in the proposed road network depends on the estimation of appropriate traffic growth rates. In this paper, the socio economic parameters of the state of Uttar Pradesh have been considered for the calculation of traffic growth rates as the economy of Uttar Pradesh is the second largest of all the states of India. Four different approaches like growth rate based on past vehicle registration, Transport demand elasticity approach, Single Exponential Smoothing approach and Autoregressive Integrated Moving Average Technique (ARIMA) have been examined in time series modeling for the establishment of traffic growth rates. It is established that, the growth rate obtained from past vehicle registration data is much on the higher side. Almost the same scenario is shown by econometric modeling procedures. For all the modes, the growth rate obtained from Single Exponential Smoothing technique is much on the lower side. Growth rates obtained from ARIMA models are considered satisfactory as it shows almost average values of remaining three methods. For the immediate next year, i. e., for year 2016-17, the traffic growth rates obtained are similar, except Single Exponential Smoothing technique for all the modes. Hence ARIMA models are suggested to be the best models for future traffic projections.

Keywords: Per Capita Income, Autoregressive Integrated Moving Average Technique, Single Exponential Smoothing technique, econometric modeling

1. Introduction

India is one of the fastest growing nations in the world. India's economy has grown manifolds in the recent past and likely to grow further as per the present trends. Road transport is the dominant mode of transport in India, because of rewards like suppleness, door-to-door service and easy approachability to rural habitations (Kadiyali and Shashikala, 2009). While motorization rate in India is lower than many developing countries-both in absolute term and relative to size of population, but over the last decade, India is experiencing one of the highest motorization growth rates in the world (Rameshwar Dayal Sharma et al., 2011). This hints to the deterioration of surface of the pavements and a need to rehabilitate them before further damage occurs. The capacity of the road network has to be increased to cater day to day traffic. The Government of India has launched major initiatives to upgrade and strengthen National Highways (NH) through various phases of National Highways Development Project (NHDP). In order to offer a better Level of Service (LOS) to the long distance moving commercial vehicular traffic along the National Highways and to enhance their capacity, it is required to project the traffic in long term duration during the time horizon of the study (Chapter 8, DPR, 2007). The refinement of road connectivity assumes greater importance, not only for benefit of the economic development, but also for improving the accessibility and mobility of the people living in the region. The first step in this scope is to calculate the correct traffic volume on each and every link with in the proposed network development which can be achieved by means of estimation of appropriate traffic growth rates. With the recent thrust on improving and developing highways for enhancing National Economy, the importance of traffic demand forecasting has increased significantly as the forecasted traffic volume contributes substantially in engineering design, economic and financial liabilities of highway improvement projects (Hemanth et al., 2013). The objective of this current study is to calculate traffic growth rates for Uttar Pradesh state in for different approaches and to suggest the best model for future traffic projections.

2. Study area (Uttar Pradesh)

The economy of Uttar Pradesh is the second largest of all the states of India. According to the state budget for 2017-18, Uttar Pradesh's Gross State Domestic Product is 16.89 lakh crores. Uttar Pradesh is a major contributor to the national food grain stock. In 2013-14, this state produced 50.05 million tonnes of food grain, which is 18.90% of the country's total production. It has witnessed rapid industrialization in the recent past, particularly after the launch of policies of economic liberalization in the country. Uttar Pradesh is the biggest state of country from geographic and population point of view having more than 300000 Km road network. It has transportation network consisting of Roads, Railways and Airways which form the lifeline for the economic and social activities of the state but there is lot of scope for further improvement of these facilities. The road network of Uttar Pradesh state comprises of National Highways, State Highways, Major and Other District Roads. Road transport is a dominant mode in the state for goods and passengers. It is absolutely necessary to link all the villages with main roads for economic and social development of state. Traffic is increasing day by day in the state, therefore maintenance of road network is very important. Public Works Department has ownership of approximately 1,70,00 Km of roads in terms of construction, maintenance and widening. Traffic growth rate is the key determining factor in all developmental issues of roads. An accurate estimate of the traffic growth rate of the Project road is very important as the financial and economic viability of a road will be calculated for future 20 to 25 years after design or upgradation. Traffic flow patterns and growth rates are necessary for many of the planning and design functions (Monica et al., 2001). The state of Uttar Pradesh with 75 districts has been considered for the calculation of traffic growth rates for the design and upgradation of National highways with in the state.

3. Statistical data collection

The most important parameter, on which the future forecast of traffic depends, is the growth rate. The economic indicators data at 2004-05 constant prices and vehicle registration data at state level has been collected for the period 2001 -2015 as shown in Table 1 and in Fig 1. The vehicle registration data is collected from Road transport year books issued by Transport research wing, Ministry of shipping, Road transport & Highways, Government of India.

Table. 1. Statistical data

S. No	Year	Vehicle Registration statistics				Economic Indicators		
		Car /Jeep	Truck	2 Wheeler	Bus	Per Capita Income (Rs)	Population (in 000's)	NSDP (Rs in Crs)
1	2001-02	460182	134342	4021887	19562	8952	177571	158962
2	2002-03	526604	147051	4488426	20452	9806	171526	168198

S. No	Year	Vehicle Registration statistics				Economic Indicators		
		Car /Jeep	Truck	2 Wheeler	Bus	Per Capita Income (Rs)	Population (in 000's)	NSDP (Rs in Crs)
3	2003-04	586202	153259	4893070	21182	10120	174955	177054
4	2004-05	606045	165123	5652044	25081	12950	178401	231029
5	2005-06	728576	184428	6083655	26549	13445	181862	244514
6	2006-07	751920	193465	7138789	25134	14241	185335	263935
7	2007-08	825191	215825	7737237	25339	14875	188807	280851
8	2008-09	910718	240433	8521198	26331	15713	192320	302192
9	2009-10	1032379	268617	9493677	28124	16390	195844	320989
10	2010-11	1161335	307058	10563850	31922	17388	199345	346621
11	2011-12	1308416	338977	12410064	34428	18014	202828	365375
12	2012-13	1434210	400061	13724495	40501	18635	206310	384458
13	2013-14	1686747	467786	15395363	45607	19233	209800	403509
14	2014-15	2063230	511631	17398458	51866	20057	213272	427759
15	2015-16	2330459	562503	19258791	57939	21484	213379	458424

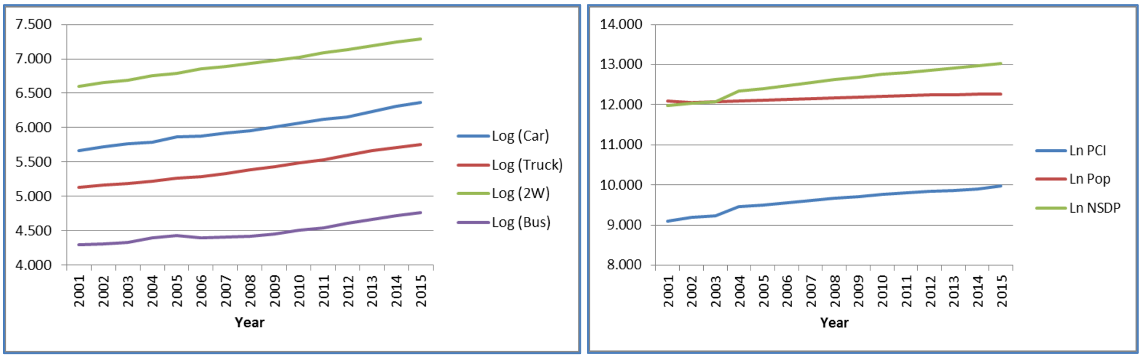


Fig. 1. Statistical data

4. Growth rate based on past vehicle registration

One of the approaches is to explore the registered motor vehicles every year growth within the state and calculation of the simple average yearly growth rate as shown in Table 2. This method is useful for small stretches and less important roads with minimum traffic. This would be an alternative approach in the absence of any additional information or useable past traffic data on the project roads and non-availability of socio economic parameters.

Table. 2. Average yearly traffic growth rate

	Car / Jeep	Truck	2 W	Bus
Average yearly growth rate (%)	12.41	10.83	11.88	8.26

5. Transport demand elasticity approach

Transport demand elasticity is defined as the ratio of percentage change in traffic to the percentage change in socio-economic parameters. The concept of developing a linear regression equation to express dependent variable in terms of one or more independent variable is the registered motor vehicles in the zone of influence (State). The preferred dependent variable is the number of registered motor vehicles and the independent variables are socioeconomic parameters. The choice of independent variable depends upon vehicle type under consideration. It is logical to relate the growth of personalized vehicles with Per Capita Income (PCI), passenger vehicles with population and commercial vehicle growth with NSDP, Industrial and agriculture output (Chapter 8, DPR, 2002). According to IRC: 108 - 2015, econometric models are derived in the form as shown in Table 3. The R^2 value indicates good correlation between the growth of socio economic parameters of the state and past vehicular registration values. The coefficient estimates are statistically significant at 95% confidence level, and the signs of the coefficient estimates are logical. The F statistic for null hypothesis indicated that these models have a good fit. Based on these models, the traffic growth rates derived are shown in Table 4.

Table. 3. Econometric models

Vehicle type	Econometric model	R^2 value	F statistic
Car/Jeep	Ln Pv = 1.75 Ln PCI–3.07	0.90	116.95
Truck	Ln T = 1.33 Ln NSDP – 4.31	0.92	147.02
Bus	Ln B = 4.29 Ln Pop – 41.88	0.89	105.34
2 Wheeler	Ln Tw = 1.8 Ln PCI – 1.34	0.94	197.69

Table. 4. Yearly traffic growth rate

	Car / Jeep	Truck	2 W	Bus
Average yearly growth rate (%)	11.60	10.71	11.92	5.71

6. Single exponential smoothing approach

Exponential smoothing is a rule of thumb technique for smoothing time series data using the exponential window function. Whereas in the simple moving average the past observations are weighted equally, exponential functions are used to assign exponentially decreasing weights over time.

This is also known as simple exponential smoothing. Simple smoothing is used for short-range forecasting, usually up to 10 years or less into the future. The model assumes that the data fluctuates around a reasonably stable mean (no trend or consistent pattern of growth). The specific formula for simple exponential smoothing is given in Eq. (1).

$$S_t = \alpha * X_t + (1 - \alpha) * S_{t-1} \qquad 0 < \alpha \leq 1,\ t > 0 \tag{1}$$

When applied recursively to each successive observation in the series, each new smoothed value (forecast) is computed as the weighted average of the current observation and the previous smoothed observation; the previous smoothed observation was computed in turn from the previous observed value and the smoothed value before the previous observation, and so on (Prajakta S. Kalekar, 2004). In this method only 10% of current year data and 90% of previous year data are considered for future growth rates calculation. The past traffic data has been analysed in this method with an alpha value of 0.1, for the next 10 years from 2016 to 2025. The traffic growth rates shown in Table 5 are for the year 2016-17.

Table. 5. Traffic growth rate

	Car / Jeep	Truck	2 W	Bus
Average yearly growth rate (%)	13.00	10.00	11.00	12.00

7. Time series modeling (autoregressive integrated moving average technique)

In statistics and econometrics, and in particular in time series analysis, an Auto Regressive Integrated Moving Average (ARIMA) model is a generalization of an Auto Regressive Moving Average (ARMA) model. Both of these models are fitted to time series data either to better understand the data or to predict future points in the series (forecasting). The models of the ARIMA family allow to represent in a synthetic way phenomena that vary with time, and to predict future values with a confidence interval around the predictions. The mathematical writing of the ARIMA models differs from one to one. The differences concern most of the time the sign of the coefficients. Univariate (single vector) ARIMA is a forecasting technique that projects the future values of a series based entirely on its own inertia. Its main application is in the area of short term forecasting requiring at least 10 historical data points. XLSTAT software has been used for the calculation of traffic growth rates by ARIMA modeling technique.

The ARIMA model can be viewed as a "cascade" of two models as given in Eq. (2) and Eq. (3).
The first is non-stationary:

$$Y_t = (1 - L)^d X_t \tag{2}$$

while the second is wide-sense stationary:

$$\left(1 - \sum_{i=1}^{p} \phi_i L^i\right) Y_t = \left(1 + \sum_{i=1}^{q} \theta_i L^i\right) \varepsilon_t \, . \tag{3}$$

Auto Correlation Function (ACF) and Partial Auto Correlation Function (PACF) parameters are estimated to define the order of series. The ACF plots represent auto correlation and PACF plots represent partial auto correlation of data sets against lags of themselves. In this given scope, based on ACF and PACF plot an ARIMA (1, 1, 0) model has been applied on the data set for the future prediction up to 10 years. Mode wise ARIMA model parameters are presented in Table 6 and future traffic projections are shown in Fig 2. The obtained Hessian standard error is less than 0.5, indicating “non-significance.” This is a desirable result.

Table. 6. Mode wise ARIMA models

Vehicle type	Parameter	Value	Hessian standard error	Lower bound (95%)	Upper bound (95%)	Asympt. standard error	Lower bound (95%)	Upper bound (95%)
Car/Jeep	MA(1)	-1.496	0.373	-2.226	-0.766	0.000	-1.496	-1.496
	MA(2)	1.000	0.469	0.080	1.920	0.000	1.000	1.000
	Constant	0.002	0.002	-0.003	0.006			
Truck	MA(1)	-1.919	0.325	-2.557	-1.282	0.000	-1.920	-1.919
	MA(2)	1.000	0.324	0.364	1.636	0.000	1.000	1.000
	Constant	0.003	0.000	0.003	0.004			
Bus	MA(1)	-0.699	0.394	-1.472	0.074	0.275	-1.239	-0.160
	MA(2)	-0.301	0.312	-0.912	0.310	0.275	-0.840	0.239

Vehicle type	Parameter	Value	Hessian standard error	Lower bound (95%)	Upper bound (95%)	Asympt. standard error	Lower bound (95%)	Upper bound (95%)
	Constant	0.003	0.002	-0.001	0.008			
	MA(1)	-1.951	0.446	-2.826	-1.076	0.000	-1.951	-1.951
2 Wheeler	MA(2)	1.000	0.448	0.122	1.878	0.000	1.000	1.000
	Constant	0.001	0.000	0.000	0.001			

One of the key issues in time series analysis is to determine whether the value we observe at time t depends on what has been observed in the past or not. The sample auto covariance function (ACVF) and the autocorrelation function (ACF) give an idea of the degree of dependence between the values of a time series. The visualization of the ACF and the partial autocorrelation function (PACF) helps to identify the suitable models to explain the passed observations and to do predictions. For all the modes, the Jarque-Bera normality test is computed once on the time series, while the other tests (Box-Pierce, Ljung-Box and McLeod-Li) are computed at each selected lag. For the Jarque-Bera test, the lower p-value indicates, the more likely the normality of the sample. For the three other tests, the lower p-value states that the randomness of the data is minimum.

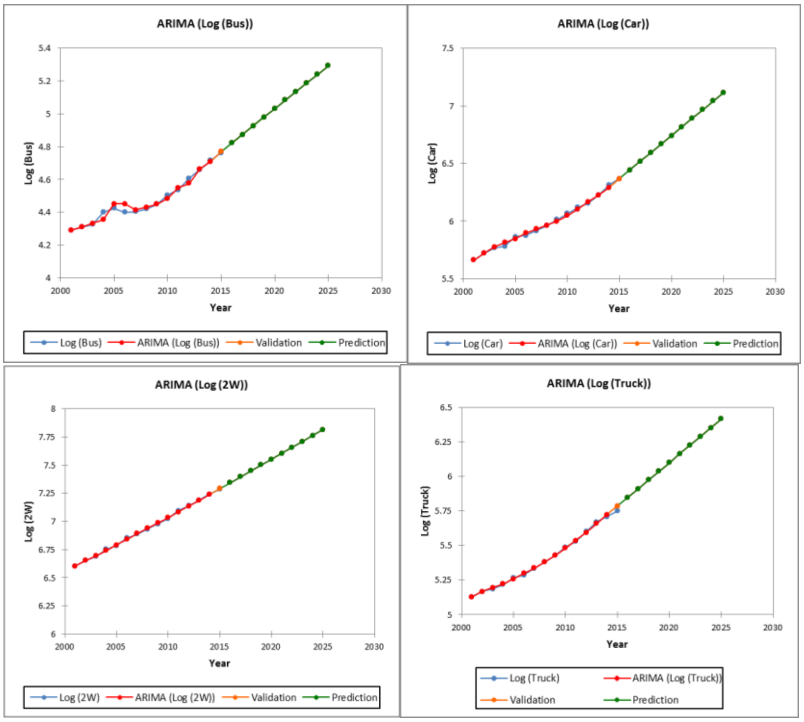
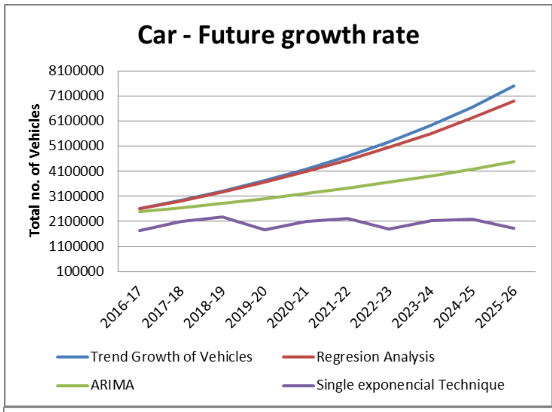
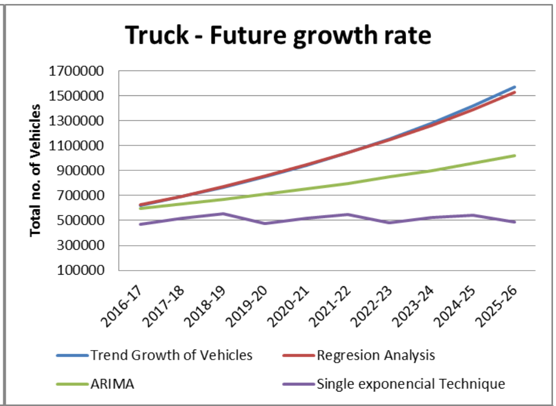


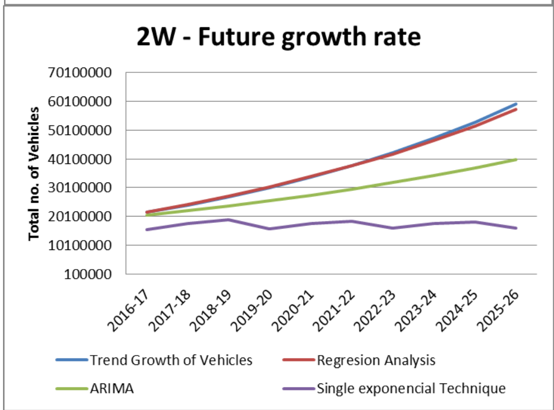
Fig. 2. ARIMA models

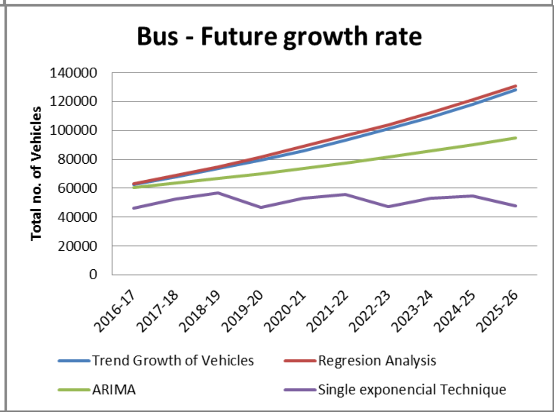
8. Comparison of different approaches - conclusions and recommendations

Present study strongly focuses on obtaining future traffic growth rates for which results from four calculation techniques (past vehicle registration, Transport Demand Elasticity Approach, Single Exponential Smoothing approach, Autoregressive Integrated Moving Average Technique) have been analysed to opt for the best fit. It is found that, the growth rate estimated from past vehicle registration data is on the extreme higher side for all the modes. Almost the same scenario is shown by econometric models. The growth rate obtained from Single Exponential Smoothing technique is much on the lower side. Growth rate obtained from ARIMA model is considered satisfactory as it shows almost average value of remaining three methods. For the immediate next year, i. e., for year 2016-17, the traffic growth rates obtained are similar, except Single Exponential Smoothing technique for all the modes. Hence, ARIMA models have been employed efficiently to find traffic growth rates.









References

L.R. Kadiyali and T.V. Shashikala (2009) “Road transport demand forecast for 2000 AD revisited and demand forecast for 2021”, Journal of the Indian Roads Congress.

Rameshwar Dayal Sharma, Sandeep Jain and Kewal Singh (2011) “Growth rate of Motor Vehicles in India - Impact of Demographic and Economic Development”, Journal of Economic and Social Studies, Volume 1, Number 2, July 2011.

Chapter 8 “Summary of the Traffic Studies and Forecasts on the Project Highway Undertaken by the Consultant”, DPR for 4/6-laning of Gonde Vadape Section of NH-3, Volume IV.

Hemanth, M., Kamplimath, Varuna. M, Vijay Kumar, Yashas Bhargav (2013) “Traffic Growth Rate Estimation using Transport Demand Elasticity Method: A Case Study for National Highway-63”, International Journal of Research in Engineering and Technology, eISSN: 2319-1163, pISSN: 2321-7308.

Monica L. Barrett, R. Clark Graves, David L. Allen and Jerry G. Pigman (2001), “Analysis of Traffic Growth rates”, Research report, Kentucky Transportation center.

Road Transport Year Book (2006-07), Transport Research Wing, Ministry of Shipping, Road Transport & Highways, Government of India, New Delhi, March 2009.

Road Transport Year Book (2007-09), (Volume I) Transport Research Wing, Ministry of Shipping, Road Transport & Highways, Government of India, New Delhi, March 2011.

Road Transport Year Book (2009-10 & 2010-11), Transport Research Wing, Ministry of Shipping, Road Transport & Highways, Government of India, New Delhi, July 2012.

Road Transport Year Book (2011-12), Transport Research Wing, Ministry of Shipping, Road Transport & Highways, Government of India, New Delhi.

Road Transport Year Book (2013-14 & 2014-15), Government of India, Ministry of Road Transport & Highways, Transport Research Wing, New Delhi, www.morth.nic.in.

Road Transport Year Book (2015-16), Ministry of Road Transport & Highways, Government of India, Transport Research Wing, New Delhi, www.morth.nic.in.

Chapter 8, DPR for 4/6-laning of Gonde Vadape Section of NH-3, Volume IV, 2002.

IRC: 108-2015 “Guidelines for Traffic Prediction on Rural Highways”, Indian Roads Congress, 2015.

Prajakta S. Kalekar (2004) “Time series Forecasting using Holt-Winters Exponential Smoothing”, Kanwal Rekhi School of Information

Technology, December 6, 2004.