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MODELLING GROWTH TREND AND FORECASTING TECHNIQUES FOR VEHICULAR POPULATION IN CHANDIGARH- A CASE STUDY

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Abstract- In India, road travel is the most widespread transportation system. Traffic forecasting process is assessment and quantification of traffic volume based on defined/identified parameters which include number of vehicles and numberof citizens/people who will leverage a specific type of transportation infrastructure in the future. There are multiple methods available to analyze and forecast the traffic volume considering multiple factors.
The objective/purpose of this study is to suggest the model which can be leveraged to predict future traffic estimates considering multiple factors and to highly suggest the finest model for future traffic estimates.
Four distinct methods have been analyzed for establishing traffic growth rates as part of this study-

- Transport Demand Elasticity
- Simple Exponential Smoothing
- Past Vehicle Registration
- Auto Regressive Integrated Moving Average Technique (ARIMA)

Based on our comparative analysis of the results generated by methods in scope, it can be established that the traffic growth rate predicted by transport demand elasticity technique is significantly higher in comparison to other methods in scope. However, the traffic growth rate calculated using ARIMA is an average of other three methods in scope. Hence, the results (traffic volume growth rate) generated by ARIMA can be considered as satisfactory.

Keywords- Time Series, ARIMA, Regression, Econometrics, Statistical Packages for Social Sciences, Single Exponential Smoothing, Registered Vehicles.

Introduction

Road travel is India’s most popular means of transportation due to features such as flexibility, door-to-door service, and easy access to rural habitations. The road network’s capacity need to be enhanced to accommodate futuristic traffic volume requirements. Enhancement in road network is required for economic development and improves accessibility to regions across India. The first step involved in developing a road upgrade proposal is to evaluate and analyze the traffic volume for the road links based on appropriate traffic growth rate. The significance of traffic demand forecasting has grown dramatically in light of the recent focus on strengthening and developing the national economy, since predicted traffic volume plays a key role in engineering design, economics, and financial obligations of road improvement projects.

Several factors influence traffic growth. Economic parameters such as Gross Domestic Product (GDP), agricultural, and industrial outputs can be separated. Population and Per Capita Income (PCI) are two demographic indicators to consider. Because these economic factors differ so considerably across the country, the rate of traffic increase differs from state to state and within each state, from region to area, depending on Socio-Economic features. The above elements must be carefully considered while determining the Traffic Growth Rate for each location. The main objective/purpose of this fact finding is to check which is the most feasible approach to calculate the traffic growth rate.

Literature Review

The literature review for this project consists of a review of existing literature on past approaches for traffic forecasting, their limitations, and areas for development, as well as a discussion of the methodology to forecasting, particularly with regard to Time Series Analysis. **Kumar M; Shabana Thabassum (2021)** looked at four different calculation procedures (prior vehicle registration, transport demand elasticity approach, single exponential smoothing approach, ARIMA methodology) to see which one was the best fit. As a result, ARIMA models can predict traffic growth rates for future horizon years in the planning.

According to **Chenetal (2016)**, traffic prediction systems are often expensive in nature. A MATLAB-based traffic prediction system is developed to address this issue. Data is acquired from the camera by this mechanism, which subsequently converts the format to meet the criteria and produces normalized data. Information is retrieved from the normalized meaning, and then predictions are made.

Seher Arslankya (2018), used time series analysis and artificial neural network methods in his research paper to anticipate sales for future months for Turkey's biggest car firm. He used multiple regressions, moving average, and an artificial neural network model to look at monthly data from January 2011 to July 2016. He also examined MAPE values for all models, finding that the ANN model produced the best results.

Arnis Kirshners (2012) conducted a comparison of short time series processing algorithms in order to assess their suitability for analyzing short time series. The author looked at the moving average method and exponential smoothening with development trends. The author found that the moving average method has the minimum squared error value but has a big forecast smoothening for initial data.

Nihanand Holmesland (1980) focus on the applications of time series analysis (as substantiated through the use of the SPSS).

Oswald et al. (2001) discussed the approximate nearest neighbor nonparametric regression approach. A process for anticipating a dynamic variable is traffic forecasting. As a result, depending on the situation, a variety of approaches to traffic forecasting may be used. Although other approaches for traffic volume forecasting exist, due to data availability constraints, the three most relevant methods were chosen for a comparative analysis in this study. The current practice in India **(Nanda, 2005)** is to gather traffic volume counts for seven days on National Highways twice a year and one to three days on other highways. For traffic projection, most NHDP programmes use one of three methods:

1. Past Trend Data: Available records from the NH Division or respective PWD agenciesduring the last 5-10 years are collected. This data is utilized to observe the current scenario's traffic growth, and the same tendency is used to forecast future demand. At the feasibility evaluation stage, this procedure is used.

2. Vehicle Registration: Data on vehicle registration is gathered from the Indian Ministry of Road Transport and Highways. Through regression analysis, it is possible to anticipate the growth rate of car registration for each unique vehicle type based on thisdata. At the feasibility stage/level, this technique is also used.

3. Elasticity of Transport Demand: The predicted future traffic involves a look for some of the most important socioeconomic characteristics as well as the expected speed of development in the project affect region over the research period. India's computed elasticities are comparable to the World Bank's recommended elasticities. During the detailed project planning stage, this method is employed.

Study Area

Chandigarh is a Union Territory in India, as well as the joint capital of the two neighboring states of Haryana and Punjab. Chandigarh covers an area of 114 square kilometers. Chandigarh was one of India's first planned townships after independence, and its architecture and urban planning are famous throughout the world. The city has one of the highest per capita wages in the country. The highest vehicle density in India is found in Chandigarh (878 registered motor cars per 1,000 inhabitants). The city's road network is divided into eight zones, or V1 to V8, each serving a different purpose for the people who use them. For example, V1 roads connect Chandigarh's major thoroughfares, Madhya Marg and Dakshin Marg, to other nearby cities, while V8 roads are cycle track roads that are still under creation. Transportation planning processes have been widely used to estimate future travel demand. In order to plan for future transportation infrastructure and services, travel demand forecasts are used. In order to lay a strong basis for the traffic network, this study examines the necessity for research in this field by examining the growth/declivity rates of various vehicle categories.

Statistical Data Gathered

Table-1

Data Category	Data Source
Vehicular Registered Data	MoRT&H Yearbook (2018-19)
PCI(Per Capita Income), NSDP (Net State Domestic Product)	Statistica of India

Table-2 Data Table for variables used in the analysis

S.No.	Year	Population of the City	Vehicular Population	Per Capita Income (in 000's)	NSDP Per Capita
1	2000-01	790000	28044	44.502	27494
2	2001-02	813000	22739	48.974	27670
3	2002-03	828000	24318	53.886	28860
4	2003-04	844000	18667	60.105	31013
5	2004-05	859000	26979	67.370	33047
6	2005-06	875000	29697	82.297	35452
7	2006-07	891000	33777	99.262	39352
8	2007-08	908000	33256	110.676	50129
9	2008-09	924000	33566	119.240	62177
10	2009-10	942000	36548	128.743	69192
11	2010-11	959000	50042	145.480	91977
12	2011-12	977000	49680	153.910	132416
13	2012-13	995000	51259	159.120	158967
14	2013-14	1013000	45013	180.620	180456
15	2014-15	1032000	46255	203.540	203357
16	2015-16	1051000	45781	212.790	212595
17	2016-17	1070000	42804	230.010	230008
18	2017-18	1090000	46687	252.24	252236

Growth Rate Based on Past Vehicle Registration Data

One method is to look at previous registered vehicle data and calculate the average annual growth rate for future years, as shown in Table-3. This strategy is excellent for short segments of road with less traffic and for less significant roadways. In the absence of any further Socio-Economic characteristics regarding the traffic influence zone, or if Socio-Economic parameters are unavailable, this would be an alternative scenario.

The registered vehicle data of past years (10 to 15 years based on availability) is evaluated to determine the future average annual growth rate of multiple vehicle classes.

This approach is suitable for below mentioned scenarios:

- Estimate vehicle volume growth for short segments of road with less traffic and for less significant roadways.
- Unavailability of Socio-Economic parameters related data.

Table-3 Average Yearly Traffic Growth Rate (Past Vehicle Registration)

Description	Car/Jeep	Motor Cycle/Scooter	Three Wheeler Passenger	Buses	Goods Vehicles	Tractors
Average Yearly Growth Rate (%)	2.48	2.87	18.52	-0.85	14.62	2.80

Transport Demand Elasticity Approach

Transport demand elasticity is described as the proportion of the percentage change in traffic to the percentage change in Socio-Economic characteristics. The idea of developing a linear regression equation to express the dependent variable in terms of one or more independent variables is the conception of registered motor vehicles in the zone of implications.

The desired dependent variable is the number of registered motor vehicles, whereas the recommended independent variables are Socio-Economic factors. The type of vehicle being considered impacts the quality of explanatory variables. The increase of personalized automobiles can be linked to per capita income, passenger vehicles to population, and commercial vehicles to NSDP. Econometric models are derived in the form indicated in Table-4 according to IRC: 108-2015.

The R-squared values show a strong relationship between the city's Socio-Economic factors and previous vehicle registration levels. At a 95% confidence interval, the coefficient estimates are statistically significant, and the signs of the coefficient estimates are reasonable. The null-hypothesis F-statistic implies that these models are well-fitting. Table-5 shows the traffic growth rates produced from these econometric models.

Transport demand elasticity is described as the proportion of the percentage change in traffic to the percentage change in Socio-Economic characteristics. A Linear regression equation is developed to express relationship between multiple variables.

Dependent variables: Number of Registered Motor Vehicles,

Independent variables: Socio-Economic factors

To elucidate the impact of variables, increase of personalized automobiles can be linked to Per Capita Income, passenger vehicles to population, and commercial vehicles to NSDP.

Table-4 Econometric Models

Vehicle Type	Econometric Model	R^2 Value	F- Statistic
Car/Jeep	y=8044 Ln (PCI)-23444	0.561	12.894
Motor Cycle/Scooter	y=7155 Ln (PCI)-12562	0.832	85.684
Three Wheeler Passenger	y=3350 Ln (Pop.)-45173	0.786	71.207
Buses	y= 455.9 Ln (Pop.)- 6153	0.353	8.245
Goods Vehicle	y= 504.1 Ln (NSDP)-5203	0.752	31.808
Tractor	y=4.429 Ln (NSDP)-34.79	0.246	1.445

Table-5 Yearly Traffic Growth Rate (Econometric Models)

Description	Car/Jeep	Motor Cycle/Scooter	Three Wheeler Passenger	Buses	Goods Vehicle	Tractors
Average Yearly Growth Rate (%)	6.61	3.69	9.07	9.75	4.37	2.96

Single Exponential Smoothing (SES) Approach

The exponential window function is used in exponential smoothing, which is a mandate common technique for smoothing time series data. Previous observations are weighted the same manner in the basic moving average, but exponential functions are employed to apply exponentially decreasing weights over time. Simple Exponential Smoothing is the term coined to this methodology. Simple Smoothing is a demand supervised learning method for the near future, usually up to ten years. The model indicates that the results fluctuates around a fairly stable mean (no trend or consistent pattern of growth).The specific formula for Simple Exponential Smoothing is given in eq. 1

$$L = \alpha * Y_t + (1 - \alpha) * L_{t-1} \quad 0<\alpha \leq 1, t>0 \quad \text{-----------------------} \quad \text{(Eq.-1)}$$

In this method, the past traffic data has been analyzed with the alpha value as 0.1 for the next ten years from the year 2017-18 to 2026-27. The traffic growth rates for the year 2018-19 as shown in the Table-6.

Table-6 Traffic Growth Rate for the Year 2018-19

Description	Car/Jeep	Motor Cycle/ Scooter	Three Wheeler Passenger	Buses	Goods Vehicle	Tractors
Average Yearly Growth Rate (%)	0.805	2.347	53.087	-4.685	3.982	-4.641

Time Series Modeling- Auto Regressive Integrated Moving Average Technique (ARIMA)

An Auto Regressive Integrated Moving Average (ARIMA) model is a generalization of the Auto Regressive Moving Average (ARMA) model in statistics and econometrics, particularly in Time Series analysis. Both of these models are applied to Time Series data in order to gain a better understanding of the data or to forecast future points in the series (forecasting). The ARIMA family of models allows for the representation of time-varying phenomena in a synthetic form, as well as the prediction of future values with a confidence interval around the predictions. ARIMA models are written mathematically in a variety of ways. The majority of the time, the discrepancies is related to the sign of the coefficients. Solitary vector (Univariate) ARIMA is a forecasting method that projects a series' future values purely based on its own inertia. Its primary use is in short-term forecasting, which necessitates at least 10 past data points.

To define the order of series, the Auto Correlation Function (ACF) and Partial Auto Correlation Function (PACF) parameters are computed. The data sets lags are represented by the ACF and PACF charts. Mode wise ARIMA model parameters are presented in Table-7.

Table-7 Growth Rate using ARIMA Models

Description	Car/Jeep	Motor Cycle/ Scooter	Three Wheeler Passenger	Buses	Goods Vehicle	Tractors
Average Yearly Growth Rate (%)	2.72	2.92	11.43	-0.42	13.73	3.32

The below Table depicts the average values calculated using three different approaches viz. Past Vehicle Registration Data, Transport Demand Elasticity Approach and Single Exponential Smoothing Approach.

Table- 8 Average Values using Three Different Approaches

Description	Car/Jeep	Motor Cycle/ Scooter	Three Wheeler Passenger	Buses	Goods Vehicle	Tractors
Average Yearly Growth Rate (%)	3.29	2.96	10.92	-1.40	7.66	3.37

One of the most important aspects of Time Series analysis is determining whether the value we observe at time t is dependent on previous observations or not. The Auto Correlation Function (ACF) and Auto Covariance Function (ACVF) samples indicate the degree of reliance between the values of a Time-Series. The ACF and PACF visualizations aid in the identification of appropriate models for explaining past observations and making predictions.

Conclusion

There are multiple approach/methodologies available to analyze time series; however, usage of non normal data set renders these methodologies ineffective. The analysis of non-stationary and non-normally distributed traffic data based on in scope methods is the primary target of this research to forecast the rate of vehicle increase. Based on the results of analysis, it is concluded that ARIMA modeling of time series data generates the output which is nearly equivalent the average of the outputs of other three approaches considered. Hence, it can be established that growth rate calculated with ARIMA modeling can be considered as satisfactory. Various validation models were generated in ARIMA with different (p,d,q) values for plotting Auto-Correlation Functions and Partial Auto-Correlation functions correlograms and considered the best fit out it.

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