INTERNATIONAL JOURNAL OF RESEARCH IN COMPUTER APPLICATION AND MANAGEMENT

# CONTENTS

# CALL FOR MANUSCRIPTS

We invite unpublished novel, original, empirical and high quality research work pertaining to recent developments & practices in the area of Computer, Business, Finance, Marketing, Human Resource Management, General Management, Banking, Insurance, Corporate Governance and emerging paradigms in allied subjects like Accounting Education; Accounting Information Systems; Accounting Theory & Practice; Auditing; Behavioral Accounting; Behavioral Economics; Corporate Finance; Cost Accounting; Econometrics; Economic Development; Economic History; Financial Institutions & Markets; Financial Services; Fiscal Policy; Government & Non Profit Accounting; Industrial Organization; International Economics & Trade; International Finance; Macro Economics; Micro Economics; Monetary Policy; Portfolio & Security Analysis; Public Policy Economics; Real Estate; Regional Economics; Tax Accounting; Advertising & Promotion Management; Business Education; Business Information Systems (MIS); Business Law, Public Responsibility & Ethics; Communication; Direct Marketing; E-Commerce; Global Business; Health Care Administration; Labor Relations & Human Resource Management; Marketing Research; Marketing Theory & Applications; Non-Profit Organizations; Office Administration/Management; Operations Research/Statistics; Organizational Behavior & Theory; Organizational Development; Production/Operations; Public Administration; Purchasing/Materials Management; Retailing; Sales/Selling; Services; Small Business Entrepreneurship; Strategic Management Policy; Technology/Innovation; Tourism, Hospitality & Leisure; Transportation/Physical Distribution; Algorithms; Artificial Intelligence; Compilers & Translation; Computer Aided Design (CAD); Computer Aided Manufacturing; Computer Graphics; Computer Organization & Architecture; Database Structures & Systems; Digital Logic; Discrete Structures; Internet; Management Information Systems; Modeling & Simulation; Multimedia; Neural Systems/Neural Networks; Numerical Analysis/Scientific Computing; Object Oriented Programming; Operating Systems; Programming Languages; Robotics; Symbolic & Formal Logic and Web Design. The above mentioned tracks are only indicative, and not exhaustive.

Anybody can submit the soft copy of his/her manuscript **anytime** in M.S. Word format after preparing the same as per our submission guidelines duly available on our website under the heading guidelines for submission, at the email addresses: **1** or **info@ijrcm.org.in**.

# GUIDELINES FOR SUBMISSION OF MANUSCRIPT

1. **COVERING LETTER FOR SUBMISSION:**

**DATED: _____**

***THE EDITOR***

IJRCM

Subject: **SUBMISSION OF MANUSCRIPT IN THE AREA OF _____.**

**(e.g. Computer/IT/Finance/Marketing/HRM/General Management/other, please specify).**

**DEAR SIR/MADAM**

Please find my submission of manuscript titled '_____' for possible publication in your journal.

I hereby affirm that the contents of this manuscript are original. Furthermore, it has neither been published elsewhere in any language fully or partly, nor is it under review for publication anywhere.

I affirm that all author (s) have seen and agreed to the submitted version of the manuscript and their inclusion of name (s) as co-author (s).

Also, if our/my manuscript is accepted, I/We agree to comply with the formalities as given on the website of journal & you are free to publish our contribution to any of your journals.

**NAME OF CORRESPONDING AUTHOR**:

Designation:

Affiliation with full address & Pin Code:

Residential address with Pin Code:

Mobile Number (s):

Landline Number (s):

E-mail Address:

Alternate E-mail Address:

2. **INTRODUCTION:** Manuscript must be in British English prepared on a standard A4 size paper setting. It must be prepared on a single space and single column with 1" margin set for top, bottom, left and right. It should be typed in 8 point Calibri Font with page numbers at the bottom and centre of the every page.
3. **MANUSCRIPT TITLE:** The title of the paper should be in a 12 point Calibri Font. It should be bold typed, centered and fully capitalised.
4. **AUTHOR NAME(S) & AFFILIATIONS:** The author (s) full name, designation, affiliation (s), address, mobile/landline numbers, and email/alternate email address should be in italic & 11-point Calibri Font. It must be centered underneath the title.
5. **ABSTRACT:** Abstract should be in fully italicized text, not exceeding 250 words. The abstract must be informative and explain the background, aims, methods, results & conclusion in a single para.
6. **KEYWORDS:** Abstract must be followed by list of keywords, subject to the maximum of five. These should be arranged in alphabetic order separated by commas and full stops at the end.
7. **HEADINGS:** All the headings should be in a 10 point Calibri Font. These must be bold-faced, aligned left and fully capitalised. Leave a blank line before each heading.
8. **SUB-HEADINGS:** All the sub-headings should be in a 8 point Calibri Font. These must be bold-faced, aligned left and fully capitalised.
9. **MAIN TEXT:** The main text should be in a 8 point Calibri Font, single spaced and justified.
10. **FIGURES &TABLES:** These should be simple, centered, separately numbered & self explained, and titles must be above the tables/figures. Sources of data should be mentioned below the table/figure. It should be ensured that the tables/figures are referred to from the main text.
11. **EQUATIONS:** These should be consecutively numbered in parentheses, horizontally centered with equation number placed at the right.
12. **REFERENCES:** The list of all references should be alphabetically arranged. It must be single spaced, and at the end of the manuscript. The author (s) should mention only the actually utilised references in the preparation of manuscript and they are supposed to follow **Harvard Style of Referencing**. The author (s) are supposed to follow the references as per following:

- All works cited in the text (including sources for tables and figures) should be listed alphabetically.
- Use (**ed.**) for one editor, and (**ed.s)** for multiple editors.
- When listing two or more works by one author, use --- (20xx), such as after Kohl (1997), use --- (2001), etc, in chronologically ascending order.
- Indicate (opening and closing) page numbers for articles in journals and for chapters in books.
- The title of books and journals should be in italics. Double quotation marks are used for titles of journal articles, book chapters, dissertations, reports, working papers, unpublished material, etc.
- For titles in a language other than English, provide an English translation in parentheses.
- The location of endnotes within the text should be indicated by superscript numbers.

**PLEASE USE THE FOLLOWING FOR STYLE AND PUNCTUATION IN REFERENCES:**

**BOOKS**

- Bowersox, Donald J., Closs, David J., (1996), "Logistical Management." Tata McGraw, Hill, New Delhi.
- Hunker, H.L. and A.J. Wright (1963), "Factors of Industrial Location in Ohio," Ohio State University.

**CONTRIBUTIONS TO BOOKS**

- Sharma T., Kwatra, G. (2008) Effectiveness of Social Advertising: A Study of Selected Campaigns, Corporate Social Responsibility, Edited by David Crowther & Nicholas Capaldi, Ashgate Research Companion to Corporate Social Responsibility, Chapter 15, pp 287-303.

**JOURNAL AND OTHER ARTICLES**

- Schemenner, R.W., Huber, J.C. and Cook, R.L. (1987), "Geographic Differences and the Location of New Manufacturing Facilities," Journal of Urban Economics, Vol. 21, No. 1, pp. 83-104.

**CONFERENCE PAPERS**

- Garg Sambhav (2011): "Business Ethics" Paper presented at the Annual International Conference for the All India Management Association, New Delhi, India, 19–22 June.

**UNPUBLISHED DISSERTATIONS AND THESES**

- Kumar S. (2011): "Customer Value: A Comparative Study of Rural and Urban Customers," Thesis, Kurukshetra University, Kurukshetra.

**ONLINE RESOURCES**

- Always indicate the date that the source was accessed, as online resources are frequently updated or removed.

**WEBSITE**

- Garg, Bhavet (2011): Towards a New Natural Gas Policy, Economic and Political Weekly, Viewed on July 05, 2011 http://epw.in/user/viewabstract.jsp

# DIFFUSION OF MOTOR VEHICLE SALES IN DELHI

*DR. DEBABRATA DAS*
*PROFESSOR*
*INDUS BUSINESS ACADEMY*
*GREATER NOIDA*

## ABSTRACT

*The aim of this paper is to project the long-term trends in the growth of four-wheelers, two-wheelers, auto rickshaws, taxis, buses and goods vehicles in Delhi up to the year 2020-21. Based on data from 1965-66 to 2005-06, the logistic model fits well in projecting the growth of four-wheelers and auto rickshaws, while in case of the growth in the number of two-wheelers, taxis, buses and goods vehicles, the Gompertz model is better. It is found that the total number of vehicles will be 11.71 millions in 2020-21 which will be nearly fifty per cent of the projected population of Delhi and out of these, 96 per cent will be private vehicles. This shows that there will be a rapid proliferation in the number of private four-wheelers during the next fifteen years with a decline in the relative share of two-wheelers. Similarly, the total number of commercial vehicles will increase from 0.28 million in 2005-06 to 0.5 million in 2020-21 with an increasing share of passenger vehicles and a decreasing share of goods vehicles. Now, motor vehicles being the worst air polluters apart from most energy intensive mode of transport, this growth of motor vehicles will pose a challenge to the policy makers, at the front of environment, energy consumption and parking.*

## KEYWORDS

Auto rickshaws, buses, four-wheelers, goods vehicles, Gompertz model, Logistic model, taxis, two-wheelers.

## INTRODUCTION

Transportation is considered as a service because it provides the mobility required for society. This service is provided by a number of different types of motor vehicles, which serve as integral part of an overall transportation system. When such system does not satisfy the numerous requirements of mobility, it leads to an increase in demand for motor vehicles. The vehicle demand is an integral part of transportation demand modeling. Unlike the demand for other commodities such as food, cloth, house, etc., vehicle demand is a derived demand (Abu-Eisheh et al. 2002). That is, a person demands to be transported not because he or she just wants to move but because he or she wants to achieve some other purpose such as reaching school, or office, or movie, or theater. Therefore, the importance of analyzing the growth in motor vehicle demands in order to be able to predict the expected number of motor vehicles in a given place should be accurate. The demand for motor vehicles form the primary input to any decision related to creation and management of transportation facilities such as road construction, energy requirement, utilization of transit system, and parking lot, etc. It also provides solution to the problems arising due to the growth of motor vehicle such as air pollution, road congestion and accident. Hence, the government, decision makers, legislatures, transport and urban planners and traffic engineers are among the many groups that have a particular interest in forecasting the motor vehicle growth.

In this paper, we highlight the various types of transportation demand in Delhi. The transport system in Delhi is predominantly road based with railways catering to only about 1 per cent of the local traffic. The buses are almost the only means of public transport system. In addition to the bus transit system, the travel demand of Delhi is also satisfied by auto rickshaws, taxis, private cars and motorcycles. Now, Delhi has also added 65.05 kilometers route of mass rapid transit system (Economic Survey Delhi 2005-06). In comparison to other cities of India, the growth of total number of vehicles in Delhi is highest with private vehicles being higher, especially the four wheelers. Thus, an attempt has been made to develop some differential model that will forecast the level of motor vehicle growth for the years 2010-11, 2015-16 and 2020-21 using annual data of registered motor vehicles from 1965-66 to 2005-06. Based on the concept of Logistic and Gompertz function, the differential model is developed under limited growth scenario, where upper limit of the growth is called saturation level. Out of these models, the best fit will be selected and utilized for forecasting the level of motor vehicle growth on the basis of $R^2$ value, mean square error (MSE) and the nature of the curves.

## TRENDS IN THE GROWTH OF MOTOR VEHICLES

The growth of motor vehicles in Delhi has increased tremendously over the years as can be observed from **Table I**. Till March 2006, bus transit was the primary mode of transportation in Delhi, which constituted only about 1 per cent of the total vehicles whereas, private vehicles (four-wheeler and two-wheeler) account for 94 per cent and the rest 5 per cent include goods vehicles, auto rickshaws and taxis. From 1965-66 to 2005-06, the number of registered vehicles increased from 80 thousand to 48 lakhs i.e. more than 60 folds increases, while population rose about 5 fold i.e. from 3.1 millions to 16 millions. Out of the total vehicles, the share of commercial vehicles is far less than the private vehicles.

**TABLE I. POPULATION AND REGISTERED NUMBER OF MOTOR VEHICLE IN DELHI**

| Year | Population | Private Vehicles | | Commercial Vehicles | | | | Total Vehicle |
|---|---|---|---|---|---|---|---|---|
| | | Four Wheeler | Two Wheeler | Passenger Vehicle | | | Goods Vehicle | |
| | | | | Auto | Taxis | Buses | | |
| **1965-66** | 3140214 | 31348 | 31351 | 6243 | 2838 | 1417 | 7223 | 80420 |
| | (4.08) | (15.13) | (31.99) | (12.82) | (7.27) | (21.01) | (16.55) | (21.94) |
| **1970-71** | 4065698 | 61521 | 109112 | 10812 | 4105 | 3266 | 15262 | 204078 |
| | (4.25) | (8.97) | (17.03) | (10.06) | (4.98) | (12.98) | (11.83) | (13.72) |
| **1975-76** | 5006283 | 93196 | 232459 | 16295 | 4996 | 5891 | 26081 | 378918 |
| | (4.25) | (5.90) | (9.53) | (5.19) | (5.80) | (7.67) | (8.21) | (8.32) |
| **1980-81** | 6220406 | 123655 | 364010 | 20920 | 6583 | 8528 | 38072 | 561768 |
| | (4.41) | (9.10) | (15.04) | (10.70) | (7.25) | (13.08) | (11.60) | (13.28) |
| **1985-86** | 7622810 | 202905 | 746619 | 40713 | 8772 | 14617 | 61860 | 1075486 |
| | (4.15) | (17.27) | (12.41) | (11.11) | (3.41) | (6.28) | (12.51) | (13.19) |
| **1990-91** | 9420644 | 427743 | 1294066 | 65829 | 10426 | 19671 | 106052 | 1923787 |
| | (4.15) | (9.62) | (7.18) | (4.30) | (6.46) | (8.77) | (5.62) | (7.57) |
| **1995-96** | 11379236 | 685850 | 1844471 | 80208 | 14593 | 29183 | 139300 | 2793605 |
| | (3.85) | (6.14) | (4.34) | (2.11) | (5.09) | (6.68) | (2.90) | (4.68) |
| **2000-01** | 13782976 | 920723 | 2230534 | 86985 | 18362 | 41483 | 158492 | 3456579 |
| | (3.09) | (11.93) | (6.32) | -(8.71) | -(2.06) | -(4.58) | -(2.31) | (6.91) |
| **2005-06** | 16021000 | 1466641 | 3062536 | 73644 | 20693 | 43500 | 141996 | 4809010 |
| **AGR** | **4** | **10** | **13** | **7** | **6** | **11** | **8** | **11** |

Source: Delhi Statistical Handbook (various years)
Note: Figures in the parenthesis are average five years annual growth rate

However, in case of commercial vehicles, the average growth rate of goods vehicle is higher than that of passenger vehicles. The passenger vehicles increased from 10.5 thousand to 0.14 million, while goods vehicles increased from 7 thousand to 0.14 millions during the period 1965-66 to 2005-06. Among passenger vehicles, the share of auto rickshaws is higher than that of taxis and buses, but, after 1975-76, the number of buses has increased more than the taxis. On the other hand, the annual average growth rate of buses is highest i.e. 11 per cent, followed by 8 per cent in case of auto rickshaws and 6 per cent for taxis. The low demand of taxi may be due to higher cost of traveling in comparison to that of auto rickshaws. Though the share of buses to total vehicles has been gradually reducing from 1.76 per cent in 1965-66 to about 1 per cent in 2005-06, still it catered to 60 per cent of the total traffic load. On the other hand, private vehicles account for 94 per cent of the total vehicles but cater to only 30 per cent of the total traffic load (Economic Survey Delhi 2005-06). Interestingly, the period between 2000-01 and 2005-06 shows an average negative growth rate for all categories of commercial vehicles. The negative growth rate is significantly higher in case of passenger vehicles (-) 8.77 per cent as compared to goods vehicles (-) 2.31 per cent. Similarly, under passenger vehicles, auto rickshaws have registered highest negative average growth rate (-) 8.71 per cent, followed by buses (-) 4.58 per cent and taxis (-) 2.06 per cent. This is due to the implementation of several directives issued by the Supreme Court of India for the control of vehicular pollution in the years 1998, 2000 and 2001. These directives are such as the phasing out or ban on plying of old commercial passenger vehicles and conversion of commercial passenger vehicles into single fuel mode i.e. on compressed natural gas (Transport Department Govt. of Delhi). In spite of negative growth rate in recent past, commercial vehicles have increased significantly over the years in Delhi. Although large proportion of mobility need is still catered by commercial vehicles, there is a rapid increase in reliance on private vehicles in the recent years. As seen from **Table I,** there has been an exponential growth in the category of private vehicles, which increased from 62.7 thousand in 1965-66 to 4.53 millions in 2005-06 at an average annual growth rate of 12 per cent. Till 1985-86, the annual growth rate of two-wheelers (motorcycle, scooter and moped) was higher than that of four-wheelers (car and jeep) and after that the growth rate of four-wheelers has been more than that of two-wheelers. Thus, the rapid increase in private vehicles during last two decades may be primarily due to increase in household income, increase in commercial and industrial activities, availability of motor vehicle product and improvement in road infrastructure. Beside these, there have been significant changes in motor vehicle sector during the last two decades. After liberalization of Indian economy during late 1980s and early 1990s, many new firms entered motor vehicle market to produce variety of cars and two-wheelers. Availability of motor vehicle and its financing at low interest rate increased the sale of private vehicles substantially after 1990. Though all these have contributed in the increase of the share of private vehicles, equally important reasons are to be found in public transport system itself. Speed, service quality, convenience, flexibility and availability favour adoption of private vehicles as the main mode of transport at present in Delhi. Finally, using the trend of motor vehicles growth per 100 persons, we develop the forecasting model for different types of vehicles in the next section.

## MODEL FOR MOTOR VEHICLE GROWTH FORECASTING

The growth of motor vehicles over time typically follows a sigmoid or S-shaped curve (Prescott. 1922). There are a number of differential functions that can describe S-shaped curves, for example, logistic, Gompertz, Von Bertalanffy, etc. (Draper, et al. 1998). These curves are to forecast how and when a given growth system will reach its saturation limit. Although the path of these growth functions can be represented in the general S-shape fashion, different types of entities can grow different patterns. Hence, the exact form of the curves, including the slop and the asymptote, may be different for each particular growth pattern. For example, the slop may be very steep during early phases, including rapid growth, or it may be gradual suggesting a slow and hesitant start, but all of them will level into saturation limit. Main advantage of these models is to obtain saturation level in long term forecast as most of the systems whether natural or artificial attain saturation level after a certain period. The properties of the S-curve growth model is such that if the growth is quite rapid at an early phase and relatively slow when approaching the saturation level, then the Gompertz function is the best method because it attains its maximum rate of growth at an earlier phase than that of logistic model. If, on the other hand, the diffusion process is such that growth is initially slow and relatively rapid during the maturing phases, then the logistic model is a superior forecasting method because it grows more rapidly towards the maximum level than the Gompertz model. The two frequently used functional forms of S-curve representing different growth patterns are the logistic and the Gompertz functions (Ogut, 2004 and Singh, 2006). The major problem that has to be solved first in these models is the saturation level. A few studies have estimated the saturation level from the S curve growth function (Singh, 2000, and Law, et al., 2005), but most of the studies provide the saturation level externally by applying rule of thumb, e.g. one car per family (Palelink, 1960), one driving member per family (Tanner, 1978), per capita vehicle ownership (Button, et al., 1993 and Kobos, et al., 2003). Therefore, using average number of seat capacity per vehicle, we assume the saturation level (100/3) = 33 for four-wheelers and (100/2) = 50 for two-wheelers. As auto rickshaw and taxi are considered as contact carriage, and their seating capacity being 2 and 3 respectively, these are assumed to be saturation level per 100 persons. However, the bus is considered as public transport system and the seating capacity ranges from 11 (TRV) to 60 (High Capacity Bus). Therefore, it is assumed that the saturation level for bus is 1 for 100 persons. In case of goods vehicle, the saturation level is assumed to be 4 per 100 persons. The assumption is based on four types of goods vehicles observed to be plying in Delhi such as: three wheeler, mini truck, tractor, and truck. Finally, using saturation level (S) and time (t), we develop logistic and Gompertz models to forecast the growth of commercial vehicle per 100 persons (V) in Delhi.

The logistic model can be developed as follows: The changes in vehicle growth with respect to time i.e. ( $\frac{dV_t}{dt}$ ) is proportional to the product of the level of vehicle growth at time $t$ i.e. ( $V_t$ ) and the percentage of market untapped i.e. ( $\frac{S-V_t}{S}$ ), where $S$ is saturation limit of the growth. The corresponding differential equation is

$$\frac{dV_t}{dt} = \frac{bV_t(S-V_t)}{S} \quad (1)$$

where $b > 0$ is the proportionality constant i.e. growth rate.

Integrating the above differential equation, we get that the logistic function is

$$V_t = \frac{S}{1+ae^{-bt}} \quad (2)$$

The parameters $a$ and $b$ model the location and shape of the curve, respectively. For $t = 0$, $V_0 = \frac{S}{1+a}$ is the starting level of the automobile growth and for $t$ = very large, $V_\infty = S$ is the saturation limit. The logistic curve reaches its maximum growth rate at half of the saturation level i.e. $V_t = S/2$, called the point of inflection of the curve and occurs at $t = \frac{\ln a}{b}$. The logistic curve is symmetric about the point of inflection.

Similarly, the Gompertz model can be develop as follows: The change in vehicle growth with respect to time i.e. ( $\frac{dV_t}{dt}$ ) is proportional to the product of present level of vehicle growth at time $t$ i.e. ( $V_t$ ) and the logarithmic density of vehicle growth level i.e. $\ln(\frac{S}{V_t})$, where $S$ is the saturation limit of the growth. The corresponding differential equation is

$$\frac{dV_t}{dt} = bV_t \ln\left(\frac{S}{V_t}\right) \quad (3)$$

where $b > 0$ the proportionality constant i.e. growth rate.

Integrating the above differential equation, we get that the Gompertz function is $V_t = Se^{-ae^{-bt}}$ (4)

The parameters $a$ and $b$ model the location and shape of the curve, respectively. The Gompertz curve reaches its maximum growth rate at $V_t = S/e$, which is the point of inflection of the curve that occurs at $t = \frac{\ln a}{b}$. For $t = 0$, $V_0 = Se^{-a}$ is the starting level of vehicle growth and for $t$ = very large, $V_\infty = S$, is the saturation limit. Unlike logistic curve, it is not symmetrical about its point of inflection.

Finally, using saturation level $S$ and time variable $t$, the parameters $a$ and $b$ are estimate by ordinary least square procedure after transforming the logistic [equation (2)] and Gompertz [equation (4)] functions into logarithmic form, where time variable $t$ is taken as 1 for 1965-66, 2 for 1966-67, ..... and 41 for 2005-06. Based on $R^2$ value and MSE, the better forecasted values are selected, where MSE is the average of square of the difference between actual and predicted values.

## ESTIMATION OF MODELS

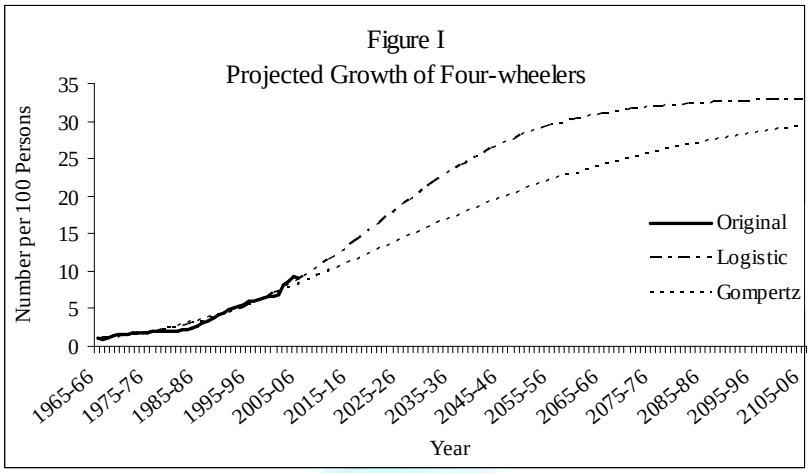
The estimated results of four-wheelers, two-wheelers, auto rickshaws, taxis, buses and goods vehicles in both these models are reported in **Table II**.

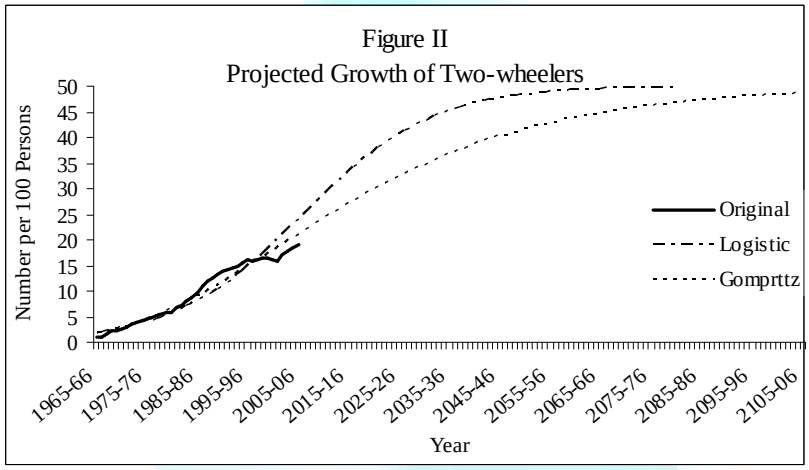
**TABLE II. ESTIMATED RESULTS OF LOGISTIC AND GOMPERTZ MODEL**

| Model | Parameters | Private Vehicles | | Commercial vehicles | | | |
|---|---|---|---|---|---|---|---|
| | | Four Wheeler | Two Wheeler | Auto Rickshaw | Taxi | Bus | Goods Vehicle |
| Logistic | b | ***0.0620*** | 0.0779 | ***0.0210*** | 0.0062 | 0.0413 | 0.0445 |
| | | ***(36.82)*** | (22.08) | ***(6.85)*** | (3.83) | (10.02) | (12.53) |
| | ln a | ***3.5379*** | 3.2904 | ***2.0778*** | 2.4193 | 2.5284 | 2.4396 |
| | | ***(87.18)*** | (38.68) | ***(12.11)*** | (62.01) | (25.47) | (28.51) |
| | R2 | ***0.97*** | 0.93 | ***0.55*** | 0.27 | 0.72 | 0.80 |
| | MSE | ***0.1264*** | 4.1303 | ***0.0374*** | 0.0271 | 0.0022 | 0.1356 |
| Gompertz | b | 0.0247 | ***0.0344*** | 0.0161 | ***0.0019*** | ***0.0184*** | ***0.0205*** |
| | | (29.06) | ***(33.20)*** | (6.37) | ***(3.99)*** | ***(9.95)*** | ***(12.54)*** |
| | ln a | 1.3361 | ***1.2684*** | 0.7353 | ***1.2304*** | ***0.9721*** | ***0.9401*** |
| | | (65.22) | ***(50.75)*** | (12.06) | ***(104.79)*** | ***(21.79)*** | ***(23.90)*** |
| | R2 | 0.96 | ***0.97*** | 0.51 | ***0.29*** | ***0.72*** | ***0.80*** |
| | MSE | 0.2215 | ***1.4901*** | 0.0503 | ***0.0002*** | ***0.0019*** | ***0.1348*** |

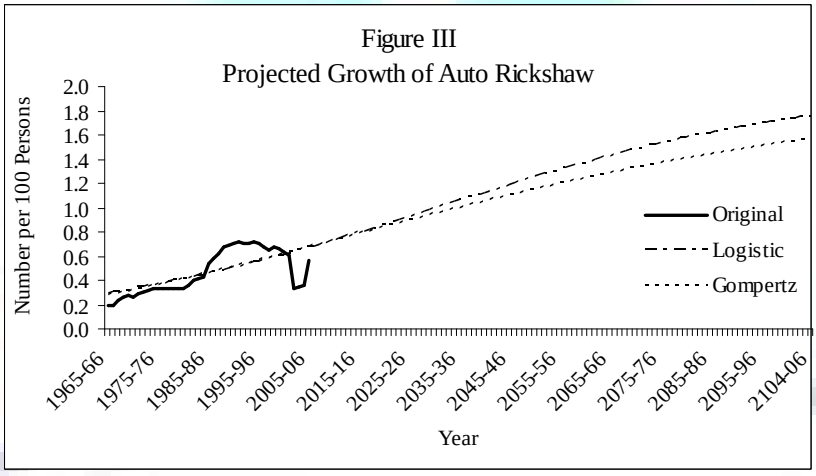
Note: Figures in the parenthesis are the values of t-statistics
Note: Bold italic figures are selected parameters

Though the models have different functional forms, they have several features in common. All of them are monotonically increasing and having horizontal asymptotes with one of them representing saturation level. According to $R^2$ values, the models fit the data very well. However, the $R^2$ value of taxis in both these models is low. All the parameters have the expected sign and most are highly significant as observed from t statistics. The highest $R^2$ and lowest MSE values of two-wheelers, taxis, buses and goods vehicles are found in Gompertz model. However, four-wheelers and auto rickshaws growth provides higher $R^2$ and lower MSE values in logistic model. Therefore, according to $R^2$ and MSE, logistic model fits the data better in the case the growth of four-wheelers and auto rickshaws whereas the Gompertz model is batter in case of two-wheelers, taxis, buses and goods vehicles (**Table II**). The properties of these models are also reflected in **Figures I to VI.**

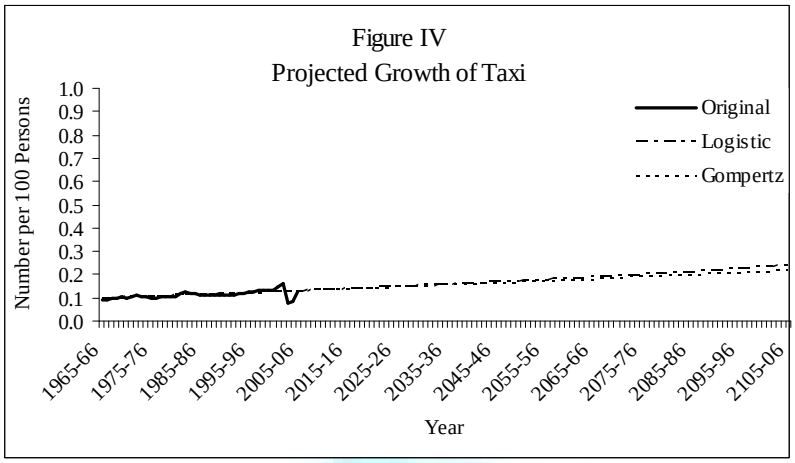


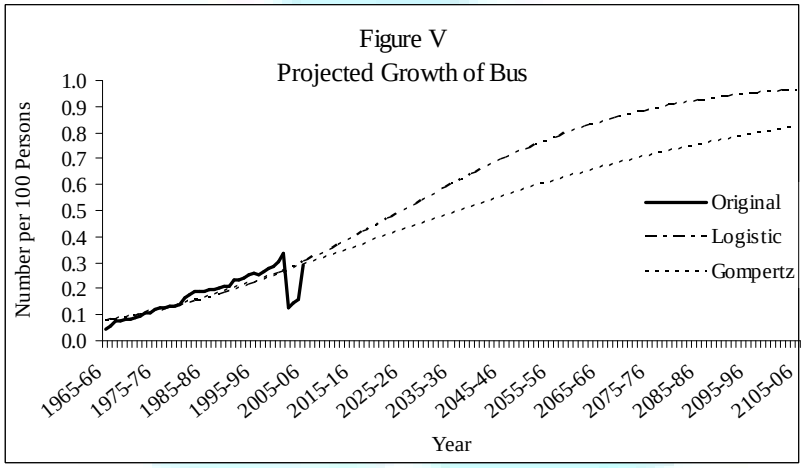

In **Figure 1**, the original growth of four-wheelers is initially slow then it takes a relatively rapid stage of growth rate, and hence it follows the logistic curve. From the figure, it is clear that in near future the growth rate will be higher. Alternatively, the growth of two-wheelers is quite rapid at an early phase as shown in **Figure II,** and hence follows Gompertz curve. In future the growth rate will be slowly proceeding towards saturation level. In case of auto rickshaw, the original growth curve is initially slow, then increases and decreases rapidly (**Figure III**). Finally it takes upward direction. This down fall in growth is due to the intervention of government's auto fuel policy.



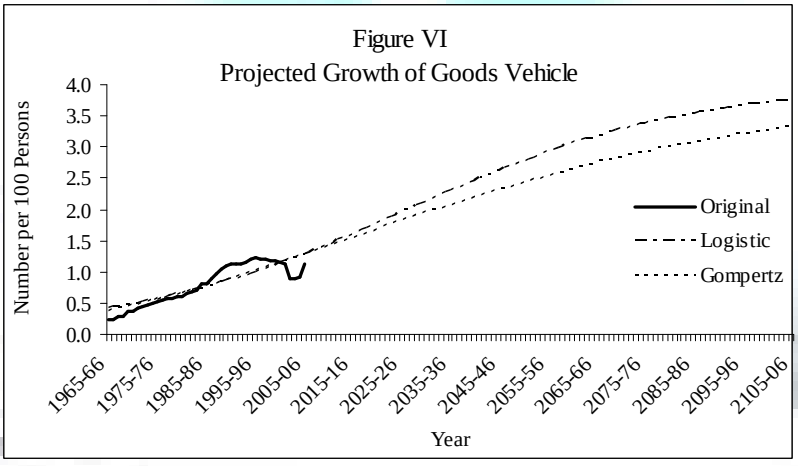

However the trend of original curve follows the path of logistic curve rather than Gompertz (**Figure IV)**. The slow growth of taxi made the logistic and Gompertz curves linear, by appearance, but it is really not so. The up and down in the original curve at the end is due to the same reason as in case of auto rickshaw model.




The original growth of bus is quite rapid at an early phase, then decreases rapidly in 2002-03, and comes to the original level after three years (**Figure V**). The negative growth is basically due to the introduction of government's auto fuel policy. Thus, if we put a trend line to the original curve it takes the path of Gompertz curve.




Similarly, original growth of goods vehicles is also quite rapid at an early phase, except a small down fall in 2002-03. Finally, it starts rising and bends towards the path of Gompertz curve (**Figure VI**).




The saturation level and selected parameters $a$ and $b$ in **Table II**, help to develop forecasting models for the growth of different types of motor vehicles per 100 persons as given bellow:

$$\text{Four wheeler}_t = \frac{33}{1+34.3930e^{-0.0620t}} \quad (7)$$

$$\text{Two wheeler}_t = 50e^{-3.5551e^{-0.0344t}} \quad (8)$$

$$\text{Auto rickshaw}_t = \frac{2}{1+7.9868e^{-0.0210t}} \quad (9)$$

$$\text{Taxi}_t = 3e^{-3.4227e^{-0.0019t}} \quad (10)$$

$$\text{Bus}_t = 1e^{-2.6435e^{-0.0184t}} \quad (11)$$

$$\text{Goods vehicle}_t = 4e^{-3.0055e^{-0.0154t}} \quad (12)$$

## PROJECTION OF MOTOR VEHICLE GROWTH UP TO 2020-21

Equations (7), (8), (9), (10), (11) and (12) project the growth of four-wheeler, two-wheeler, auto rickshaw, taxi, bus and goods vehicle per 100 persons for the years 2010-11, 2015-16 and 2020-21, by substituting t = 46, 51 and 56 respectively. The projected value of above motor vehicles per 100 persons is converted into absolute value by multiplying the projected population and dividing it by 100 reported in **Table III**.

Note that the year 2005-06 contains the actual number of vehicles. The total number of motor vehicles in Delhi will rise from 4.8 millions in 2005-06 to 11.7 millions in 2020-21, which is nearly half of the projected population of Delhi, and out of which 96 percent will be private vehicles (two-wheeler and four-wheeler) i.e. 11.2 millions. In the category of private vehicles, the number of four-wheelers will be three time to the present (2005-06) number, while two-wheelers is less than two and a half time at the end of 2020-21. It is also observed that, the share of four-wheelers will increase with a decreasing share of two-wheelers. On the other hand, the analysis of the personal vehicles growth per 100 persons provides that 16 and 30 persons will have four-wheelers and two-wheelers in 2020-21 (**Figure I** and **Figure II**). The two-wheelers have already attained its maximum growth rate in 2001-02, when 18 $(V_t = S/e = 50/e)$ persons had two-wheelers out of 100 persons. The four-wheelers will reach its maximum growth rate just beyond our forecasting period i.e. in 2021-22 and at that time 17 $(V_t = S/2 = 33/2)$ persons will have four-wheelers out of 100 persons. The total number of commercial vehicles in Delhi will rise from 0.28 million in 2005-06 to 0.5 million in 2020-21, with nearly equal share of passenger and goods vehicles at the initial stage (2005-06). However, the share of passenger vehicles will increase gradually and at the end of 2020-21, it will be 53.66 per cent of the total commercial vehicles. Similarly, in the category of passenger vehicles, auto rickshaws will increase two fold from 73 thousand in 2005-06 to 141 thousand in 2020-21 by keeping the same share to the passenger vehicles. The growth of taxis will be slow and its share to passenger vehicles will be in decreasing trend i.e. 15.01 per cent in 2005-06 to 12.59 per cent in 2020-21. Interestingly, the number of buses will increase more than double during the same period i.e. 43 thousand in 2005-06 to 95 thousand in 2020-21. At the same time the percentage share of the buses will increase from 31.56 per cent to 35.23 per cent. The major finding as per **Table III**, is the rapid proliferation in the number of private four-wheelers i.e. cars or jeeps during the next fifteen years with a decline in the relative share of two-wheelers. Another interesting finding is that the bus fleet will be increasing. This may slow down the growth of private vehicles. The expansion of metro rail may also reduce the growth of private vehicles as observed from the study conducted by us.

**TABLE III. PROJECTED GROWTH OF MOTOR VEHICLES IN DELHI**

| Year | Population | Private Vehicles | | | Commercial Vehicles | | | | | Total Vehicle |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Four Wheeler | Two Wheeler | Private Vehicle | Auto | Taxis | Buses | Passenger Vehicle | Goods Vehicle | |
| | | A | B | C=A+B | D | E | F | G=D+E+F | H | C+G+H |
| **2005-06*** | 16021000 | 1466641 | 3062536 | 4529177 | 73644 | 20693 | 43500 | 137837 | 141996 | 4809010 |
| | | (32.38) | (67.62) | [94.18] | {53.43} | {15.01} | {31.56} | [2.87] | [2.95] | |
| **2010-11** | 18451000 | 2038726 | 4448060 | 6486787 | 91329 | 24233 | 59438 | 175000 | 168546 | 6830334 |
| | | (31.43) | (68.57) | [94.97] | {52.19} | {13.85} | {33.96} | [2.56] | [2.47] | |
| **2015-16** | 21285000 | 2858624 | 5758748 | 8617371 | 113898 | 28801 | 75755 | 218454 | 203369 | 9039194 |
| | | (33.17) | (66.83) | [95.33] | {52.14} | {13.18} | {34.68} | [2.42] | [2.25] | |
| **2020-21** | 24485000 | 3905663 | 7300195 | 11205858 | 141338 | 34118 | 95438 | 270893 | 233944 | 11710696 |
| | | (34.85) | (65.15) | [95.69] | {52.17} | {12.59} | {35.23} | [2.31] | [2.00] | |
| | | **2.7** | **2.4** | **2.5** | **1.9** | **1.6** | **2.2** | **2.0** | **1.6** | **2.4** |

Note: * Actual growth
The figure in the parenthesis ( ) are percentage to the private vehicle
The figure in the parenthesis { } are percentage to the passenger vehicle
The figure in the parenthesis [ ] are percentage to the total vehicle
The last row is the number times the vehicle grow from 2005-06 to 2020-21

## CONCLUSION

A simple examination of trends over the past forty-one years clearly shows a rapid increase in motor vehicle growth in Delhi. These trends support logistic and Gompertz model to forecast the growth of all types of motor vehicle per 100 persons up to the years 2020-21. The logistic function fits well for forecasting the growth of four-wheelers and auto rickshaws, whereas Gompertz function is better for taxis, buses and goods vehicles. In absolute term, these models provide that the total number of vehicles will be 11.7 millions in 2020-21 which will be nearly fifty percent of the projected population of Delhi at that time. Out of these, 96 per cent will be the private vehicles. This shows that there will be an exponential growth in the number of private four-wheelers during the next fifteen years with a decline in the relative share of two-wheelers. Since motor vehicles are the worst air polluters (Kush S. 2001) apart from most energy intensive mode of transport (Reddy A. K. N. et al. 2000), the expected growth of motor vehicles will pose a challenge to the policy makers. At the same time, it is also linked with growing number of road accidents and fatalities. The demand for vehicle parking in commercial places is also an area of concern.

## BIBLIOGRAPHY

Abu-Eisheh, S. A. and Mannering, F. L. (2002), "Forecasting automobile demand for economies in transition: a dynamic simultaneous equation system approach", Transportation Planning and Technology, Vol.25, pp.311-331.

Button, K., N. Ngoe and Hine, J. L. (1993), "Modeling vehicle ownership and use in low income countries", Journal of Transport Economics and Policy, Vol. 27, No.1, pp.51-67.

Dayal, A. (2003), "A dream revisited: an archival journey into the making of the Delhi metro rail", Delhi Metro Rail Corporation Ltd.

Directorate of Economic and Statistics, Government of NCT of Delhi, "Delhi Statistical Hand Book", various issues, New Delhi.

Draper, N. R. and Smith, H. (1998), "Applied Regression Analysis", John Wiley & Sons.

Graham, D. J. and Glaister, S. (2004), "Road traffic demand elasticity estimates: a review", Transport Reviews, Vol. 24, No. 3, pp.261-274.
Kush, S. (2001). "Automobile Pollution" IVY Publishing House.
Ogut, K. S. (2004), "S-curve models to determine the car ownership in Turkey", ARI, Vol. 54, No. 2, pp.65-69.
Palelink, J. (1960), "Projection du parc Automobile en Belgique", Cashiess Economiques de Bruxellers, Vol.3, pp.407-418.
Peter, H. K., Jon, D.E. and Thomas, E.D. (2003), "Scenario analysis of Chinese passenger vehicle growth", Contemporary Economic Policy, Vol.21, No.2, pp.200-217.
Planning Department Government of NCT of Delhi, "Economic Survey of Delhi 2006", New Delhi.
Prescott. R. B. (1922), "Law of growth in forecasting demand", Journal of American Statistical Association, pp.471-479.
Reddy, A. K. N., Anand, Y. P. and D'Sa, A. (2000), "Energy for a sustainable road/rail transport system in India", Energy for Sustainable Development, Vol.4, No.1, pp.29-44.
Singh, S. K. (2000), "Estimating the level of rail and road based passenger mobility in India", Indian Journal of Transport Management, Vol.24, No.12, pp.771-781.
Singh, S. K. (2006), "The demand for road-based passenger mobility in India: 1950-2030 and relevance for developing and developed countries", European Journal of Transport and Infrastructure Research, 6(3): 247-274.
Storchmann, K. (2005), "Long-run gasoline demand for passenger cars: the role of income distribution", Energy Economics, 27: 25-58.
Tanner, J. C. (1978), "Long term forecasting of vehicle ownership and road traffic", Journal of the Royal Statistical Society, Vol. 141, No.A, pp.14-63

# REQUEST FOR FEEDBACK

**Dear Readers**

At the very outset, International Journal of Research in Computer Application and Management (IJRCM) acknowledges & appreciates your efforts in showing interest in our present issue under your kind perusal.

I would like to request you to supply your critical comments and suggestions about the material published in this issue as well as on the journal as a whole, on our E-mails i.e. **infoijrcm@gmail.com** or **info@ijrcm.org.in** for further improvements in the interest of research.

If you have any queries please feel free to contact us on our E-mail **infoijrcm@gmail.com**.

I am sure that your feedback and deliberations would make future issues better – a result of our joint effort.

Looking forward an appropriate consideration.

With sincere regards

Thanking you profoundly

**Academically yours**

Sd/-

**Co-ordinator**