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MODELING CAR OWNERSHIP IN EGYPT*

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ABSTRACT

Car ownership influences the city structure, public investment priorities including the roadway infrastructure, and the patterns of daily life. The study of car ownership, as a classic topic in the area of transportation, is assistive to the transportation officials in the road system planning, policies, and design. In the developed countries, car ownership study has already been advanced to the household level and currently is being refined to the daily usage level through micro simulation. However, in the developing countries, due to the lack of the disaggregated data, the car ownership study is at the aggregated level. In this study, the car ownership in Egypt is modeled by using three different modeling types, which are the log-linear, quasi-logistic, and Gompertz curves. In addition, several scenarios are developed in order to make forecasts until 2024.

KEY WORDS: Log-Linear Model, Quasi-Logistic Model, Gompertz Curves, Car Ownership, Low Income Countries.

MODÉLISATION POSSESSION D'UNE VOITURE EN EGYPTE *

RÉSUMÉ

Le taux de motorisation influence la structure de la ville, les priorités d'investissement public, y compris l'infrastructure routière, et les motifs de la vie quotidienne. L'étude de la possession d'une voiture, comme un sujet classique dans le domaine des transports, est Aides aux responsables des transports dans la planification du réseau routier, des politiques, et de la conception. Dans les pays développés, l'étude de motorisation a déjà été avancée au niveau des ménages et est actuellement en cours de perfectionnement au niveau de l'utilisation quotidienne par micro simulation. Cependant, dans les pays en développement, en raison de l'absence de données désagrégées, l'étude de possession d'une voiture est au niveau agrégé. Dans cette étude, la possession d'une voiture en Egypte est modélisée en utilisant trois types de modélisation différente, qui sont le log-linéaire, quasi-logistique, et les courbes de Gompertz. En outre, plusieurs scénarios sont développés afin de faire des prévisions jusqu'en 2024.

MOTS CLÉS: modèle log-linéaire, quasi-logistique du modèle, les courbes de Gompertz, possession d'une voiture, pays à faible revenu.

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1. INTRODUCTION AND BACKGROUND

1.1 Introduction

Considerable efforts have been expanded over the years to develop sophisticated forecasting models for car ownership in developing countries [1]. Efforts to look at the probable growth patterns of vehicle ownership in the very low income countries have been much more limited. Traffic is, however, growing in many of the world's poorer nations, albeit at very variable rates, and this has implications for both the countries themselves and, via potential environmental implications, for the industrialized world.

The implications for nations where growth is taking place are being felt in terms of pressures on road networks together with high import bills for vehicles and fuel [2]. Since the growth in vehicle ownership is continuing hand-in-hand with rapid urbanization, the strains are particularly severe in cities [3]. Rising vehicle fleets also impose strains on the vehicle maintenance facilities available and the administrative structure required to police and regulates the road system. Road traffic also contributes significantly to local, trans-boundary and global environmental degradation.

It is important for transport infrastructure planning and for microeconomic planning, that reasonable car ownership forecasts are available for these countries, together with robust forecasts of future commercial vehicle levels. From the perspective of aid-giving agencies, it is relevant to know whether similar trends in vehicle ownership occur across a range of developing countries. As these forecasts are themselves not exogenous to the planning process, it is also helpful to have indications of the main determinants of vehicle ownership, since actions to influence it become a key policy consideration.

1.2 Objective and Scope.

The aim of this study is to determine a mathematical model, which is able to forecast the car ownership (CO) in Egypt. There is no pretence that the model used is by any stretch of the imagination sophisticated by modern econometric standards, but rather it seeks to be fairly general and robust with the minimum number of independent variables which themselves must be projected.

1.3 Previous Work

The CO models can be grouped into two basic categories. First category includes the regression models whereas the second is composed of the S-curve models [4].

Beesley [5], Bottiny [6], Dyckman [7], and Kulash [8] developed different regression models for the CO forecast in USA. Apart from these, lots multiple regression approaches for various countries as for Great Britain [9], for the developing countries [10], for Singapore [11], and for the Asia countries [12] have carried out. The most famous specification of this model type is the log-linear regression with a linear time trend of the following form:

$$CO = \exp(a).I^{b}.\exp(c.T) \tag{1}$$

where CO is the car ownership per capita at year T and I is the per capita income; a, b, and c are model coefficients. This type of specification, though, tends to ignore the ultimate saturation level towards which, following standard product-life cycle theory [13], the consumption of all commodities tends.

S-curve models have two branches namely an extrapolatory model that depends on aggregated data and cross sectional models which are developed generally by using the disaggregated data. The first type of extrapolatory models is quasi-logistic model which has the following form [14]:

$$\ln\left(\frac{CO}{S-CO}\right) = a + b.\ln(I) + c.\ln(T) + d.\ln(P) \tag{2}$$

where S is the saturation level of CO and P is the composite index of the real motoring costs (purchase and running cost); a, b, c, and d are model coefficients. The model is easy to calibrate, flexible, and relatively straightforward to interpret. It has also proved useful in earlier work in less-developed countries conducted at the national case-study level [15].

Tanner [16, 17] introduced the power growth function whereby the rate of the CO growth slows rather quickly over time, thus giving a slower approach to the saturation level.

$$CO = \frac{S}{1 + [a + b.T + c.\ln(I) + d.\ln(P)]^{-n}} \qquad (3)$$

where n is the additional coefficient and if it approaches infinity then the Eq. 3 is approximated by Eq. 2.

Gompertz curve, another extrapolatory curve, is used for determining CO in Netherlands [18], and in the developing countries [19]. The form of Gompertz curve is;

$$CO = S.\exp[a.\exp(b.X)] \qquad (4)$$

where X is the major independent variable that effects CO.

The development of the cross sectional models has reached to their validity after many censuses and surveys in the form of data. These censuses and surveys provided the data set for CO modelling. Quarmby and Bates [20] developed first cross sectional model. This approach is followed by Burns et al. [21], Button et al. [22], Berkovec [23], Kitamura [24], Olszawski and Turner [25], Sansom et al. [26], and Jong and Pommer [27]. These models are determined for the developed countries where the disaggregate data are present.

2. CAR OWNERSHIP IN EGYPT

In the developed models, the CO consists of the number of the private cars. Trial cars, as taxis and the cars owned by the government are excluded from the total car population. CO values have been expressed as the number of private car per 1000 persons.

The data of CO in Egypt is available for the period 1990-2009 from the World Bank statistics [28]. Thus, the starting year of the CO model is chosen as 1990 and all models are developed with the data between 1990 and 2009. The development of CO in Egypt is given in Fig. 1 between 1990 - 2009.

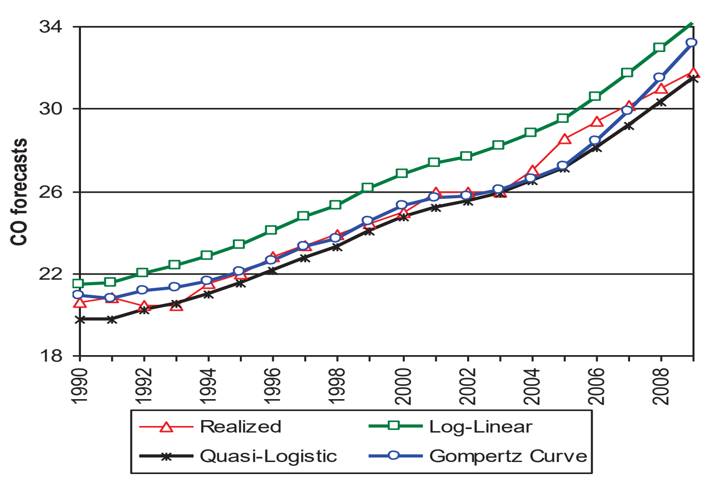

Fig. (1): CO in Egypt between 1990 - 2009

The gross domestic production per capita (GDPPC) is used as the user income variable. Because of the high inflation, it is expressed with the 2000-constant price in US Dollar.

In order to express the cost variable in the model structure, the average vehicle cost and the gasoline price are thought. However, these two variables, have an increase trend between 1990-2008 [29]. When the cost variables, which are the average vehicle cost and/or the gasoline price, are involved into the model structure, the CO is determined as it is directly proportional with the cost. In other word, the cost variable coefficients are calculated as positive value, thus the increase of the cost caused to an increase at the CO. Due to this unrealistic result, the cost variable is omitted at the CO models.

While the saturation level has been the subject of a number of different theoretical interpretations over the years, here it is seen as no more than a technical aid to improving the quality of the ultimate forecasts generated. The saturation level is the level that would be reached in the distant future, when the income no longer acts as a restraint. The level reached in the distant future is then a function of socio-economic variables as well as of the hypothetical saturation level. Button et al. [14] grouped the low-income countries into five categories, based on GDPPC, with different saturation levels ranging from 300 to 450. Based on these groups, the saturation level of the CO for Egypt is estimated as 350 private cars per 1000 person.

Calibrations are conducted using the statistical analysis software SYSTAT. The best models are as follows:

2.1 Log-Linear Model

The log-linear formula of the developed model is:

$$CO = \exp(-20.7) * GDPPC^{0.5495} * \exp(0.01T) \quad (5)$$

The explanatory power of the model is high (R2 = 0.99), the coefficients are significant (p-value = 0.0018 and 0.0205 for GDPPC and T, respectively), the Percentage Standard Error of Estimates (PSEE) is very small (0.1%), and all coefficients take the expected sign.

2.2 Quasi-Logistic Model

The quasi-logistic model formula of the developed model is:

$$\ln\left(\frac{CO}{350 - CO}\right) = -161.7 + 0.6143 * \ln(GDPPC) + 20.348 * \ln(T) \quad (6)$$

The explanatory power of the model is high (R2 = 0.99), the coefficients are significant (p-value = 0.0013 and 0.0266 for GDPPC and T, respectively), the Percentage Standard Error of Estimates (PSEE) is very small (0.1%), and all coefficients take the expected sign. Further, comparison between the quasi-logistic model and the log-linear model indicates a considerable degree of similarity. This suggests that the saturation level adopted is unlikely to be dominating the quasi-logistic results.

2.3 Gompertz Curve

Gompertz curve formula is determined as follows:

$$CO = 350 \exp\left[-3.6977 \exp\left(-2.4 * 10^{-4} GDPPC\right)\right] \quad (7)$$

The explanatory power of the model is high (R2 = 0.97), the Percentage Standard Error of Estimates (PSEE) is very small (1.2%), the coefficients are significant, and all coefficients take the expected sign

2.4 Comparison of Models

At each model, the time and the GDPPC are used as independent variables. The models' outputs and the realized values for the period 1994-2009 are presented in Fig. 2. The sum-square of error terms, SSE, which is defined as $\sum (CO_{model} - CO_{realized})^2$ are calculated in order to compare the models. The SSE terms are calculated as 48, 11, and 7 for the log-linear, quasi-logistic, and Gompertz curve, respectively. The model outputs of the quasi-logistic and Gompertz models are nearly similar to each other and show high forecasting accuracy, while the log-linear model has overestimated the CO; however, its accuracy is still acceptable.

Forecasting purposes the approach adopted is, therefore, to employ sensitivity analysis and to offer a range of projections of future growth in per capita car ownership based upon alternative scenarios of how income may change in the future. The assumed rates of growth in per capita income are 0%, 1%, 2 %, 3%, and 4 %. These cover the range of predictions made by the major international institutions in recent years, with figures in the 2 to 3 % range being regularly given [14].

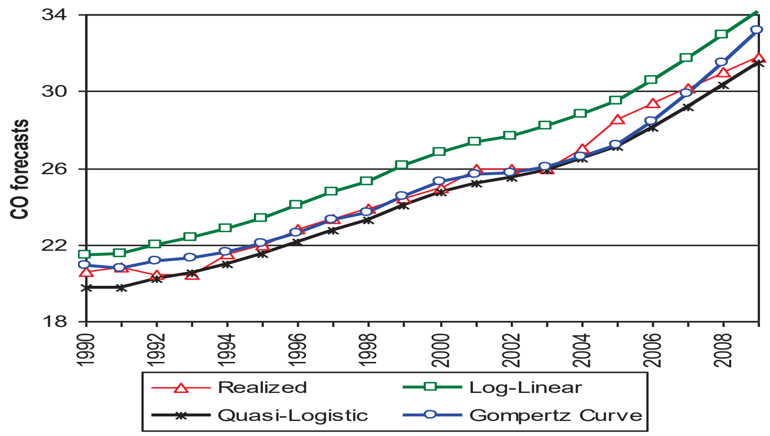

Fig. (2): Estimates of Developed Models for CO in Egypt

2.5 Forecasts

Forecasting involves making use of the models developed above and feeding into them predicted values of the independent variables (i.e. income and time).

The major exogenous variable in all forms of vehicle ownership forecasting is income. This is itself, however, difficult to predict with any accuracy even for a short period. Bodies such as the World Bank, Asian Development Bank, and other agencies provide periodic forecasts of the anticipated future growth rates for low-income countries. But, because they are regularly updated and modified, no single projection represents a stable input for transport

According to each scenario of income growth, the forecasts of the quasi-logistic and Gompertz curve models are presented separately in Fig. 3.

Realized car ownership levels, together with the levels predicted by the models, are also shown for comparative purposes.

Noting the scale on the vertical axes, the overall picture which emerges is that on high assumptions regarding income growth, Egypt will experience very considerable growth in per capita car ownership in the medium term. In contrast, on conservative assumptions regarding income growth, there will be less dramatic rises in per capita car ownership.

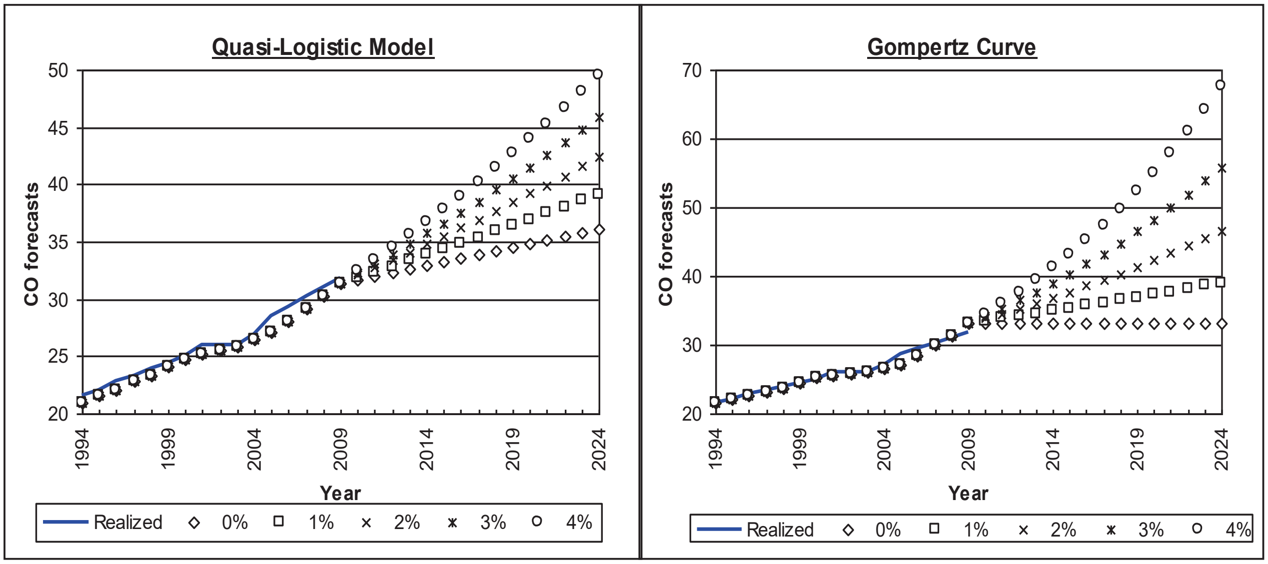

Fig. (3): CO Forecasts for Different Scenarios of Income Growth Rate

3. CONCLUSIONS AND RECOMMENDATION

3.1 Car ownership in Egypt is modeled by using three model forms, which are the log-linear, quasi-logistic, and Gompertz curves. The developed models show that CO depends on time and GDPPC.
The log-linear model overestimated the CO and it gives the biggest CO level upon the forecast.

3.2 Forecasts of the quasi-logistic and Gompertz models are nearly similar to each other and give considerable forecasting accuracies. However, the Gompertz model has the highest forecasting accuracy.

3.3 At the projection year 2024, the forecasts of the quasi-logistic model are 36, 39, 42, 46, and 50 for the 0%, 1%, 2 %, 3%, and 4 % income growth scenarios, respectively. These values are 33, 39, 47, 56, and 68 for the Gompertz curve model.

3.4 There is less than 10% difference between the outputs of the two models for all income growth scenarios. But, for the 3% and 4% income growth rate scenarios, in the projection period 2017-2024, the difference increases and reaches to about 25% in 2024. The similarity of the models outputs and the SEE values for the quasi-logistic and Gompertz curve models increase the reliability of these model forecasts.

3.5 However, the models' forecasts are based on the continuous increase of GDPPC, which means they are not sensitive to an economic crisis.

In the future, by gathering especially disaggregated data, the cross sectional models, which are more powerful and reliable, must and will be studied in Egypt. On the other hand, as the socioeconomic and financial variables are unstable in Egypt, the models with disaggregated data must be studied more carefully then in the developed countries.

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