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The Factors Affecting Automobile Demand in Türkiye

Türkiye'de Otomobil Talebini Etkileyen Faktörler

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Abstract

Per capita demand for cars is significantly higher in societies with higher purchasing power. Globally, demand for automobiles has been growing steadily, especially in developing countries. In Türkiye, where the automotive sector plays an important role in exports and the overall economy, per capita demand for automobiles has also been steadily increasing. This study examines the effects of national income and labor force participation rates on Türkiye's automobile demand. Using data from 1990 to 2022, the number of automobiles per 1,000 people is analyzed as the dependent variable, while national income per capita and labor force participation rate are analyzed as independent variables. The results of this study show that while labor force participation rate and national income per capita are expected to influence automobile ownership, the findings suggest that these variables do not exhibit a significant direct relationship with car ownership in Türkiye. The error correction coefficient (ECT) is found to be statistically significant, indicating that the system adjusts to long-run equilibrium within approximately 11.75 periods. However, both the long-run and short-run coefficients for the labor force participation rate and national income per capita are not statistically significant. This suggests that other factors, beyond income levels and labor force participation, may play a more substantial role in determining automobile demand. These results imply that the dynamics of automobile ownership in Türkiye are influenced by a broader range of factors, including infrastructure development, government policies, and consumer preferences, rather than solely by income and labor force participation rates. Future research could further explore the impact of these additional factors on car ownership, providing a more comprehensive understanding of the drivers behind automobile demand in Türkiye.

Keywords: Automobile Demand, Labor Force Participation, National Income, Automotive Sector, ARDL Model

Türkiye'de Otomobil Talebini Etkileyen Faktörler

Öz

Satın alma gücü daha yüksek olan toplumlarda kişi başına düşen otomobil talebi önemli ölçüde daha yüksektir. Küresel olarak, özellikle gelişmekte olan ülkelerde otomobil talebi istikrarlı bir şekilde artmaktadır. Otomotiv sektörünün ihracatta ve genel ekonomide önemli bir rol oynadığı Türkiye'de de kişi başına düşen otomobil talebi istikrarlı bir şekilde artmaktadır. Bu çalışma, milli gelir ve işgücüne katılım oranlarının Türkiye'nin otomobil talebi üzerindeki etkilerini incelemektedir. 1990-2022 yılları arasındaki veriler kullanılarak, 1.000 kişiye düşen otomobil sayısı bağımlı değişken olarak, kişi başına düşen milli gelir ve işgücüne katılım oranı ise bağımsız değişkenler olarak analiz edilmiştir. Bu çalışmanın sonuçları, işgücüne katılım oranı ve kişi başına düşen milli gelirin otomobil sahipliğini etkilemesi beklenirken, bulgular bu değişkenlerin Türkiye'de otomobil sahipliği ile anlamlı bir doğrudan ilişki sergilemediğini göstermektedir. Hata düzeltme katsayısı (ECT) istatistiksel olarak anlamlı bulunmuştur ve sistemin uzun dönem dengesine yaklaşık 11.75 dönem içinde uyum sağladığını göstermektedir. Ancak, işgücüne katılım oranı ve kişi başına düşen milli gelir için hem uzun hem de kısa dönem katsayıları istatistiksel olarak anlamlı değildir. Bu durum, otomobil talebinin belirlenmesinde gelir düzeyi ve işgücüne katılımın ötesinde başka faktörlerin daha önemli bir rol oynayabileceğine işaret etmektedir. Bu sonuçlar, Türkiye'de otomobil sahipliği dinamiklerinin yalnızca gelir ve işgücüne katılım oranlarından değil, altyapı gelişimi, hükümet politikaları ve tüketici tercihleri de dahil olmak üzere daha geniş bir dizi faktörden etkilendiğini ima etmektedir. Gelecekteki araştırmalar, bu ek faktörlerin otomobil sahipliği üzerindeki etkisini daha fazla inceleyerek Türkiye'de otomobil talebinin arkasındaki itici güçlerin daha kapsamlı bir şekilde anlaşılmasını sağlayabilir.

Anahtar Kelimeler: Otomobil Talebi, İşgücüne Katılım, Milli Gelir, Otomotiv Sektörü, ARDL Modeli

Giriş

The global demand and sales of automobiles have been steadily increasing, with significant implications for both international and national markets. In many European Union countries, the number of automobiles per 1,000 individuals exceeds 500, and this figure continues to rise rapidly (Eurostat, 2023). Similarly, global automobile ownership rates remain high

(Haber7, 2024), supported by production figures surpassing 85 million units globally in 2022 (OSD, 2023). In Türkiye, analyzing automobile market demand is particularly important due to the dynamic nature of its automotive industry and its critical role in the national economy. The growing demand for automobiles, coupled with the increasing adoption of electric vehicles, is expected to further energize the market (ODMD, 2023). Additionally, the automotive sector has long been a significant contributor to Türkiye's exports. For instance, while the number of automobiles per 1,000 people in Türkiye was 30.37 in 1990, this figure rose to 167.91 by 2022 (TUIK, 2023a). Developments such as the introduction of the domestic electric vehicle TOGG and rising investments in electric vehicle production are poised to further enhance the sector, which already holds a prominent position in Türkiye's industry and export portfolio (Dilek and Konak, 2022, pp.394-397).

Numerous studies in the economic literature have examined automobile market demand using various methods, highlighting the sector's significance. These methods include surveys, face-to-face interviews, and data analysis from sources such as TUIK (Yayar & Yılmaz, 2018; Uslu and Demirel, 2022; Akal et al., 2019; Aydın and Arı, 2016; Önder, 2022; Dilek, 2022). Some studies have employed artificial neural networks (Karaatlı et al., 2012; Akyurt, 2015), while others utilized econometric approaches (Işık et al., 2017; Önder and Şahin, 2018; Özçelebi and Şafak, 2018). For instance, Özçelebi and Şafak (2018) investigate the impact of credit volume on automobile demand through time series analysis. Building on this literature, the present study examines the influence of unemployment, labor force participation rates, and per capita national income on the number of automobiles per 1,000 individuals.

Household welfare emerges as a critical determinant of demand for normal goods. For such goods, increases in household income and purchasing power generally lead to higher demand. However, existing studies on Türkiye's automobile market indicate that the relationship between automobile demand and household welfare has not been adequately explored. Income fluctuations can increase consumer uncertainty, prompting precautionary savings and reducing consumption (Malley and Moutos, 1996; Bentolila and Ichina, 2008; Stephens, 2004). Research on this topic in Türkiye has primarily relied on survey-based methods (Yavuz, 2017; Dilek, 2022; Yayar et al., 2015; Önder, 2022; Aydın and Arı, 2016; Uslu and Demirel, 2022). Econometric studies have analyzed factors such as credit expansion (Özçelebi and Şafak, 2018), Special Consumption Tax (SCT), vehicle loan interest rates (Önder and Şahin, 2018), and exchange rates (Işık et al., 2017). Declining unemployment rates, increasing labor force participation, and rising per capita income are generally assumed to enhance household welfare, thereby stimulating automobile demand.

This research contributes to the existing literature by employing econometric methods to analyze the relationship between automobile demand and household welfare in Türkiye. In the first phase, it examines the key determinants of automobile demand. In the second phase, the study investigates the relationship between automobile demand, national income per capita, unemployment rates, and labor force participation rates using data from 1990 to 2022.

1. Automobile Demand

The automobile market is often characterized as a differentiated oligopoly, with numerous buyers and relatively few sellers offering diverse products (Dilek, 2017, p.148). A variety of

factors influencing automobile demand have been examined in the literature. Among these, environmental concerns have played a significant role in increasing the preference for electric vehicles (Thanausak et al., 2017, p.1). The factors influencing automobile demand can be categorized into four main groups: cost, performance factors, sales efforts and advertisements, and the socio-economic characteristics of households.

- **Cost:** As in most traditional demand models, the price of a vehicle or its total cost to the consumer is a primary determinant of automobile demand (Palmer et al., 2018, p.117). Similar to other goods, higher prices generally lead to decreased demand. In Türkiye, additional factors such as high taxation (e.g., Special Consumption Taxes [SCT]), limited credit access, and exchange rate volatility further elevate automobile costs, negatively affecting demand. For instance, SCT rates pose a major barrier to sufficient automobile demand in Türkiye (Önder and Şahin, 2018, pp.352-353). Moreover, the perception of excessive taxation also dampens demand (Yavuz, 2017, pp.386-387). Although sensitive to economic fluctuations, long-term automobile demand in Türkiye tends to rise due to income and population growth, though it remains vulnerable to tax increases (Kırcova et al., 2012, pp.3-4). Credit availability is another key driver, with easier financing conditions significantly influencing demand, especially for low-income households (Özçelebi and Şafak, 2018, pp.65-66; Önder and Şahin, 2018, p.353). Additionally, in high-inflation economies like Türkiye, exchange rate volatility raises costs, further suppressing demand (Işık et al., 2017, p.91).
- **Performance Factors:** Automobiles are not homogeneous goods; each model is distinguished by unique features (Thanausak et al., 2017). Consumers often make informed decisions after researching factors such as a car's age, mileage, horsepower, transmission type, fuel efficiency, engine size, safety features, and brand reputation (Mola and Kutlu, 2021, pp.50-51; Akal et al., 2019, pp.194-195). Studies also suggest that brand recognition strongly influences purchasing decisions (Yayar and Yılmaz, 2018, p.50). Moreover, the growing demand for electric vehicles post-2010 demonstrates a significant shift, though demand dynamics for electric versus fossil-fuel-powered vehicles remain distinct (Chen et al., 2020, p.13; Uslu and Demirel, 2022, p.973).
- **Sales Efforts and Advertisements:** Research indicates that sales strategies and media advertisements significantly shape consumer preferences for automobile brands (Köksal and Türedi, 2014, pp.120-121).
- **Household Welfare and Socio-Cultural Characteristics:** Household wealth and socio-economic attributes greatly influence consumption decisions. Factors such as being a male head of household, holding a specific profession, or having a high income positively affect automobile ownership (Yayar et al., 2015, p.615). Interestingly, higher incomes reduce demand for low-priced vehicles while increasing demand for medium- and high-priced ones, suggesting that lower-priced automobiles exhibit characteristics of inferior goods (Önder, 2022, p.224). Moreover, homeownership and equitable income distribution are correlated with increased automobile demand, as households with greater wealth are better positioned to fulfill

both housing and automobile needs (Aydın and Arı, 2016, pp.95-96; Kırcova et al., 2012, p.4).

Our study aims to analyze the impact of household welfare and socio-economic characteristics on automobile demand. An increase in labor force participation implies that more individuals are employed and earning wage income, which reduces income uncertainty and raises average household income. Academic research shows that persistently higher unemployment rates increase uncertainty, leading households to reduce consumption and increase savings (Malley and Moutos, 1996; Bentolila and Ichina, 2008; Stephens, 2004; Ruiz and Lugilde, 2019). Moreover, studies confirm that higher unemployment rates are associated with lower consumption expenditures (Ganong and Pascal, 2019).

As unemployment increases, average household income declines, reducing the consumption of normal goods while increasing the consumption of inferior goods (Dilek and Çolakoğlu, 2011, pp.1222-1223). Conversely, the rising average income of households can drive demand for medium and high-priced automobiles, indicating that such vehicles possess the characteristics of normal goods (Önder, 2022, p.224).

Building on these findings (Malley and Moutos, 1996; Bentolila and Ichina, 2008; Stephens, 2004; Ruiz and Lugilde, 2019; Dilek and Çolakoğlu, 2011), we hypothesize that the unemployment rate and labor force participation rate serve as indicators of income levels. Specifically, as unemployment decreases and labor force participation increases, average household income and wealth are presumed to grow. This assumption enables us to explore how changes in household welfare influence automobile demand.

2. Dataset and Method

This study analyzes data spanning the period from 1990 to 2022, focusing on the number of automobiles per 1,000 individuals, labor force participation rates, and per capita national income. The data used in the study were obtained from the Turkish Statistical Institute (TurkStat). To enhance the precision and interpretability of the results, the natural logarithms of these variables are utilized. The econometric framework employs the Autoregressive Distributed Lag (ARDL) model, which is particularly suited for examining both short-term and long-term relationships in time series data.

The ARDL model offers significant advantages, particularly its ability to handle variables with mixed integration orders, whether stationary at level (I(0)) or first difference (I(1)). This flexibility eliminates the need for pre-testing for cointegration, setting it apart from traditional methods such as those developed by Engle and Granger (1987) (Pesaran and Shin, 1999). By incorporating lagged values of the dependent variable alongside current and lagged values of independent variables, the ARDL model effectively captures short-term fluctuations and long-term equilibrium relationships (Pesaran et al., 2001).

The estimation process of the ARDL model involves two key stages. In the first stage, bounds testing using the F-statistic is conducted to identify potential long-term relationships among the variables. If cointegration is established, the second stage estimates both short-term and long-term coefficients. Short-term dynamics are represented through the Error Correction Model (ECM), while lagged variables in the model capture the long-term relationships. This comprehensive approach provides valuable insights for researchers and policymakers (Nkoro

and Uko, 2016). The mathematical representation of the ARDL model for both long-term (1) and short-term (2) dynamics is presented as follows:

$$Lotoper_i = a_0 + a_1 EC_{i-1} + \sum_{j=1}^{m} a_{2j} \Delta Lotoper_{i-j} + \sum_{j=0}^{m} a_{4j} \Delta LLabpart_{i-j} + \sum_{j=0}^{m} a_{5j} Lgdpc_{i-j} + \varepsilon_i \quad (1)$$

$$Lotoper_i = a_0 + + \sum_{j=1}^{m} a_{2j} Lotoper_{i-j} + \sum_{j=0}^{m} a_{4j} \Delta LLabpart_{i-j} + \sum_{j=0}^{m} a_{5j} Lgdpc_{i-j} + \varepsilon_i \quad (2)$$

In the model, Lotoper represents the logarithm of the number of automobiles per 1,000 individuals, which is calculated by combining data on the annual number of automobiles in Türkiye, sourced from TÜİK (2023a), and population figures obtained from the World Bank (2024a). These variables are derived from data provided by TURKSTAT (2023c). National income per capita, another key variable in the analysis, is obtained from the World Bank (2024b). Using logarithms for these variables helps improve the clarity and facilitate more robust econometric analysis.

3. Findings

Table 2 presents the descriptive statistics for the variables used in this study, each based on 33 observations. The average (mean) values are 1.878 for Lotoper, 1.672 for llabpart, and 4.175 for lgdpc. Lotoper and lgdpc have more variation in their values, while llabpart is more stable. The values of Lotoper range between 1.399 and 2.196, llabpart between 1.633 and 1.725, and lgdpc between 3.927 and 4.573. The results show that Lotoper is slightly left-skewed, while llabpart and lgdpc are slightly right-skewed. The kurtosis values are all below 3, meaning the distributions are flatter than a normal distribution. Overall, the data is fairly stable without extreme differences.

Table 1. Descriptive Statistics

	Lotoper	llabpart	lgdpc
Mean	1.878	1.672	4.175
Std. dev.	0.229	0.029	0.207
Min	1.399	1.633	3.927
Max	2.196	1.725	4.573
Variance	0.052	0.0008	0.042
Skewness	-0.449	0.621	0.361
Kurtosis	2.303	1.948	1.619
Obs	33	33	33

Table 2 displays the stationarity analysis of the variables, conducted using both the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests at level (I(0)) and first difference (I(1)) for both constant and trend specifications. The *autoper* variable is found to be stationary at the first difference according to the ADF test, whereas the PP test indicates that it is already stationary at level, making differencing unnecessary. In contrast, the l*abpart* and gdp variables are non-stationary at level but become stationary after first differencing, as confirmed by both tests. These results highlight the importance of applying appropriate models, such as the ARDL Bounds Test, to explore long-run equilibrium relationships.

Table 2. Unit Root Test Results

Variable		$ADF_{constant}$	$ADF_{constant+trend}$	$PP_{constant}$	$PP_{constant+trend}$
lotoper	Level	-2.843	-3.735**	-3.683**	-2.595
	Differenced	-2.925**	-	-	-3.877**
llabpart	Level	0.066	-1.861	-0.116	-1.839
	Differenced	-5.685***	-6.227***	-5.614***	-6.227***
lgdpc	Level	0.564	-1.637	-1.721	-1.720
	Differenced	-4.324***	-6.081***	-5.978***	-6.083***

Note: All variables are in logs in the series. (***) and (**) show values are significant at 1%, and 5% level with MacKinnon (1996), respectively.

Following the stationarity analysis conducted through the ADF and PP tests, which indicated that the variables are integrated of order one (I(1)), the subsequent step involves determining the appropriate lag length for the model to ensure accurate specification and reliable estimation. The optimal lag length is determined using Final Prediction Error (FPE), Akaike's Information Criterion (AIC), Schwarz Information Criterion (SIC), and Hannan-Quinn Information Criterion (HQC), favoring the model with the fewest lags. Table 3 shows that at the 5% significance level, the Final Prediction Error (FPE), Schwarz Criterion (SC), and Hannan-Quinn Criterion (HQC) consistently recommend a lag length of one. Overall, three out of the four information criteria suggest that one lags are optimal. Therefore, the preferred lag length selected for this study is lag one, balancing both model efficiency and the robustness of the estimations.

Table 3. Optimal Lag Order Selection Criteria

Lag	FPE	AIC	HQC	SIC
0	8.1e-11	-11.879	-11.820	-11.690
1	**2.5e-14***	**-19.997**	**-19.702***	**-19.054***
2	3.1e-14	-19.828	-19.296	-18.130
3	2.6e-14	**-20.184***	-19.416	-17.732
4	4.5e-14	-20.065	-19.0616	-16.859

After confirming the optimal lag length, the cointegration relationship among the variables is analyzed. Table 4 presents the detailed F-statistic results from the ARDL bounds testing procedure. According to the results, the computed F-statistic (9.223) substantially exceeds the upper critical bound value at the 1% significance level (7.64), providing strong empirical evidence for the existence of a long-run cointegration relationship among lotoper, llabpart, and lgdpc in the model. This finding confirms that the variables move together over the long term, thereby justifying the use of the ARDL framework for subsequent long-run and short-run estimations.

Table 4. ARDL Bounds Test for Co-integration

Variables	**F-Statistics**	**Inference**
F(lotoper/labpart, lgdpc)	9.223***	Co-integration
Significance Value	**Lower Bound I(0)**	**Upper Bound I(1)**
1%	6.15	7.64
5%	4.22	5.40
10%	3.41	4.47

Note: Kripfganz and Schneider (2020) critical values and approximate p-values for the Pesaran, Shin, and Smith (2001) bounds test

After establishing the existence of a long-run relationship among the variables, the next step is to estimate the short-run and long-run coefficients. Table 5 reports the estimated results.

Table 5. Long-run and short-run coefficients under ARDL (1,0,0,0) Model

Panel A: Long-run estimations		
Regressors	**Coefficient**	**t-stat**
Llabpart	1.687	0.660
lgdp	0.390	0.910
Panel B: Short-run estimations		
ECT_{t-1}	-0.085***	-3.350
ΔLlabpart	0.144	0.750
Δlgdp	0.033	0.740
Panel C: Residual Diagnostic Tests		
R^2	0.497	
$R^2_{adjusted}$	0.443	
Root MSE	0.012	
Log Likelihood	96.97	
$X^2_{Serial\ correlation}$	0.279 (0.597)	
$X^2_{Heteroscedasticity}$	1.190 (0.274)	

Note: *** indicates 1% level of significance. (.) refers p-values.

The goodness-of-fit indicators for the estimated ARDL model show that the R-squared value is 0.497, meaning that about 50% of the variation in the dependent variable is explained by the model. The adjusted R-squared value is 0.443, indicating a reasonable explanatory power considering the number of variables included. The Root Mean Square Error (Root MSE) is low at 0.012, suggesting good prediction accuracy. In addition, the log-likelihood value of 96.97 confirms that the overall performance of the model is statistically sound.

Panel A and B shows the short-run and long-run estimates. In the analysis of long-run coefficients, the variables llabpart and lgdpppp are found to be statistically insignificant, with p-values of 0.515 and 0.373, respectively. Similarly, in the short-run analysis, the coefficients for both variables remain statistically insignificant (p=0.462 and p=0.463, respectively). These results suggest that there is no significant dynamic relationship between *llabpart* and *lgdpppp* and the dependent variable in either the short or long run. In addition, the error correction coefficient (ECT), which indicates that the disequilibrium in *lotoper* from the previous period's shock will be converged back to the long-run equilibrium in the current period, of the estimated ARDL model is -0.085 and statistically significant at the 1% level (p=0.002). This indicates that deviations from the long-run equilibrium are corrected by

approximately 8.5% each period, implying that the system stabilizes within roughly 11.75 periods

Various diagnostic tests (Panel C) were conducted to evaluate the accuracy of the model and to detect potential specification issues. The Breusch-Pagan Lagrange Multiplier (BPG LM) test yields an F-statistic probability of 0.279, exceeding the 5% significance level and indicating no evidence of serial correlation in the long-run relationship. Similarly, the normality test results show a probability above 5%, confirming that the residuals are normally distributed. The Breusch-Pagan-Godfrey (BPG) test for heteroskedasticity also indicates no heteroskedasticity problem, supporting the model's overall validity.

Lastly, to assess the stability of the short- and long-term coefficients estimated through the ARDL model, the CUSUM and CUSUM of Squares (CUSUMQ) tests are employed. The CUSUM (Cumulative Sum of Recursive Residuals) test evaluates whether model parameters remain constant over time by analyzing the cumulative sum of residuals. If the cumulative sum stays within the critical bounds, the parameters are deemed stable; if the bounds are exceeded, it suggests the presence of a structural break in the model (Brown et al., 1975). Similarly, the CUSUMQ test assesses model stability by analyzing the cumulative sum of the squared residuals. Stability is confirmed if the statistic remains within the specified limits; otherwise, a parameter change or structural break is indicated (Ploberger and Krämer, 1992).

Figure 1. Evaluation of the stationarity of short-term coefficients (CUSUM)

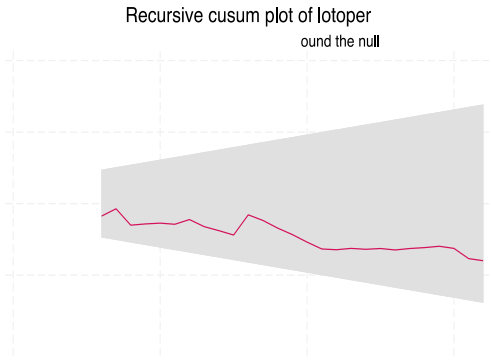
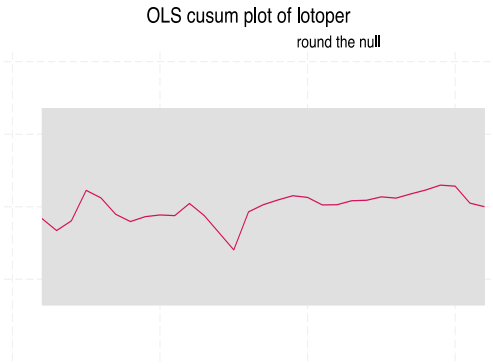


Figure 2. Evaluation of the stationarity of long-term coefficients (CUSUMQ)



The CUSUM test results, which assess the stability of the model for the period 1994–2022, include the cumulative sum of the residuals along with the 5% significance boundaries. The results show that the cumulative sum remains within the critical bounds, indicating that the model parameters are stable over this period and that no structural break is present. Similarly, the CUSUM of Squares (CUSUMQ) test confirms that the cumulative sum of squared residuals remains within the limits, supporting the stability of the model parameters. As with the CUSUM test, the CUSUMQ results suggest that the parameters remain constant and that no structural break occurred during the 2004–2022 period.

Conclusion and Discussion

This study investigates the relationship between the labor force participation rate, per capita national income, and automobile ownership. The findings reveal that the anticipated strong link between these economic indicators and car ownership is weaker than expected. The

assumption that rising household incomes and a more equitable income distribution, driven by higher labor force participation, would significantly increase automobile ownership is not supported by the results.

Although economic factors are frequently highlighted in studies of consumer behavior, this research emphasizes that their direct impact on automobile ownership is limited. Both short- and long-term analyses indicate that economic variables alone are insufficient to fully explain the dynamics of car ownership. Instead, the findings suggest that trends in automobile ownership are influenced by a complex set of factors, including transportation infrastructure, urban planning, social and cultural norms, and government policies such as taxation and incentives for alternative transportation modes.

This study underscores the importance of moving beyond purely economic explanations to gain a more comprehensive understanding of consumer behavior related to automobile ownership. The results indicate that while economic growth and rising income levels may have indirect or secondary effects on car demand, non-economic factors may play a more decisive role.

Future research should address these complexities by incorporating a broader range of variables, including social, environmental, and policy-related factors, to better capture the interplay of forces shaping automobile ownership. Such an approach would provide deeper insights into the evolution of car ownership patterns in both developed and developing economies, ultimately informing more effective policies in transportation planning and urban development.

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