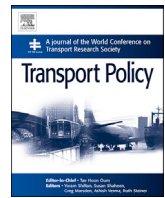




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Modeling the dynamic response of automobile sales in troubled times: A real-time Vector Autoregressive analysis with causality testing for Greece[☆]

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ABSTRACT

In this paper, we investigate the factors that affect multi-segments automobile sales in Greece. Various relevant quantitative techniques have been employed, such as stationarity, causality and cointegration. A Vector Autoregressive (VAR) model was also developed and long-term impacts of the different variables of interest on car sales have been estimated through generalized impulse response functions (GIRF). The impact of the current financial crisis on the Greek automobile market was also taken into account. The results show that fuel prices Granger cause total car sales. The results also indicate the absence of long run cointegrating relationships among the variables. The full blown model shows that demand for new automobiles depends on the existing social, financial and political conditions of the local economy and that the various shocks observed have a temporary medium-run character on car sales, whereas the system is found to be stable.

1. Introduction

Car sales analysis can serve a dual purpose. First, to help the car sales industry to adjust to demand forecasts, since underestimation of new car sales demand might lead to lost sales and thus to reduced profit; meanwhile, overestimation could result in the production of unwanted cars that remain overstock (Wang et al., 2011). Second, at the economy-wide level of analysis, accurate demand modeling of car sales can assist policy decisions, related to the total economy and the transport sector. The car industry offers a large range of products and the particular position of each type of car in the market varies over time as economic conditions change and, therefore, it depends on a large number of factors such as GDP, unemployment, fuel, car prices and taxation policies (Danielsen and Hilliard, 1983).

Although private cars have played an important role as an urban transport mode over the past decades, the car sales sector in Greece has been significantly affected by the ongoing crisis showing a reduction of total sales that exceeded 20% (Roul et al., 2012). This is a much higher trend than the respective one (13%) observed in the OECD area (OECD, 2013). Meanwhile, government policies on car sales has to face the conflicting objectives of raising tax revenues, improving the balance of

foreign trade and reducing environmental effects. New car sales have a twofold impact on the economy: on the one hand, they bring revenues through taxation and tend to have a positive effect on the environment; on the other hand, they have a negative impact on the foreign balance of payment. In times of recession and economic instability the above conflicting objectives lead to frequent changes in taxation policies that create positive or negative shocks in car sales. Moreover, car sales and car use affect the share of the other transport modes. Thus, car sales policy measures affect both the economy and the transport sector.

The aim of the paper is to analyze the main factors that affect new car sales and explore the impact of financial recession on the car sales market in Greece, using monthly time series data. More precisely, the present study attempts to identify the determinants of car sales in Greece and, more broadly, their bi-directional dependence with the economy, using aggregate data and a Vector Autoregressive (VAR) model.

In this context, we employ a number of econometric tests to identify the properties of the data and specifically their order of integration, the causality from a number of potential determinants towards car sales and their mutual equilibrium relations using the Generalized Impulse Response Functions (GIRFs) introduced by Pesaran and Shin (1998) that are capable of producing robust results that are invariant of the ordering

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of equations. The study spans the period 2000M9–2012M9. The period under investigation includes both a period of growth as well as the downturn, following the global financial crisis and the Greek crisis. Therefore, our study benefits from the examination of a through-the-cycle sample enhancing the reliability of our results.

The paper is organized as follows: a brief literature review on car sales is followed by a brief description of the methodology used and the dataset employed. Then, empirical results are presented and discussed followed by relevant policy insights. Finally, closing remarks are made in the last section.

2. Related studies

A number of factors that affect new car sales have been analyzed, in the literature, using a variety of methodologies.

First, regarding the factors affecting car sales, statistically significant relations have been identified among new car sales and income, interest rates, oil and car prices, tax increases and employment level variations. According to [Danielsen and Hilliard \(1983\)](#), demand for new car sales is affected by variations in income and oil price variables. [Sivak \(2013\)](#) examined the relationship between car sales and GDP in both developed and developing countries and concluded that GDP is a strong predictor of automobile sales. The link between gasoline prices and vehicle sales was analyzed by [McManus \(2007\)](#). Moreover, automobile demand is affected by advertising and sales promotion as well as by technological development ([Donatos and Kioulafas, 1999](#); [Landwehr et al., 2011](#)). Relatively recently, [Mabit \(2014\)](#) analyzed vehicle purchasing behavior through vehicle type choice using a mixed logit model. Technological development, fuel prices and tax reform were used as the explanatory variables.

Variations in car sales market due to changes in the social and economic environment is considered to be a crucial issue in demand analysis. According to [Vasconcellos \(1997\)](#), automobile demand is highly influenced by economic and transportation policies. Taxation can definitely determine consumers' purchase decision, especially in times of economic recession ([Ryan et al., 2009](#); [Hennessy and Tol, 2011](#)). [Ryan et al. \(2009\)](#) found that car related taxes (fuel, vehicle registration, circulation) show a strong impact on new passenger car sales. There is no doubt that in times of crises—that imply economic and social instability—demand for new cars is shrinking. Moreover, increasing inequalities in income distribution result in an increase in the top and the low-cost car segment market shares ([Chung, 2015](#)). Thus, during economic recession periods, car segments are not affected in the same way, with consumers revealing a clear preference towards small and used cars on one hand ([OECD, 2009](#)) and expensive, luxury vehicles on the other ([Köhler and Jiménez, 2012](#)).

Second, regarding the methodological framework, different methodologies for analyzing car sales demand, using both aggregate and disaggregate data, have been adopted in the literature ([Karlaftis and Golias, 2002](#)). Depending on the nature of the data, two main methodological procedures are followed: time series and discrete choice analysis. Generally, the former analysis examines the process of car sales over time (macro level), while the later explores consumers' preferences on car types and attributes (micro level), using revealed and stated choice experiments ([Lee and Cho, 2009](#)).

Discrete choice models have been used in the literature to investigate the impact of socio-demographic attributes and psychological variables on car purchases. These factors mainly explain consumers' preferences regarding the type and the characteristics of the vehicle. Location of residence and intention to buy an environmentally friendly car influence the type of car purchased, including the level of emissions ([Nayum et al., 2013](#)). Preferences on alternative fuel vehicles (electric car, fuel cell car) depend on commuting behavior, gender and annual mileage ([Hoen and Koetse, 2014](#)). Based on behavior demand models, [Dagsvik and Liu \(2009\)](#) estimated demand price elasticities and willingness to pay for alternative fuel vehicles. According to their results high income households value alternative fuel vehicles higher than conventional cars.

There is also a substantial body of research on time series analysis and demand forecasting for vehicles. However, there is limited research exploring automobile demand taking into account the (non-) stationary characteristics of the economic indicators. The (non-) stationary properties of the automobile sales indicators present additional challenges to new car sales prediction ([Sangasoongsong et al., 2012](#); [Karlaftis and Vlahogianni, 2009](#)). [Barber et al. \(1999\)](#) used a structural VAR model to investigate the impact of shocks to oil prices and exchange rates on new car sales of American and Japanese automakers in U.S. market. They applied unit root and cointegration tests and finally concluded that estimation of a VAR is an appropriate methodology. [Franses \(1994\)](#) estimated an econometric model for new car sales using cointegration techniques. [Sangasoongsong et al. \(2012\)](#) used Granger-causality and cointegration techniques in order to identify the dynamic relationships among automobile sales and macroeconomic variables.

Based on the methodological framework of time series analysis, the purpose of this study is to investigate the impact of specific variables related to financial recession on automobile market using unit root, cointegration and causality for Greece.

3. Methods

We briefly present step-by-step econometric properties of the original series and their derived components, their causality with respect to other variables of interest, the existence of mutual long-run relationships and, finally, the incorporation of this information into a full-blown model. In this context, standard practice of modern econometric techniques dictate that all the time series employed in the model should be stationary over time, i.e. their statistical properties should be time invariant, whereas in case of I(1) variables possible existence of long-run relationships among them should be accessed based on relevant cointegration tests. Lastly, specification of endogenous variables in VAR models is assessed *a priori* using Granger causality testing.

• Stationarity

Following, among others, [Pesaran et al. \(2004\)](#), we begin our analysis by testing for stationarity, based on the popular Augmented Dickey-Fuller (ADF) methodology ([Dickey and Fuller, 1979](#)).

• Optimum Lag Length

In this paper, we make use of the so-called Schwartz-Bayes Information criterion (SBIC) introduced by [Schwarz \(1978\)](#), because it is an optimal selection criterion when used in finite samples ([Breiman and Freedman, 1983](#); [Speed and Yu, 1992](#)).

• Granger Causality

After examining the stationarity properties of the data series, we use Granger causality to test the predictive ability of the variables that enter the model. As [Engle and Granger \(1987\)](#) showed, if two variables are cointegrated, the general model is not appropriate for testing causality. Instead, a test based on cointegration and error-correction models should be employed. Through building an error-correction model (ECM), the dynamic co-movement among variables and the adjustment process toward long-term equilibrium may be examined without facing cointegration issues if necessary. After having estimated the ECM term, we modify the Granger test in order to incorporate the adjustment towards long-run equilibrium.

• Cointegration

Consequently, as a preliminary step before estimating the model, we investigate the existence of cointegration among the variables of the system, in order to inform the model's specification. We employ

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