
A Time Series Analysis Using R for Understanding Car Sales On The Romanian Market

Mihaela Cornelia SANDU (mihaela.sandu@faa.unibuc.ro)

Elena DRUICĂ (elena.druica@faa.unibuc.ro)

Rodica IANOLE (rodica.ianole@faa.unibuc.ro)

Faculty of Business and Administration, University of Bucharest

ABSTRACT

The size of the Romanian automobile industry is relative small compared to the main car producers in Europe and the world, but an analysis of its structure and dynamic appears to be most relevant given the strong linkages with the main macroeconomic indicators and important microeconomic variables at the level of the household. The paper presents a time series analysis for car sales in Romania, in the period 2007-2014, focusing on the sales dynamic of the national main producer – Dacia Pitesti. The aim of the investigation is twofold: to test the impact of macroeconomic variables on this important and underexplored segment of the economy and to emphasize potential differences between the factors influencing the buying decision for domestic versus foreign cars (observed in three regimes: new, registered and reenrolled). While the major influence of the global economic crisis cannot be ignored for the analyzed interval, we believe that it may also help to illustrate the real behaviors of individuals by setting the line between the immediate period after the crisis as treatment under scarcity conditions and the re-installment of normality towards the second half of the time interval. The results are confirming the general findings of the literature for the main indicators but they not entirely consistent with the rational economic models, especially with regard to the nature of the investigated goods (the cars) – normal or positional.

Keywords: automotive industry, time series analysis, positional goods

JEL classification: C10, C22, L62

INTRODUCTION

The automobile industry represents an important driver of economic growth in many car-producing countries. At the level of European Union, the turnover generated by this sector in 2013 was 6.9% of the GDP (European Automobile Manufacturers Association, 2013), while in Romania, at the level of the same year the added value was 11% of the GDP and 24% of the total exports (Financial Newspaper, 2013). An important share of this percentage is attributed to the sales of Dacia cars, one of the most powerful brands in the Romanian economy. In the same time, Dacia stands in the first line of low-budget cars (under 7000 euro), providing the cheapest cars in

Europe and positioning Romania among the top five Central and Eastern European automotive markets in terms of sales and production (next to the Czech Republic, Hungary, Poland and Slovakia).

Given this significant economic influence, both of the industry and the firm, for the internal business environment, the paper aims to tackle the dynamic of car sales in Romania, for the period 2007-2014, taking into account the registrations for Dacia and foreign new cars, registration cars (those cars that have an owner before) and reenrollment cars (those cars that have more than one owner before).

The analyzed period encompasses the global recession so it is only natural to assume as a first hypothesis that the decline in car sales was due to the financial crisis. However, even if we start by assessing the liaison with the macroeconomic climate (section 2.1), our approach is not limited to underpinning the sole impact of economic factors, but it strives to underline some important non-economic variables behind the decision of buying a car (section 2.2). An extensive time series analysis is presented in the third and fourth section using the statistical package R. We conclude by formulating a set of minimal policy implications and pointing out future paths of extending the current research.

LITERATURE REVIEW

Top-down: macroeconomic variables

Compared to the significant size and complexity of the automobile industry, the economic literature is not very generous regarding the number of studies examining the existence and intensity of the potential correlations between the number of cars sales and a certain pool of macroeconomic variables (Carlsson&Umble, 1980). Not very surprising given the historical legacy (Pavlinek, 2002), this literature gap is wider for Central and Eastern European countries. One possible reason may be the lower rate of car ownership compared to Western Europe (according to the passenger cars indicator, Eurostat data) but this is however not enough evidence to disregard the aggregate impact of this industry at the level of these smaller and, some of them still transitioning, market economies.

The work of Shahabudin (2009) on domestic and foreign car sales offers a synthetic view on the issue, building up a multiple regression model (with and without a lag) for US data with a high explanatory power. The pool of independent variables include durable industrial demand, durable personal consumption, population, discount rate, non-durable industrial goods, non-durable personal consumption, gross national product, gross domestic product, and the value of different monetary aggregates (money in cash, short-term institutional funds etc). While the perspective is helpful in showing a clear direction of interest, the depth of the analysis needs calibration and refinement, as pointed out by Muhammad et al. (2012) in empathizing the heteroscedascity of the model and, by consequence, its impaired efficiency.

Interest rate, and particularly the conditions associated to loan interest rate, is another important addition, evaluated in terms of negative impact on car sales

(Ludvigson, 1998). Unemployment rate and inflation stand mainly as structural influences on the consumption of durable goods, in line with the fluctuation over the business cycle, making it hard to isolate their specific effects.

Bottom-up: microeconomic variables

The cornerstone of traditional microeconomics impact factor – the income level – seems to have a good representation of the car sales dynamic: a positive correlation for income increase and a negative one for income reduction (Dargay, 2001). However, it is worth mentioning that the permanent income hypothesis model of durable expenditures presents some inconsistencies with empirical data (Mankiw, 1982), opening the floor to further theoretical explorations.

In order to differentiate between the economic and non-economic factors that may influence the buying decisions, we start by proposing a certain understanding of utility and rationality for this particular context. The utilitarian approach deals, naturally, with the utility of the good in discussion, in terms of its value of use, thus asserting decisional utility.

A behavioral perspective would also take into consideration the experienced utility, pointing out particularly to the pleasure brought by the object or outcome at the effective moment when it is gained (Kahneman et al., 1997). This type of utility appears at the end of the decision process (Glimcher et al., 2003) and its hedonic impact often includes aspects related to satisfying the need for status and differentiation.

DATA

The trigger factor of our subsequent analysis was the simple observation of Dacia sales between 2005 and 2013. As depicted in figure 1, it is obvious that after 2006 Dacia sales decreased in our country and export of Dacia cars increased (red line – domestic sales of Dacia, blue line- external sales of Dacia). Wondering if there is a more intricate reason for this evolution, apart from the financial crisis, we have naturally ended up in exploring the bigger of the registered cars in Romania.

Dacia sales

Figure 1

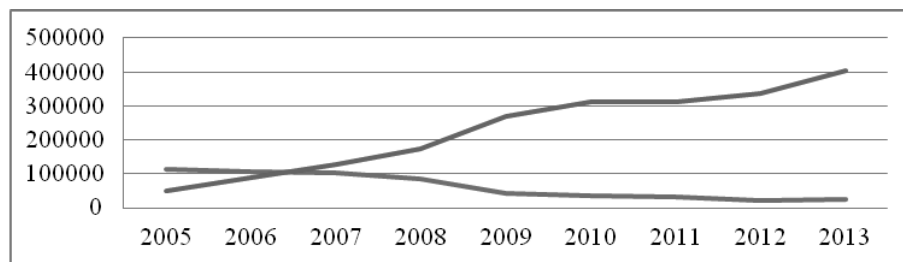
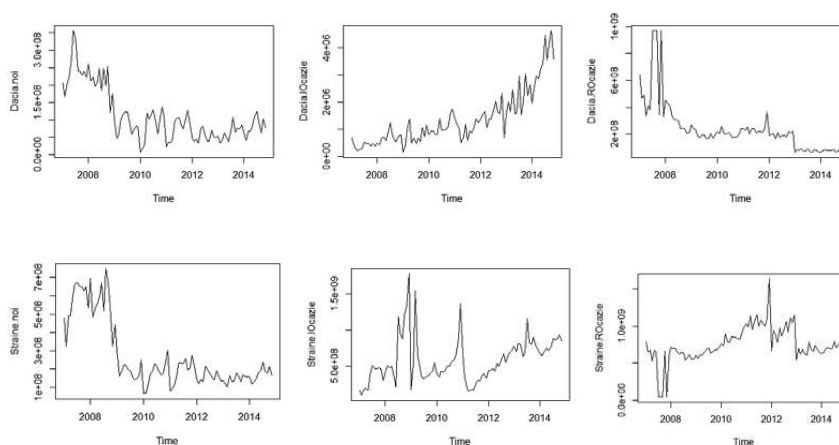


Figure 2 presents the time series used in our analysis, with monthly data from 1st of January 2007 to 30th of November 2014, regarding the registered cars in Romania. We can see the evolution of Dacia and foreign cars registered – new cars, registration cars (those cars that have an owner before) and reenrollment cars (those cars that have more than one owner before).

Evolution of the number of registered cars – Dacia (new, registration and reenrollment) on the first row and foreign cars (new, registration and reenrollment) on the second row.

Figure 2



The non-stationary of the time series is easily noticed from the graphs, while the table below completes the picture with the usual descriptive statistics. We can observe that sales of Dacia new cars decreased after 2006 and sales of foreign cars increased permanently.

Descriptive statistics for registered cars

Table 1

Variable	Minim	Median	Mean	Maximum	Standard deviation
Total new cars	2134	7828	11360	32640	8578,122
Total registration cars	3084	15270	16260	54710	9133,788
Total reenrollment cars	14060	29510	27890	51030	7030,347
Dacia registration	5	30	35,21	107	21,746
Foreign cars registration	3069	15230	16220	54690	9128
Dacia reenrollment	1514	5991	7158	31040	6184,447
Foreign cars reenrollment	1347	21380	20730	41700	6323,008
Dacia new cars	201	2497	3327	11410	2514,554
Foreign new cars	1933	5387	8032	22930	6143,258

TIME SERIES ANALYSIS

In this context, the first hypothesis is that Romanian cars are mostly evaluated through the decisional utility paradigm, while foreign cars follow the path of experienced utility.

We have tested mean differences for new Dacia and foreign cars. The results presented in table 2 (the inequality $-1,98 < -12,02 < 1,98$ is obviously false) allow us to accept the alternative hypothesis stating the existence of differences between the number of Dacia and foreign registered cars.

Mean differences for new Dacia and new foreign cars

Table 2

	Variable 1	Variable 2
Mean	3326,768421	8032,021053
Variance	6322982,52	37739614,62
Observations	95	95
Pearson Correlation	0,955542167	
Hypothesized Mean Difference	0	
df	94	
t Stat	-12,02672364	
P(T<=t) one-tail	5,03412E-21	
t Critical one-tail	1,661225856	
P(T<=t) two-tail	1,00682E-20	
t Critical two-tail	1,985523395	

In light of this evidence, we consider appropriate to examine the particular character of foreign cars on the Romanian market: are they perceived as positional goods? Whereas there is no absolute answer to found in the existing studies, there are some compelling results confirming at least the validity of this orientation (Alpizar et al., 2005; Carlsson et al., 2007). The underlying hypothesis rests on the power of social comparison and the on the manner in which a car (foreign in our case) may be considered a signal of the status. The next step is to observe how the signaling process may change when confronted with significant constraints. The time series for foreign car sales, illustrating the decline of purchases during the peak of the crisis, can be interpreted as proof that in these difficult financial times the good drops in the normal category. The time moment is equalizing the trend of the market since individuals seem to express very similar choices both for Dacia-Renault and foreign cars. In other words, under the paradigm of revealed preferences, we may say that we witness a preference change, induced by the crisis.

Apparently this may look like shifting the focus from the experience self to the utilitarian approach, perspective strengthened also by the increased number of

re-registration (in translation, efficiency becomes more important and trumps other behavioral, non-economic factors).

However, analyzing the registration and reenrollment for foreign cars, in comparison with the Dacia-Renault re-registration, we actually see that the buying behavior has not really changed. The crisis plays the role of a sniping factor of our analyzed universe, slightly hiding that the patterns stays the same (the discrepancy between sales continues to be very high).

A second layer of the analysis is continued by computing the value of the Pearson correlation index, value which is pointing out to a strong relationship between different pairs of variables. For example, we notice that GDP is positively correlated, above the average, with second registration cars (0.61), while the latter is negatively correlated with inflation (-0.58). The level of credits generates a lot of strong relationships, positive ones with the GDP (0.61) but highly negative with new Dacia cars (-0.73), third registration Dacia cars (-0.68) and new foreign cars (-0.72).

Pearson correlation matrix

Table 3

	Dacia new	Dacia registration	Dacia reenrollment	Foreign new	Foreign registration	Foreign reenrollment	Inflation (BNR)	GDP	Credits (lei)
Dacia new	1								
Dacia registration	-0,48672	1							
Dacia reenrollment	0,725247	-0,53556	1						
Foreign new	0,955542	-0,49906	0,743568	1					
Foreign registration	0,019688	0,265024	-0,1373	0,065768	1				
Foreign reenrollment	-0,30621	-0,10514	-0,36828	-0,33171	-0,18072	1			
Inflation (BNR)	0,337143	-0,58102	0,292238	0,413954	0,144235	0,169959	1		
GDP	-0,37716	0,617827	-0,50439	-0,38029	0,326195	0,065096	-0,33883	1	
Credits (lei)	-0,74329	0,580467	-0,68922	-0,72031	0,073706	0,244192	-0,28237	0,617226	1

Checking for multicollinearity is a necessary step before moving forward and we have used the variance inflation factor (VIF) to assess its presence. Table 4 is presenting a summary of the computed VIFs and it is easy to observe the instances with values over 10, a clear sign of multicollinearity: between Dacia new cars and all the variables, except the new foreign cars.

Multicoliniarity

Table 4

	Dacia new	Dacia registration	Dacia reenrollment	Foreign new	Foreign registration	Foreign reenrollment	Inflation (BNR)	GDP	Credits (lei)
Dacia new	1	13,392	13,403	3,127	13,341	13,278	12,940	13,293	12,577
Dacia registration	2,887	1	2,816	2,889	2,684	2,781	2,287	2,757	2,765
Dacia reenrollment	3,025	2,948	1	2,888	2,935	2,774	3,025	2,996	2,965
Foreign new	3,416	14,642	13,981	1	14,516	14,234	13,319	14,627	14,643
Foreign registration	1,526	1,424	1,487	1,520	1	1,454	1,309	1,404	1,479
Foreign reenrollment	1,549	1,505	1,434	1,520	1,483	1	1,446	1,547	1,564
Inflation (BNR)	2,104	1,725	2,179	1,982	1,861	2,016	1	2,112	2,086
GDP	2,272	2,186	2,269	2,288	2,098	2,267	2,220	1	1,861
Credits (lei)	3,295	3,359	3,441	3,511	3,388	3,511	3,361	2,851	1

At this point, a multivariate regression was performed with Dacia new cars as a dependent variable, without taking into consideration the time period. We have obtained three significant models, with a similar (very high) explanatory power (91.3%, 91.9% and 92.3%) depicted in table 5.

Multivariate regression for Dacia new cars

Table 5

Dacia new	b_0	Foreign new	Credits	Inflation	F-stat	R square
Model 1	185,269	0,391			976,713	0,913
		t-stat				
		31,252				
Model 2	1047,683	0,357	-9,263e-8		524,359	0,919
		t-stat	t-stat			
		20,457	-2,678			
Model 3	1296,144	0,370	-9,081e-8	-0,736	364,721	0,923
		t-stat	t-stat	t-stat	Darbin Watson	
		20,458	-2,675	-0,068	1,125	

In order to check for the autocorrelation of first degree errors, we have applied the Durbin Watson test. The phenomenon exists only for the third model (DW = 1,125, DL = 1,60 and DU = 1,73, with the inequality $DW < DL$).

Another regression analysis was conducted for the time series per se, resulting in six statistically significant models (table 6), with a more realistic appearance, given that now the temporal ordering was included.

Regressions models for time series

Table 6

Dependent variable	Model used	Model Summary					Parameter Estimates			
		R Square	F	df1	df2	Sig.	Constant	b1	b2	b3
Dacia new	Quadratic	,776	159,079	2	92	,000	9147,638	-221,219	1,570	
Dacia registration	Cubic	,796	118,674	3	91	,000	3,808	1,675	-,041	,000
Dacia reenrollment	Exponential	,814	406,213	1	93	,000	17616,256	-,025		
Foreign new	Quadratic	,762	147,372	2	92	,000	21894,129	-514,940	3,552	
Foreign registration	Cubic	,156	5,614	3	91	,001	5405,282	1241,717	-31,732	,220
Foreign reenrollment	Cubic	,359	17,009	3	91	,000	13526,827	324,597	,007	-,038

For Dacia and foreign new cars the appropriate model was the Quadratic one: $\hat{y} = a + b_1 \cdot x + b_2 \cdot x^2$. For both equations the values of the coefficients b_1 are negative and the values of the coefficients b_2 are positive, which means that the values are decreasing in time but tend to return to normal.

To model Dacia reenrollment time series we can use an Exponential equation: $\hat{y} = a \cdot e^{bx}$. When the value of x increase with one, the value of y increase with the value of e^{bx} . The value of the coefficient a is positive which means that the model has an increasing slope. The value of the coefficient b is negative so we can say that we have an exponential but not too abrupt increasing of the values.

For Dacia and foreign registration cars and foreign reenrollment cars is appropriate to use Cubic models: $\hat{y} = a + b_1 \cdot x + b_2 \cdot x^2 + b_3 \cdot x^3$. For Dacia and foreign registration cars the value of the coefficient b_3 is positive which determine an increasing slope but for foreign reenrollment cars the value of the coefficient b_3 is negative and the slope of the model is decreasing.

The next step in our study is to determine the seasonality of the series. In table 7 we can see the seasonal factor. After this a new model of regression was computed for deseasonalized values of Dacia new cars as the dependent variable (table 8).

The seasonality factor for Dacia and foreign registered cars

Table 7

Month	Dacia new	Dacia registration	Dacia reenrollment	Foreign new	Foreign registration	Foreign reenrollment
January	1,29	1,14	1,13	1,17	1,16	0,95
February	1,20	1,05	1,07	1,18	1,10	0,92
March	0,93	0,96	1,08	1,05	1,03	0,90
April	1,24	1,09	1,03	1,12	1,18	1,15
May	1,23	1,19	1,18	1,17	1,25	0,95
June	1,19	1,10	1,15	1,25	1,41	1,24
July	0,72	0,87	0,95	0,83	0,91	1,00
August	0,56	0,97	0,99	0,66	0,88	1,03
September	0,68	1,12	1,06	0,76	1,08	1,06
October	0,95	1,10	0,94	0,96	0,88	0,99
November	1,01	0,71	0,83	0,97	0,68	0,88
December	1,10	0,95	0,87	1,01	0,62	0,90

Regression model for deseasonalized values of Dacia new cars

Table 8

Dependent variable	Model Summary			Parameter Estimates		
	R Square	F	Sig.	Constant	b1	t-stat
Dacia new	0,5942	133,29	1,6e-19	6754,05	-71,79	-11,54

Lastly, we have recurred to the analysis of autocorrelation (ACF) and partial autocorrelation (PACF) using a non-seasonal differentiating equal to 1 and maxim number of 16 lags.

For a comprehensive understanding of these results it is important to contextually ground the manner in which the Rabla program has influenced the registering trend, departing from the situation illustrated in sales trends in July 2007. The objective of this program was to support the national automobile industry (measured in our sample by the number of new registered Dacia cars). In assessing the effects, we see indeed, at a first glance, a decrease of the number of registered foreign cars and an increase of re-registered Dacia cars. However, this is a sort of false positive because the actually scope of the re-registration is only to obtain some vouchers. And this is further reflected by the sales increase of foreign cars.

DISCUSSION AND CONCLUSIONS

The size of the Romanian automobile industry is relative small compared to the main car producers in Europe and the world, but an analysis of its structure and dynamic appears to be most relevant given the strong linkages with the main macroeconomic indicators and important microeconomic variables at the level of the household.

Our research confirms that despite the somewhat ubiquitous multicollinearity, there is a significant impact of variables GDP, inflation and credits, explaining the general sales trends of Dacia and foreign cars. Not including a time component in the models leads to some very idyllic and non-realistic situations, characterized extremely high values of the coefficient of determination (in all our specified regression models), along with the autocorrelation of errors phenomenon. Thus, a time series analysis is more than a justified choice in terms of appropriate statistical procedures. The obtained results are less general, pointing out to specific trends for each component: for Dacia and foreign new cars the appropriate model was the Quadratic one, covering the variation of the dependent variable in percentage of 77.6%, respectively 72.2%, with negative b_1 coefficients and positive b_2 . In other words, the values are decreasing in time but they tend to return to normal. The Exponential models has the highest fit with the data Dacia reenrollment time series (81.4%), while the Cubic models, with significantly more modest results for the last two cases, were best descriptors for Dacia registration, foreign cars registration and foreign reenrollment cars.

Not last, a good proportion of understanding the national car market seems to fall also on the micro and contextual level analysis. The Rabla program implemented by the Romanian government needs a separate analysis itself in order to assess not only its economic efficiency, but also to unveil some of the hidden attitudes of the population when comparing national and foreign cars. We strongly believe that discussing upon the positional nature of foreign car (and identifying a proper measure of quantification) is not only a conceptual preoccupation but it may translate into an externality issue with significant implications for the response of consumer welfare to different environment policies.

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