

Modeling of Trend in Sales of New Passenger Vehicles in Poland Using the Arima-X-12 and Tramo-Seats Methods

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Abstract

The purpose of this article is to present development trends in sales of new passenger vehicles in Poland. The authors of the article suggest that this way of presenting sales results is incorrect. When decomposing the time series of the number of passenger car sales per seasonal component, the trend and accidental fluctuations and irregular fluctuations, it was proved that the analyzed phenomenon is more complex. In addition, it has been proved that the sale of new cars is a component of sales of passenger cars produced this year and sales of vehicles produced in the previous year, in which sales are characterized by different seasonality.

The monthly data from January 2013 to November 2018 were used to decompose the time series of sales of new passenger vehicles in Poland. The data from the Central Register of Vehicles and Drivers was made available. The ARIMA-X-12 and TRAMO-SEATS methods were used to decompose the analyzed time series.

Keywords

Time series, seasonality, vehicle sales, trend, TRAMO-SEATS, ARIMA-X-12, outliers

JEL code

C15, D24, O52, R40

INTRODUCTION

The available literature on the subject emphasizes that in the last decades in the field of motorization a very significant technological progress (Nolan, 2010) has been recorded. This process concerned both the global automotive industry and the countries of Eastern Europe. Almost all stages of motor vehicles production at that time introduced new, cheaper production technologies, which led to the current state, in which the car has become the goods available to almost every consumer (Kudlak et al., 2017).

Observations of market reality made by the authors of the article clearly show that in the trade press, as well as in the scientific literature, the sale of passenger vehicles is analyzed as the ratio of current sales

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to the result from the previous month and analogous to the month from the previous year. As the sale of new passenger vehicles, the number of new vehicles registered for the first time is presented (Prieto et al., 2013; Nolan, 2010; George et al., 2009; Klimkowska, 2012; Sołtysiak, 2015; Sryjakiewicz, 2015; Michalak and Merło, 2015; Mutrynowski, 2015).

Moreover, as the in-depth analysis of the available literature has shown, no such analyzes exist. The authors of the article suggest that this way of presenting sales results is incorrect. When decomposing the time series of the number of passenger car sales per seasonal component, the trend and accidental fluctuations and irregular fluctuations, it was proved that the analyzed phenomenon was more complex. In addition, it was proved that the sale of new cars was a component of sales of passenger cars produced this year and sales of vehicles produced in the previous year. It was demonstrated that these sales were characterized by varying seasonality. Therefore, presenting the considerations regarding the development trends of sales of new passenger vehicles in Poland seems to be the appropriate marking of the research problem, covering both sales trends and the selection of analytical tools and methods for analyzing and forecasting the sales volume of automotive products (and studies referring to this market, which makes the subject even more interesting and worth considering, in order to diagnose the correctness of steps taken in this matter (Urban, 2000; Grudkowska and Paśnicka, 2007).

The article has been divided into individual sections. Section 1 discusses and justifies the selection of ARIMA-X-12 and TRAMO-SEATS research methods. Section 2 draws attention to the essence of research issues, indicating at the same time the irregularities in the current method of analysis of vehicle sales in Poland. Section 3 presents the first results of research, analyzing seasonal trends and fluctuations. The conclusions and next steps are included in the summaries in the last part of this article.

The addressees of the presented research results are selected entities from the automotive and insurance market, including dealers of new vehicles, authorized service stations, leasing partners and insurance companies. In addition, the presented research can also be used by public administration bodies to forecast the future number of vehicles on the road.

1 METHODS

As the literature on the subject indicates, describing the time series, the trend of the studied phenomenon is identified, as well as the strength and trend of seasonal and accidental factors. Isolation of individual components can be done using mechanical or analytical methods. Mechanical methods (moving average methods and smoothing methods) smooth time series by removing seasonal fluctuations and outliers. When examining the development trends of economic phenomena, the trend and the occurrence of seasonal fluctuations are most often made (Fischer, 1995). Analytical methods are most frequently used to evaluate these components, which result in econometric models describing the evolution of the studied phenomenon over time. Irregular effects, outliers are often eliminated as those that distort the general level of the phenomenon (Dagum, 1980). These effects may, however, be a source of more accurate knowledge about the formation of the phenomenon. Analyzing the sales of new passenger vehicles in Poland, the authors used the following methods: TRAMO-SEATS and ARIMA-X-12.

The TRAMO-SEATS procedure and the ARIMA-X-12 procedure are methods that combine analytical and mechanical analysis of time series (Sax et al., 2018) These methods allow the analysis of non-stationary time series, unambiguous identification of the trend, seasonal and accidental fluctuations and allow to determine the nature of these fluctuations (Cabrero, 2000). The ARIMA-X-12 procedure was developed and is used by the United States Census Bureau. The TRAMO-SEATS procedure was developed by A. Maravell and V. Gomez in 1996. In both procedures, the ARIMA model is estimated, with the TRAMO-SEATS procedure matching the ARIMA model to each of the time series components when the ARIMA-X-12 procedure estimates such a model only for the original series. The smoothing process is also different. In the first method, the test results

determine the selection of the seasonal adjustment filters. In contrast, in the long-term method, ad hoc filters are used (Lian et al., 2018).

The TRAMO-SEATS and ARIMA-X-12 procedures identify seasonal effects when performing the Fredman test, the Kruskal-Wallis test (is one of the most popular alternatives to the one-way ANOVA variance analysis), the mobile seasonality test, the seasonally traceable test and the complex seasonality test (Dagum et al., 2016). Thanks to this, it is possible to identify seasonality and mobile seasonality, based on the evolution of the seasonal pattern in time. Testing is based on the isolated seasonal component (Baron et al., 2018).

The Friedman test, created by the American economist Milton Friedman, compares average levels over several periods. The null hypothesis of this test is: "*k different samples come from the same population*" or: "*k different samples come from several populations of equal average*." The studied series do not show seasonal fluctuations when there are no grounds to reject the null hypothesis (Friedman, 1940).

The Kruskal-Wallis test, like the Friedman test, examines whether the samples come from the same population. The test hypotheses are also consistent with the Friedman test hypotheses.

The mobile seasonality test is a two-factor analysis of variance of the SI component. The variance S^2 used in this test is divided into season-related S_b^2 variability, i.e. months or quarters, year-related S_m^2 variation, and intra-group variability S_s^2 . The null hypothesis of this test is that the seasonal pattern does not evolve over time.

The identifiable seasonality test verifies the null hypothesis that there is identifiable seasonality in the analyzed time series (Kruskal and Wallis, 1952).

The seasonality composite test is a procedure that verifies the hypothesis of the occurrence of seasonality in time series. This test is a combination of the Friedman test, Kruskal-Wallis test, mobile seasonality test and traceable seasonality. The result of a composite seasonality test is one of the following: there is identifiable seasonality, there is no seasonality, there is a low probability of identifiable seasonality.

As a result, it is possible to identify seasonal and mobile seasonality, consisting in the evolution of the seasonal pattern over time. Testing is based on a separate seasonal component (Enders, 2010). In this case, the various types of outliers analyzed concerned the number of newly registered passenger vehicles produced both in the current year and the previous year.

The calendar effects identified in the seasonal adjustment process are effect business days and the effect of movable holidays. The effect of working days is the effect of different number of working days in particular periods on the phenomenon studied. It is recognized that the activity of business entities is more intense on business days (Maravall et al., 2014). The effect of movable festivals concerns in particular the world of Easter and Corpus Christi and concerns the variable economic activity in the period of the Christmas celebrations. Christmas holidays (Muirhead, 1986) are not included in holiday effects.

The irregular component, which is extracted through the TRAMO-SEATS and ARIMA-X-12 procedures, are unusual and irregular effects, such as random or unpredictable factors. Atypical observations are impulses that may have different character (Muirhead, 1986), Additive Outliers (one-off, significant variations from the expected value of the studied phenomenon, which does not affect the value in subsequent periods), Level Shift (permanent change in the level of the variable), Temporary Change (temporary change of the variable level and return to the initial level, usually in accordance with the exponential or linear function) and Innovation Outliers (innovative impulses caused, for example, by the use of new production technology, resulting in a change of the entire process generating data, including changing the form of the trend) (Cabrero, 2000).

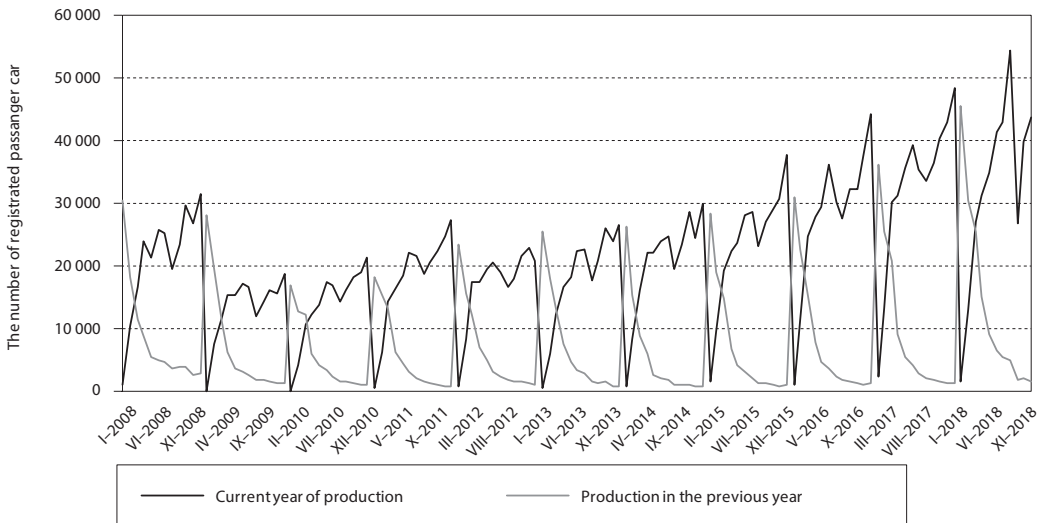
Comparing the TRAMO SEATS procedure and the ARIMA-X-12 procedure, it can be concluded that in the first of them there were more comprehensive possibilities of automatic seasonal adjustments methods. This procedure, like the ARIMA-X-12, provides decomposition of the multiplicative and additive time series and comprehensive model identification. However, the procedure for detecting outliers is different.

TRAMO automatically detects individual types of atypical observations in the form of transient changes (Ghysels and Osborn, 2010). Other types of outliers, i.e. long-lasting (LS) and one-time (AO), are detected as in ARIMA X-12. As a result, a non-standard observation may be classified differently depending on the procedure (Atuk and Ural, 2002). It does not change the fact that these methods are commonly used by almost all statistical offices in the world (Sax and Eddebuettel, 2018). Calculations were made using the package DEMETRA + (Grudkowska, 2011).

2 DATA

Previous analyzes of sales of new passenger vehicles in Poland, appearing in industry press, general internet websites, as well as in scientific literature, usually refer to the number of newly registered passenger vehicles in Poland in total and broken down into the most popular car brands. An example is the reports of the Polish Association of the Automotive Industry, in which data from the Central Register of Vehicles and Drivers is presented. Analyzing such data, the authors of this article consider it incorrect. According to the principles of statistics, one should analyze collections of a uniform nature. The set of the number of newly registered vehicles is not a homogeneous set in terms of the tested feature, because under the name "newly registered" there are vehicles registered for the first time and from the current production as well as from the production of the previous year. This approach is considered incorrect by the authors, pointing to the need to analyze these data divided into two subsets: newly registered passenger vehicles from current production and newly registered passenger cars produced in the previous year. Such data were obtained directly from the Central Register of Vehicles and Drivers, which records all vehicles moving around Poland, as well as records issued documents entitling to drive vehicles. The data obtained are monthly data from the period from January 2008 to November 2018. The study did not include December 2018 due to the fact that the vehicles registration in the database systems has changed.

Figure 1 Sales of new passenger cars in the current and previous year production in Poland in 2008–2018



Source: Own study based on CEPIK data

At the beginning of the surveyed period, in January 2008, the total number of newly registered vehicles in Poland was 32 000, with 95% of that number being sales of vehicles from production in 2007.

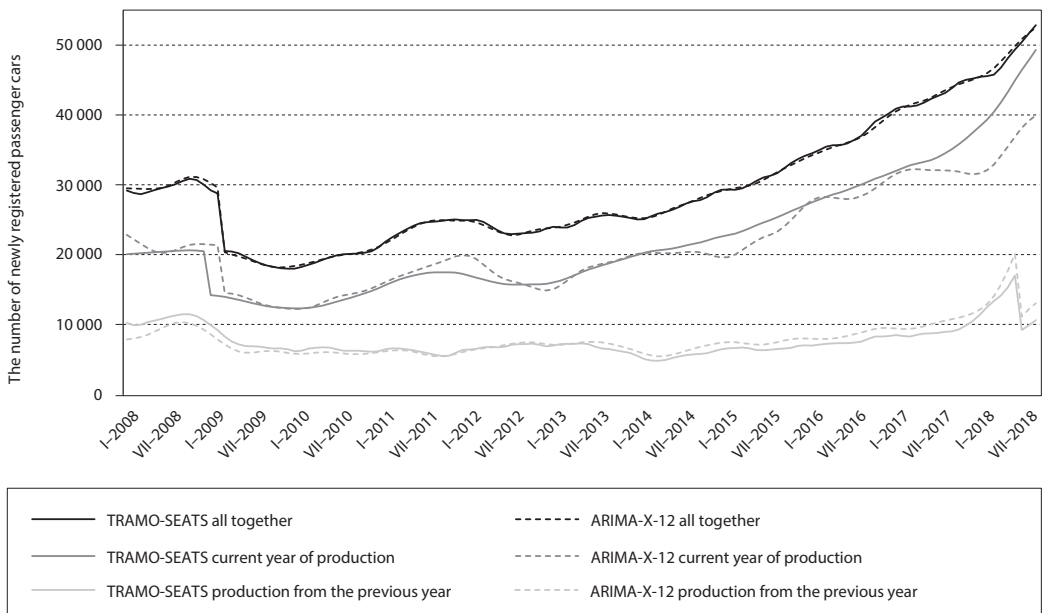
In December 2008, total sales amounted to approximately 35 000 vehicles, of which nearly 95% were sales of vehicles manufactured in the current year. In the following years, the situation was analogous. The share of newly registered vehicles from current production was small at the beginning of the year and then increased, reaching the maximum at the end of the year. The number of newly registered vehicles from production from the previous year was the reverse. The share of these vehicles represented a large share of the total number of newly registered passenger vehicles at the beginning of the year and decreased, reaching a minimum at the end of the year. It is noticeable, therefore, that the occurring fluctuations may indicate the occurrence of seasonality, different for cars from current production and from the previous year. In addition to seasonal fluctuations, an upward trend is visible (see Figure 1).

3 RESULTS AND DISCUSSION

3.1 Trend

The use of the TRAMO-SEATS and ARIMA-X-12 procedures allowed for the decomposition of the time series of the number of newly registered passenger vehicles in Poland. Firstly, the seasoned trend component was obtained (see Figure 2). As can be seen in the chart below, the number of newly registered passenger vehicles in total, vehicles registered and produced in the same year as well as vehicles manufactured in the previous year, were characterized by an increasing trend. However, a significant drop is noticeable at the beginning of 2009. Such a sharp drop in sales was a nipple of reaching the Polish global crisis. This decrease is relatively larger in the case of sales of new vehicles manufactured in the current year than in the case of vehicles from the previous year. The decrease translated into the overall result of sales of new passenger vehicles. However, in the case of the number of newly registered passenger vehicles from production from the previous year, a sudden increase is noticeable, followed by a decrease at the end of 2018. This was influenced by the introduction

Figure 2 The trend of the number of newly registered passenger vehicles in Poland in 2008–2018



Source: Own study based on CEPIK data

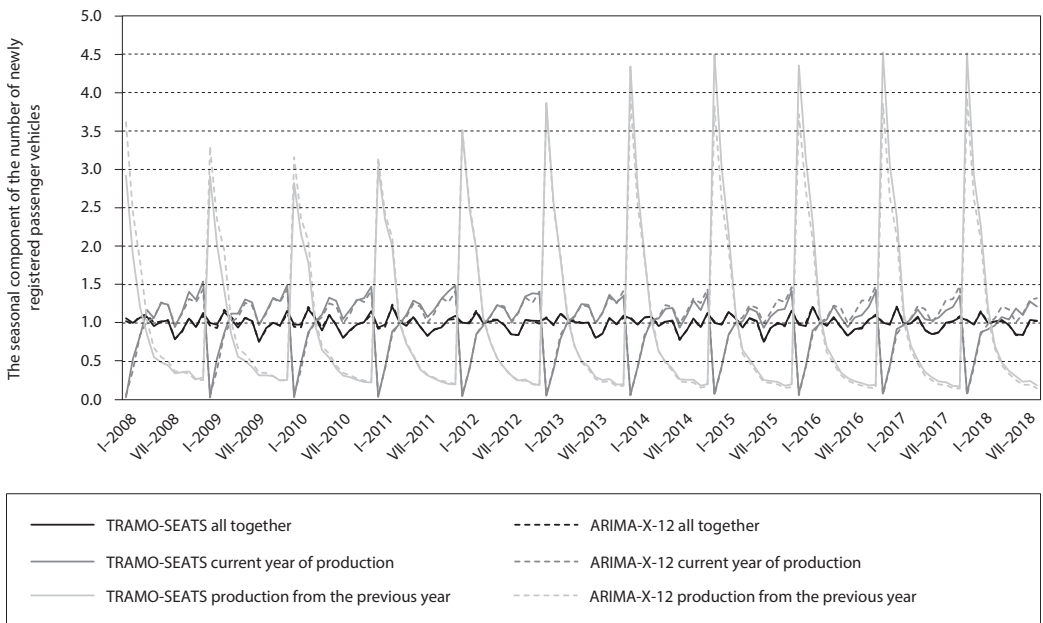
of the "worldwide harmonized light vehicle test procedure", i.e. procedures for fuel consumption, carbon dioxide and exhaust emissions standards.

The results obtained by using both procedures TRAMO-SEATS and ARIMA-X-12 were very similar in the case of the total number of newly registered passenger vehicles and in the case of new passenger vehicle registrations from the previous year production. Differences between the trend estimates occurred in the number of newly registered vehicles from current production.

3.2 Seasonality

Many of the effects is not only the trend and random fluctuations, but also a certain seasonality. It was assumed that the seasonal fluctuations are independent of the level assumed by the time series. The isolated seasonal component of the number of newly registered vehicles in Poland shows variations from the trend. Values below 1.0 indicate a decrease in the number of newly registered vehicles in relation to the trend. Values above 1.0 mean an increase in the number of newly registered vehicles. As can be seen (Figure 3), the higher values of variations from the trend were characterized by sales of passenger vehicles from current production. In addition, the decline in sales of passenger vehicles from current production was matched by the increase in sales of vehicles manufactured in the previous year. This indicates the occurrence of a different seasonality.

Figure 3 The seasonal component of the number of newly registered passenger vehicles in Poland in 2008–2018



Source: Own study based on CEPIK data

Occurrence of seasonality was confirmed by statistical tests (see Table 1). The results of both the Friedman test and the Kruskal-Wallis test indicate statistically significant differences between the average levels of the number of newly registered vehicles in individual months. This applies to both the general number of newly registered passenger vehicles as well as the sale of vehicles manufactured in the current year and produced in the previous year. The results of the seasonality test indicate,

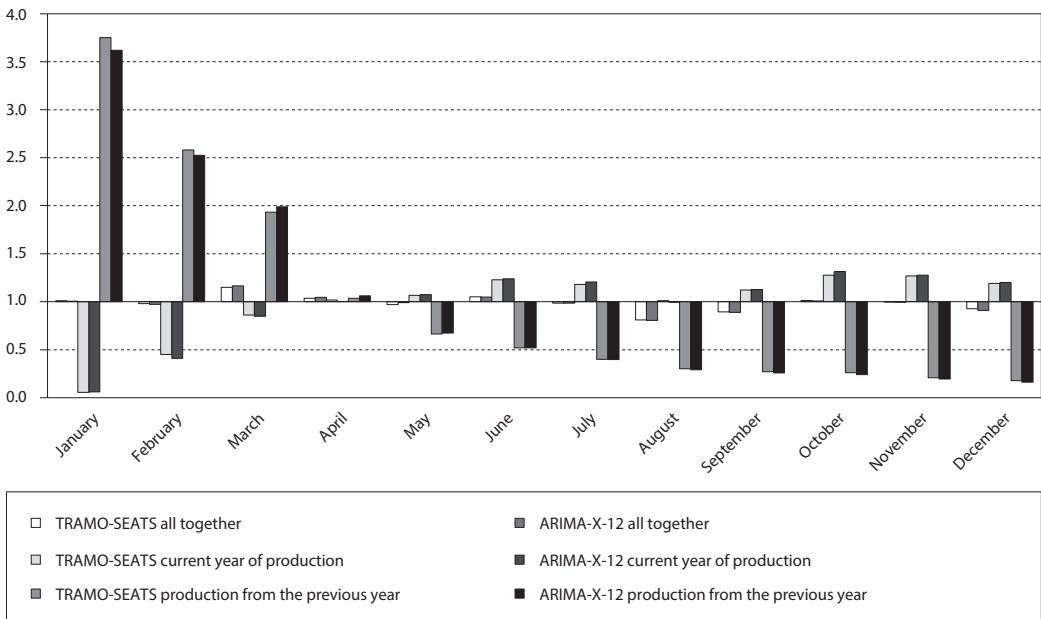
on the other hand, the evolution of the seasonal pattern over time, in the case of the total number of newly registered passenger vehicles – both for the value of the seasonal component extracted by the TRAMO-SEATS and ARIMA-X-12 procedures. Changes to the seasonal pattern were not found for newly registered vehicles manufactured in the previous year. As for the sale of passenger vehicles from the current year, different results were obtained using TRAMO-SEATS and ARIMA-X-12 procedures.

Table 1 Results of statistical tests of seasonality of newly registered passenger vehicles in Poland in 2008–2018

T – TRAMO-SEATS A – ARIMA-X-12		Friedman Test	Kruskal-Wallis Test	Evolutionary Seasonality Test
		F-statistic		
Newly registered vehicles in total	T	43.4023***	107.2579***	0.2755
	A	101.4514***	62.3837***	0.1383
Newly registered vehicles from current production	T	144.5800***	113.5749***	4.2080***
	A	154.3249***	122.5364***	1.5453
Newly registered vehicles from the previous year's production	T	1 028.9032***	124.9036***	3.6385***
	A	996.4687***	121.4024***	5.7494***

Note: Statistical significance at the level *** – 0.001, ** – 0.05, * – 0.10.
Source: Own study based on CEPIK data

Figure 4 The average deviation of the seasonal component of newly registered passenger cars in Poland in the years 2008–2018



Source: Own study based on CEPIK data

Analyzing the average monthly variations of the seasonal component (see Figure 4), it is possible to confirm the previously observed regularity, that increases in the registration of new vehicles produced in the current year correspond to the decrease in the number of passenger vehicle registrations produced in the previous year. Seasonal variations of new vehicle registrations were the biggest for vehicles manufactured in the previous year. Their sales increased the most (in relation to the trend) at the beginning of the year, when sales of yearbooks continue (first quarter) and then decreased until the end of the year. In the case of sales of new vehicles manufactured in the current year, sales increases were recorded in the second half of the year, and declines in the first quarter. However, variations from the trend in this case were much smaller. Seasonal fluctuations in the sales of vehicles from current production and production from the previous year translated into the seasonality of sales of new vehicles in total, characterized by an increase in sales in March and a drop in sales in particular in the months of August, September and December.

3.3 Outliers

The development of the studied phenomenon in time is not only a trend and seasonal fluctuations, but also outliers will result from random events, legislation, etc. TRAMO-SEATS and ARIMA-X-12 procedures allow for seasoning time series and identifying outliers along with the determination of their character. The largest amount of outliers was characterized by the sale of new vehicles manufactured in the current year. Using the TRAMO-SEATS procedure, 8 outliers were distinguished, their character and the moment of occurrence being different. Only for September 2018 the results of both procedures indicated a temporary change. It is difficult to determine which of the procedures distinguished outliers better. At present, it is difficult to clearly determine which events influenced individual outliers (Were these changes legislation also changes related to exhaust gas reduction standards?).

The number of newly registered passenger vehicles manufactured in the previous year was characterized by two unusual observations – in the case of the TRAMO-SEATS procedure and one – in the case of the ARIMA-X-12 procedure. The results of both procedures indicated a change in the trend level in September 2018, which was already signaled in (see Figure 2). In July and August 2018 there was a significant increase in the number of newly registered vehicles, after which a decline was noted. The effect of the increase in sales was caused by the announcement of changes in legislation regulating the possibility of deducting in full the purchase costs (leasing) of vehicles by entrepreneurs. This caused that entrepreneurs wishing to take advantage of the existing possibility of deducting the full leasing installment for the purchased vehicle, accelerated their purchasing decisions.

Outliers identified for the number of newly registered passenger cars from current production and produced in the previous year, have not translated into identifying the same outliers for the total number of newly registered passenger vehicles. For this time series, a change in the trend level

Table 2 Outlier values of the number of newly registered passenger vehicles in Poland in 2008–2018

Date / Method		Total number of vehicles	Production vehicles from the year under analysis	Production vehicles from the previous year
2008-01	T	-	AO	-
	A	-	-	-
2008-02	T	-	-	-
	A	-	LS	-

Table 2

(continuation)

Date / Method T – TRAMO-SEATS A – ARIMA-X-12		Total number of vehicles	Production vehicles from the year under analysis	Production vehicles from the previous year
2009-01	T	-	LS	-
	A	-	AO	-
2009-03	T	LS	-	-
	A	LS	LS	-
2010-01	T	-	-	-
	A	-	AO	-
2010-02	T	-	AO	-
	A	-	-	-
2011-01	T	-	AO	-
	A	-	-	-
2012-01	T	-	TC	-
	A	-	-	-
2014-04	T	-	-	AO
	A	-	-	-
2015-01	T	-	-	-
	A	-	TC	-
2016-01	T	-	AO	-
	A	-	-	-
2017-01	T	-	-	-
	A	-	AO	-
2018-01	T	-	TC	-
	A	-	-	-
2018-08	T	AO	-	-
	A	AO	AO	-
2018-09	T	TC	TC	LS
	A	TC	TC	LS

Note: LS – Level Shift, TC – Temporary Change, AO – Additive Outliers.

Source: Own elaboration based on CEPIK data

in March 2009 was distinguished, a one-off shock in August 2018 and a temporary change in September 2018. These values were identified using both seasonal methods procedures: TRAMO-SEATS and ARIMA-X-12. The values, which were identified for 2018, reflect the reaction of buyers to the announcement of changes in legislation limiting the possibility of including in the costs of business the full leasing installment for the purchase of a vehicle.

3.4 Calendar Effects

An extraordinary advantage of using the procedures TRAMO-SEATS and ARIMA-X-12 is the ability to identify the effects of the calendars. These effects include the Easter Effect, which in the case of the number of newly registered vehicles in Poland has not been identified. Analysis made by the authors, however, allowed to the Week Days Effect, which is also a calendar effect. It is interesting because the effect, although it concerns days of the week, is identifiable on the basis of monthly data. No daily data is needed to identify this effect, as both procedures are based on calendars with working days, fixed and movable holidays. Comparing the number of working days and counting individual days of the week in each of the analyzed months, a decision is made about the occurrence of the tested effect. In the case of the total number of newly registered vehicles, a statistically significant increase in sales on Tuesdays (assuming a significance level of 0.05) and on Fridays and statistically significantly reduced

Table 3 Week Days effect of the number of newly registered passenger vehicles in Poland in 2008–2018

Day of the week / Method T – TRAMO-SEATS A – ARIMA-X-12		Total number of vehicles	Vehicles from production from the previous year
		Parameter – Value	
Monday	T	-0.0193	0.0180
	A	-0.0193	0.0043
Tuesday	T	0.0285**	0.0159*
	A	0.0301**	0.0270*
Wednesday	T	0.0169	0.0087
	A	0.0147	0.0116
Thursday	T	0.0050	0.0115
	A	0.0050	0.0080
Friday	T	0.0233**	0.0121
	A	0.0232**	0.0117
Saturday	T	-0.0376***	-0.0354**
	A	-0.0369***	-0.0377**
Sunday	T	-0.0167	-0.0307**
	A	-0.0167	-0.0250*

Note: Statistical significance at the level *** – 0.001, ** – 0.05, * – 0.10.

Source: Own study based on CEPIK data

on Saturdays was identified. In the case of the number of newly registered vehicles from production from the previous year, a statistically significant reduced sale was observed for Saturdays and Sundays. The sale of new vehicles from current production was not characterized by the occurrence of the week days effect.

CONCLUSION

The authors of the article hypothesized that analyzing the sale of new vehicles in Poland in total, without taking into account the year of production of the vehicle, was incorrect. In order to verify the hypothesis they analyzed data on the number of newly registered passenger cars in Poland in general, and by the year registered vehicle. New vehicles, new ones are vehicles that have been registered for the first time. As new, vehicles registered and manufactured in the same year as well as vehicles registered for the first time but produced in the previous year were included. The monthly data necessary to verify the research hypothesis was obtained from the Polish Central Register of Vehicles and Drivers. The data covered the years 2008–2018. To verify the hypothesis, the TRAMO-SEATS and ARIMA-X-12 methods were used, allowing the distribution of time series for trends, seasonal, irregular and random components.

Based on the results of the time series decomposition, it was found out that the total number of new vehicle sales in Poland increased. The sales of new vehicles, produced in the current year and produced in the previous year also increased. Seasonality have confirmed its occurrence. However, the nature of seasonality was different. Sales of new cars produced this year were the smallest at the beginning of the year and increased towards the end of the year. This was the result of high vehicle prices at the beginning of the year. Available reports and studies indicate that this relationship also occurred in vehicle sales in January 2019 (PZPM, 2019). The sales of vehicles manufactured in the previous year were reversed. The number of sales of these vehicles was the highest at the beginning of each year and decreased with the passage of time, making the slightest deviation from the trend towards the end of the year. During this period, the year, the vehicles are sold at a reduced price. Experts estimate that depending on the model and brand, it can range from 4% to even 25%. Seasonal fluctuations in vehicle sales by year of production influenced the shape of seasonal variations of total vehicle sales, which was characterized by positive seasonal variations in March and negative in August and September. This change was affected, among others, by changes in legislation. In addition, outliers were found, with the lowest observed for the sales of vehicles manufactured in the previous year and the highest for the sale of vehicles from the current production. Performed analyzes also allowed to identify The Weekday Effect (on Tuesdays and Fridays). Increased vehicle sales occurred on Tuesdays, and decreased on weekends. This is also confirmed by the research made by other authors (Nolan, 2010).

The differences observed in the trends in sales of new passenger cars in Poland, produced in the year of registration and in the previous year, allow for a positive verification of the hypothesis. Sales of passenger vehicles in Poland should not be presented in general, but divided into the year of vehicle production.

Summing up the presentation, considerations regarding new vehicle sales trends in Poland do not fully exhaust the essence of the issue but provide the basis for further analysis and research in order to use statistical methods in the process of identifying determinants affecting the number of new vehicle sales in Poland as well as other in Eastern European countries such as Romania, Bulgaria and the Czech Republic.

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