Correlation between Car Sales and the GDP in EU Countries with Focus on the Impact of Covid Pandemics

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Abstract. The present paper deals with the sales of passenger cars and light utility vehicles in relationship to the GDP of EU countries. This relationship is evaluated with the correlation coefficient. A maximum period of up to 20 years is considered at first stage. In the second step the correlation is evaluated over a 10-year period prior to the Covid pandemics. The pandemics hit the EU countries in 2020. Therefore, the correlation is finally evaluated over a 10-year period including the year 2020. This paper studies the impact of a major external negative factor on the evolution of car sales across EU countries while considering their GDP.

Keywords: car sales, passenger cars, light utility vehicles, correlation, pandemics, Covid-19

JEL classification: *M21, L25, L21*

1   Introduction

Car sales represent an important part of the global economy, and they maintain their importance on the EU market. During the financial crisis in 2008, incentives were put in place across the EU countries to support their sales and to maintain the automotive industry in good shape. This paper focuses on the correlation between the car sales and the Gross Domestic Product of EU countries. The objective is to study the link between the two indicators in relationship to a negative external influence represented by the Covid-19 pandemics that hit the EU first in 2020.

The link between the car sales and the GDP is evaluated with the correlation coefficient. The EU countries represent an economic group with various internal performances. Therefore, it's likely that the car sales evolve differently in reaction to an external factor such as the pandemics. The present paper will monitor this evolution and look for findings that can be used for managerial actions.

2   Methodology

Data from several sources were processed to achieve an overview of the car sales and the economic performance in terms of GDP in EU countries.

At the first stage the data on the Gross domestic product (GDP) were processed. The GDP was considered at market prices. It is the result of the production activity of resident producer units. It is defined as the value of all goods and services produced less the value of any goods or services used in their creation. The ESA 2010 (European System of Accounts) regulation may be referred to for more specific explanations on methodology. Data are presented in million units of national currency. No conversion to a single currency such as Euro was done. Institutional source of the data analysed in this paper is Eurostat. The data is presented on annual basis. [15]

Countries considered: Belgium, Bulgaria, Czechia, Denmark, Germany (until 1990 former territory of the FRG), Estonia, Ireland, Greece, Spain, France, Croatia, Italy, Cyprus, Latvia, Lithuania, Luxembourg, Hungary, Malta, Netherlands, Austria, Poland, Portugal, Romania, Slovenia, Slovakia, Finland, Sweden. The data was downloaded from the database located at ec.europa.eu/eurostat/databrowser.

Data used for analysing the car sales in the mentioned countries were sourced at a database located on carsalesbase.com. [14] Information regarding total passenger and light utility vehicles are present over a period starting frequently from the year 1995. Data on Cyprus, Estonia and Malta were not present in a complete manner suitable for the present paper. Therefore, these countries were excluded from this overview. The data from Eurostat were not used as they didn't reach up to the year 2020 at the time of the creation of this paper. The data obtained from the above source is used throughout this paper.

The correlation coefficient is a numerical value of correlation. It means a statistical relationship between two variables. The variables may be two columns of a given data set of observations, or two components of a multivariate random variable with a known distribution. [17]

Several types of correlation coefficient exist. They all assume values in the range from −1 to +1. The value ±1 indicates the strongest possible agreement. 0 represents the strongest possible disagreement. As tools of analysis, correlation coefficients present certain problems. Correlation should not be incorrectly interpreted as it does not imply causation.[17]

As much as the correlation coefficient is closer to +1 or -1, it indicates positive (+1) or negative (-1) correlation between the arrays analysed. Positive correlation means that if the values in one array are increasing, the values in the other array increase as well. [16] The equation for the correlation coefficient is:

Equation

$$Correl(X,Y) = \frac{\sum (x-\bar{x})(y-\bar{y})}{\sqrt{\sum (x-\bar{x})^2 \sum (y-\bar{y})^2}}$$

Fig. 1. Formula of the correlation coefficient [16]

In this formula $\bar{x}$ *and* $\bar{y}$ are the sample means average of array1 and average of array2 respectively.

There is no clear definition of correlation values that define the strength of a correlation. Only the extreme values of -1, 0 and 1 are given. For the purposes of this article a strong correlation is the one with absolute value over 0,75. A week medium correlation is between 0,25 and 0,75. A week correlation is below 0,25. Data in the present paper are evaluated accordingly. The positive correlation is valid for values over 0 and negative bellow 0.

Table 1. Interpretation of absolute correlation values for purposes of the present paper

From	To	Correlation type
1	0,75	Strong
0,75	0,25	Medium
0,25	0	Weak

Table 2. Interpretation of correlation values

| From	To	Correlation type
1	0	positive
0	0	no correlation
0	-1	negative

3 Results and Discussion

In the first stage a general overview show how car sales (passenger cars and light commercial vehicles) were changed between 2019 and 2020. This is shown in the following table.

Table 3. Volume of car sales before the pandemics and in its first year

Year	Passenger Cars	Light Commercial	Sales
2019	12990239	1743145	14733384
2020	9913698	1434561	11348259
Change	76%	82%	77%

A drop in volumes is visible between these 2 years. The impact was stronger on the passenger cars and weaker on the light commercial vehicles. It must be noted that the utility vehicles represent a much smaller volume in unitary sales. Therefore, their overall impact on the total sales of these two groups is relatively smaller. In most economies the total car sales closely follow the sales of passenger cars.

The EU market is composed of 27 countries. 24 of them were subject to analysis. A pareto analysis of share of each member country in the total volume of car sales shows the dominance of Germany, France, and Italy as the largest markets. Further markets are smaller while half of the countries analysed represent less than 2% of the total market.
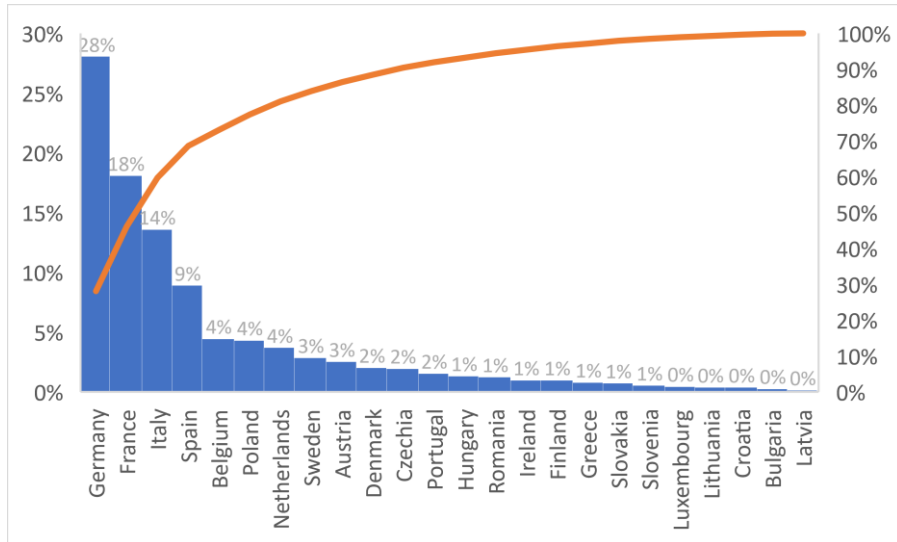
Fig. 2. Pareto analysis of the EU car sales volumes in 2020

The following overview shows how the cars sales and the GDP changed between 2019 and 2020.

Table 4. Change of car sales and GDP per country at the in 2020 compared to 2019

Country	Passenger Cars	Light Commercial Veh.	Sales	GDP
Austria	76%	84%	77%	95%
Belgium	78%	88%	80%	96%
Bulgaria	63%	85%	66%	100%
Croatia	57%	76%	59%	92%
Czechia	81%	84%	81%	98%
Denmark	88%	94%	89%	100%
Finland	84%	87%	85%	99%
France	75%	84%	76%	95%
Germany	81%	88%	81%	97%
Greece	71%	87%	72%	90%
Hungary	81%	84%	82%	102%
Ireland	75%	86%	77%	105%

Country	Passenger Cars	Light Commercial Veh.	Sales	GDP
Italy	72%	85%	73%	92%
Latvia	76%	78%	76%	96%
Lithuania	87%	66%	85%	101%
Luxembourg	82%	87%	83%	102%
Netherlands	80%	79%	80%	98%
Poland	77%	85%	78%	102%
Portugal	65%	72%	66%	93%
Romania	78%	81%	78%	100%
Slovakia	75%	75%	75%	98%
Slovenia	73%	60%	71%	97%
Spain	68%	74%	69%	90%
Sweden	82%	58%	79%	100%

The market of Passenger Cars was the least impacted in Denmark where it reached 0,88 of 2019 sales. This market was the most impacted in Croatia where it reached 0,57 of 2019 sales.

The market of Light Commercial Vehicles was the least impacted in Denmark where it reached 0,94 of 2019 sales. This market was the most impacted in Sweden where it reached 0,58 of 2019 sales.

The market of Total Car Sales was the least impacted in Denmark where it reached 0,89 of 2019 sales. This market was the most impacted in Croatia where it reached 0,59 of 2019 sales.

The GDP was the least impacted in Ireland where it reached 1,05 of its 2019 value. The GDP was the most impacted in Spain where it reached 0,9 of its 2019 value.

A more detailed analysis is carried out on these countries in the central European region. Austria, Czech Republic (addressed by the Eurostat as Czechia), Slovakia, Poland and Hungary. These markets have different properties. While the Polish market is relatively large, the Austrian market has more history without a centrally managed economy. Czech, Slovak, and Hungarian markets are small however they behave differently.
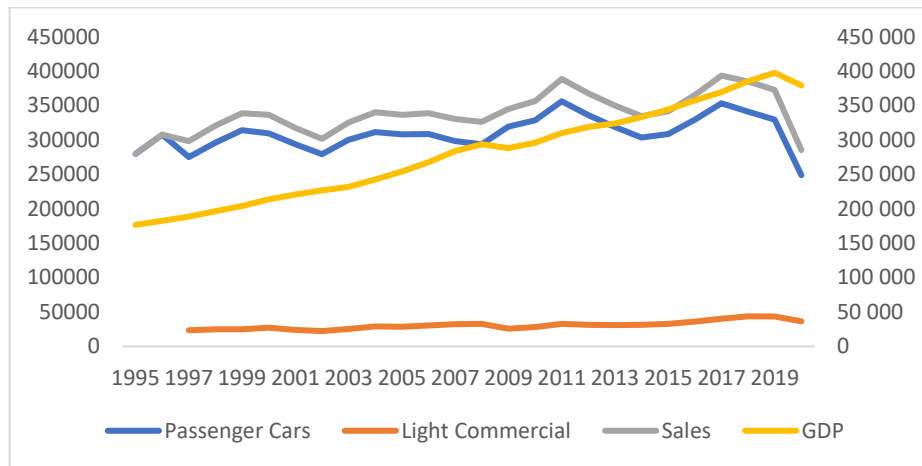
3.1   Austria

The correlation between the GDP and sales of Passenger Cars in Austria in the pre-pandemic years between 2019 and 2000 can be described as positive with medium strength with a correlation at the level of 0,66. For the Light Commercial vehicles in the same period the correlation is positive with strong strength and a correlation of 0,89. The total car sales in Austria during this period have strong and positive correlation at the level of 0,76.

A more specific analysis of the correlation between the GDP and car sales is done in the period of 10 years prior to the Covid pandemics. During this timeframe Passenger Cars had a positive and weak correlation with value of 0,11. The Light Commercial

vehicles had a positive and strong correlation at the level of 0,95. The car sales in Austria had a in general a positive and medium correlation at the level of 0,35.

A third step of the analysis focuses on the correlation between sales and the GDP in a 10-year period while the last year of that period is 2020 i.e., the first year of the Covid 19 pandemics. This adjusted period shows the following results. For Passenger Cars the correlation is weak and negative at the level of -0,21. Regarding the Light Commercial vehicles, the correlation is positive and strong with value of 0,91. Total car sales in relationship with the GDP had a negative and weak correlation with a value of -0,06.

Including the first year of Covid pandemics had the following impact on the correlation between car sales and GDP: Passenger Cars changed by -0,32, the Light Commercial vehicle sales by -0,05 and the total sales by -0,42.

Fig. 3. Evolution of car sales and GDP in Austria
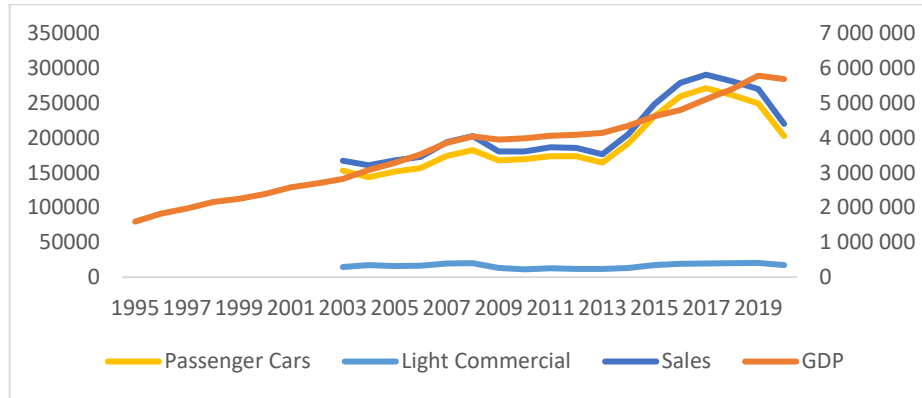
3.2   Czechia

The correlation between the GDP and sales of Passenger Cars in Czechia in the pre-pandemic years between 2019 and 2003 can be described as positive with strong strength with a correlation at the level of 0,9. For the Light Commercial vehicles in the same period the correlation is positive with medium strength and a correlation of 0,44. The total car sales in Czechia during this period have strong and positive correlation at the level of 0,89.

A more specific analysis of the correlation between the GDP and car sales is done in the period of 10 years prior to the Covid pandemics. During this timeframe Passenger Cars had a positive and strong correlation with value of 0,87. The Light Commercial vehicles had a positive and strong correlation at the level of 0,93. The car sales in Czechia had a in general a positive and strong correlation at the level of 0,88.

A third step of the analysis focuses on the correlation between sales and the GDP in a 10-year period while the last year of that period is 2020 i.e., the first year of the Covid 19 pandemics. This adjusted period shows the following results. For Passenger Cars the correlation is medium and positive at the level of 0,69. Regarding the Light Commercial

102

vehicles, the correlation is positive and strong with value of 0,85. Total car sales in relationship with the GDP had a positive and medium correlation with a value of 0,7.

Including the first year of Covid pandemics had the following impact on the correlation between car sales and GDP: Passenger Cars changed by -0,19, the Light Commercial vehicle sales by -0,08 and the total sales by -0,18.

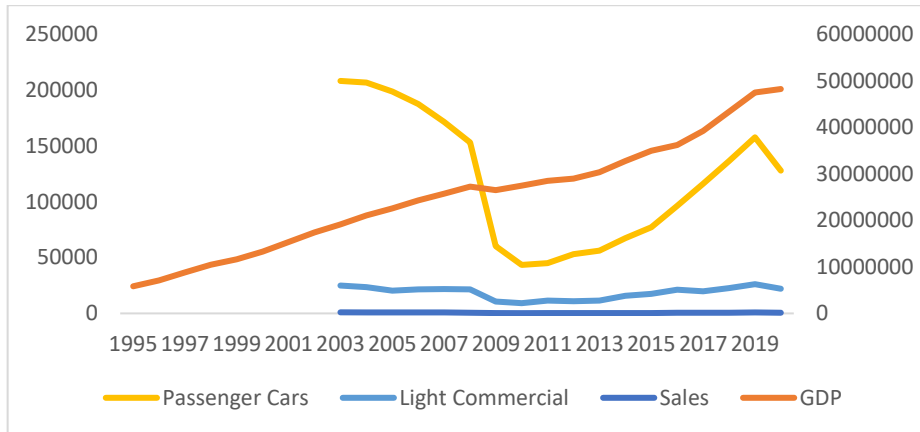**Fig. 4.** Evolution of car sales and GDP in Czechia

3.3   Hungary

The correlation between the GDP and sales of Passenger Cars in Hungary in the pre-pandemic years between 2019 and 2003 can be described as negative with medium strength with a correlation at the level of -0,28. For the Light Commercial vehicles in the same period the correlation is positive with weak strength and a correlation of 0,15. The total car sales in Hungary during this period have weak and negative correlation at the level of 0,24.

A more specific analysis of the correlation between the GDP and car sales is done in the period of 10 years prior to the Covid pandemics. During this timeframe Passenger Cars had a positive and strong correlation with value of 0,99. The Light Commercial vehicles had a positive and strong correlation at the level of 0,96. The car sales in Hungary had a in general a positive and strong correlation at the level of 1.

A third step of the analysis focuses on the correlation between sales and the GDP in a 10-year period while the last year of that period is 2020 i.e., the first year of the Covid 19 pandemics. This adjusted period shows the following results. For Passenger Cars the correlation is strong and positive at the level of 0,96. Regarding the Light Commercial vehicles, the correlation is positive and strong with value of 0,92. Total car sales in relationship with the GDP had a positive and strong correlation with a value of 0,96.

Including the first year of Covid pandemics had the following impact on the correlation between car sales and GDP: Passenger Cars changed by -0,03, the Light Commercial vehicle sales by -0,04 and the total sales by -0,03.

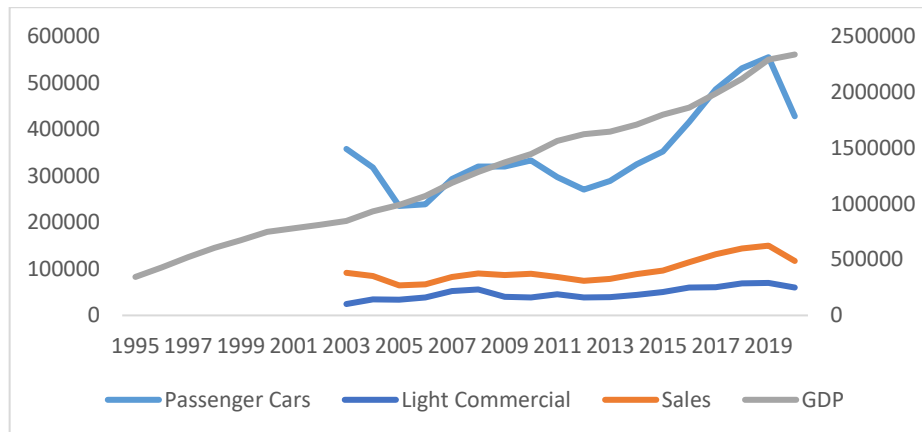**Fig. 5.** Evolution of car sales and GDP in Hungary

3.4   Poland

The correlation between the GDP and sales of Passenger Cars in Poland in the pre-pandemic years between 2019 and 2003 can be described as positive with strong strength with a correlation at the level of 0,75. For the Light Commercial vehicles in the same period the correlation is positive with strong strength and a correlation of 0,82. The total car sales in Poland during this period have strong and positive correlation at the level of 0,78.

A more specific analysis of the correlation between the GDP and car sales is done in the period of 10 years prior to the Covid pandemics. During this timeframe Passenger Cars had a positive and strong correlation with value of 0,93. The Light Commercial vehicles had a positive and strong correlation at the level of 0,94. The car sales in Poland had a in general a positive and strong correlation at the level of 0,93.

A third step of the analysis focuses on the correlation between sales and the GDP in a 10-year period while the last year of that period is 2020 i.e., the first year of the Covid 19 pandemics. This adjusted period shows the following results. For Passenger Cars the correlation is strong and positive at the level of 0,87. Regarding the Light Commercial vehicles, the correlation is positive and strong with value of 0,87. Total car sales in relationship with the GDP had a positive and strong correlation with a value of 0,87.

Including the first year of Covid pandemics had the following impact on the correlation between car sales and GDP: Passenger Cars changed by -0,06, the Light Commercial vehicle sales by -0,08 and the total sales by -0,06.

104

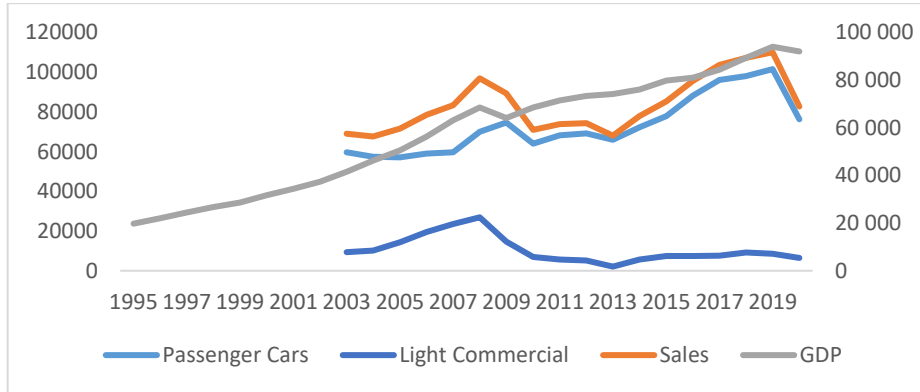**Fig. 6.** Evolution of car sales and GDP in Poland

3.5 Slovakia

The correlation between the GDP and sales of Passenger Cars in Slovakia in the pre-pandemic years between 2019 and 2003 can be described as positive with strong strength with a correlation at the level of 0,87. For the Light Commercial vehicles in the same period the correlation is negative with medium strength and a correlation of 0,35. The total car sales in Slovakia during this period have medium and positive correlation at the level of 0,73.

A more specific analysis of the correlation between the GDP and car sales is done in the period of 10 years prior to the Covid pandemics. During this timeframe Passenger Cars had a positive and strong correlation with value of 0,96. The Light Commercial vehicles had a positive and medium correlation at the level of 0,67. The car sales in Slovakia had a in general a positive and strong correlation at the level of 0,95.

A third step of the analysis focuses on the correlation between sales and the GDP in a 10-year period while the last year of that period is 2020 i.e., the first year of the Covid 19 pandemics. This adjusted period shows the following results. For Passenger Cars the correlation is strong and positive at the level of 0,78. Regarding the Light Commercial vehicles, the correlation is positive and medium with value of 0,69. Total car sales in relationship with the GDP had a positive and strong correlation with a value of 0,79.

Including the first year of Covid pandemics had the following impact on the correlation between car sales and GDP: Passenger Cars changed by -0,18, the Light Commercial vehicle sales by 0,02 and the total sales by -0,16.

Fig. 7. Evolution of car sales and GDP in Poland

The following overview shows mostly positive correlation between the GDP and the car sales. In Hungary the correlation is quite weak. In Slovakia there seems to be some anomaly on the market.

Table 5. Correlation between GDP and car sales over 20 years before the Covid pandemics for Austria, over a 17-year period for remaining countries

Country	Passenger Cars	Light Commercial	Sales
Austria	0,66	0,89	0,76
Czechia	0,90	0,44	0,89
Hungary	0,09	-0,06	0,09
Poland	0,75	0,82	0,78
Slovakia	0,87	-0,35	0,73

During a shorter, 10 years period prior to the Covid pandemics the correlations evolve. They seem rather strong for passenger cars and fluctuate more for passenger cars.

Table 6. Correlation between GDP and car sales over 10 years before the Covid pandemics

Country	Passenger Cars	Light Commercial	Sales
Austria	0,11	0,95	0,35
Czechia	0,87	0,93	0,88
Hungary	-0,49	-0,19	-0,51
Poland	0,93	0,94	0,93
Slovakia	0,96	0,67	0,95

Table 6. Correlation between GDP and car sales over 10 years including the first year of the Covid pandemics

Country	Passenger Cars	Light Commercial	Sales
Austria	-0,21	0,91	-0,06
Czechia	0,69	0,85	0,70
Hungary	-0,64	0,92	-0,63
Poland	0,87	0,87	0,87
Slovakia	0,78	0,69	0,79

Table 6. Comparison of a 10-year correlation before and including pandemics

Country	Passenger Cars	Light Commercial	Sales
Austria	-0,32	-0,05	-0,42
Czechia	-0,19	-0,08	-0,18
Hungary	-0,14	1,11	-0,11
Poland	-0,06	-0,08	-0,06
Slovakia	-0,18	0,02	-0,16

When the pandemics are considered, the correlation decreases in Austria, Czech Republic, and Poland. The lowest drop can be found on the light commercial vehicles. The correlation of at passenger cars and subsequently on total car sales is faces a much stronger drop in its value. Only Hungary is an exception where the correlation rises for commercial vehicles. On the other hand, it reaches a value that is more in line with the other countries.

The group of light commercial vehicles shows a stronger correlation with the GDP compared to the passenger cars.

4   Conclusion

The objective of this paper is to study the correlation between the car sales and the GDP in the EU countries in relationship to a negative external influence represented by the Covid-19 pandemics that hit the EU first in 2020.

Data analysis shows that passenger car sales are weaker correlated to the GDP in the reaction to an external negative influence presented by the Covid pandemics. On the other hand, the light commercial or light utility vehicles seem to have a much stronger correlation to the GDP in case of an external impact.

The present conclusions can be a base for a further analysis to show the causality between the car sales and the GDP. It must be reminded that the correlation does not imply causality only a link between two datasets. The direction of influence needs to be studied differently.

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