THE GROWTH OF THE NUMBER OF MOTOR VEHICLES IN THE SLOVAK REPUBLIC

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Abstract: Transport and delivery of shipments in the shortest possible time should be a priority for any company working in the field of postal and logistics services. The aim of this paper is to point to an annual increase in the number of registered motor vehicles in the Slovak Republic. The first part of the paper contains a test of statistical hypotheses and in the second part estimates the future growth of motor vehicles in 2017. The paper highlights the increased growth of motor vehicles in the Slovak Republic registry. The final part contains a proposal for a new way of delivery of shipments.

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Keywords: growth, motor vehicle, traffic, logistic

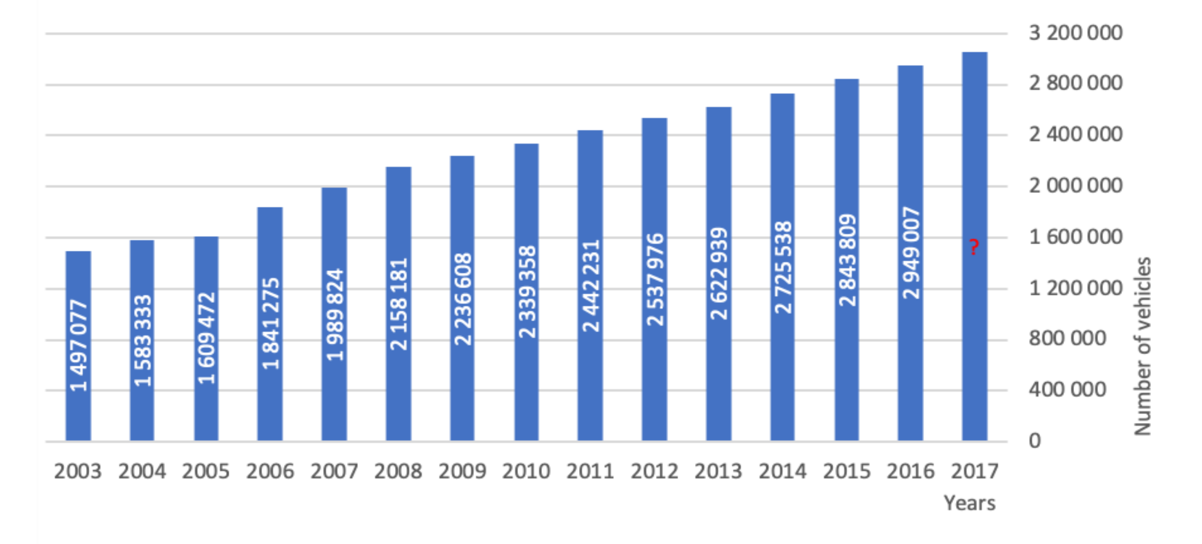
Introduction

We live in a fast and changing era when everyone wants everything right now, or in the shortest time possible. Lambert et al., (2000) claims that is why real logistics plays a key role in the economy of the state in two basic directions. Firstly, logistics is one of the main cost items of businesses, and thus affects all other economic activities and is influenced by them. Secondly, logistics promote the movement and fluidity of many economic transactions. It is necessary to sell virtually any goods or provide any service. In order to understand this role of logistics, it is necessary to realize a simple fact: If goods do not arrive in time to the right place, customers cannot buy them. The distortion of logistical functions causes all economic activities and entities within the logistic chain to suffer.

With an increasing number of motor vehicles there comes denser urban traffic, which prolongs the delivery time of postal packages.

In Figure 1, we can see the number of registered motor vehicles in the territory of the Slovak Republic in the last years.

Figure 1: The number of registered motor vehicles in Slovakia since 2003



Source: Minv.sk (2017). Celkový počet evidovaných vozidiel v SR.

When exploring Figure 1 better, it can be said that since year 2006, an average of one hundred thousand motor vehicles have been annually registered in the territory of the Slovak Republic. This is not expected to change in 2017 either.

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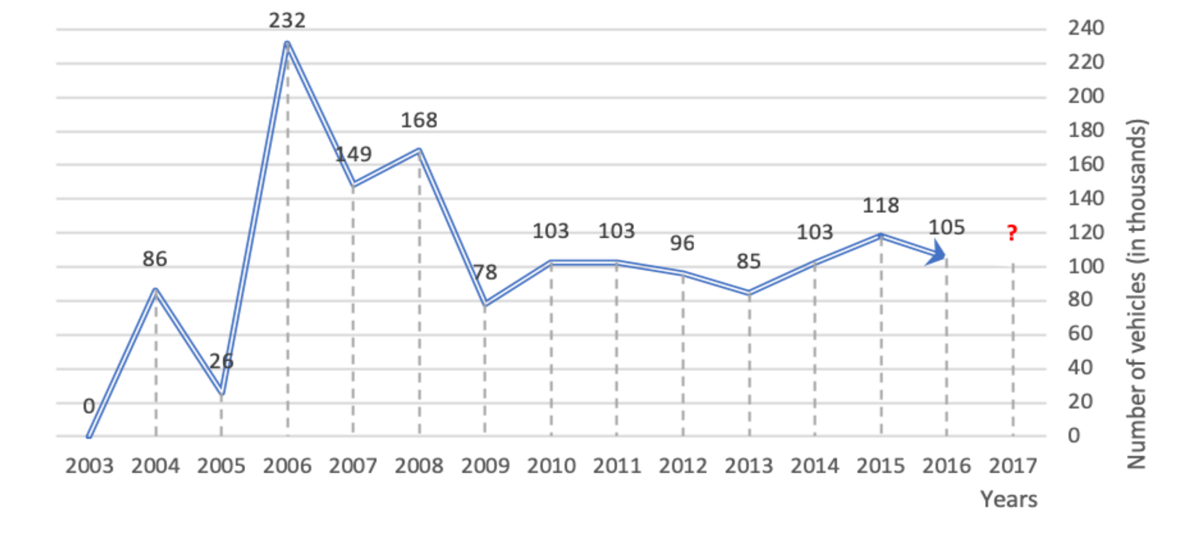
By the end of 2016, we began to tackle the issue of unmanned aircraft. The reason we started to address this issue will be explained in greater detail at the end of the article. First, we set the hypothesis that "For the year 2017, at least 100,000 motor vehicles will be registered in the Slovak Republic." We have verified our hypothesis through a student's distribution. Consequently, we attempted to forecast the increase in the number of motor vehicles using the Forecast function of Microsoft Excel and the moving average method.

Testing of statistical hypotheses

Markechova et al., (2011) claims that a statistical hypothesis is called every assumption or statement that concerns the entire basic set. Verifying hypotheses based on experimental results is an important part of mathematics. The verification of the statistical hypothesis consists in testing the correctness of our assumption on a random basis.

The previous graphical representation of our study was also made using a polygon, which can be seen in Figure 2, to better formulate the hypothesis:

Figure 2: The annual narration of registered motor vehicles in Slovakia since 2003



Source: Minv.sk (2017). Celkový počet evidovaných vozidiel v SR.

Daňo and Ostertagova (2000) claims that when testing statistical hypotheses, it is advisable to follow the following steps:

- **Formulation of hypotheses**

We describe the basic, null hypothesis (H_0) and this is the hypothesis we tested. Against this we construct an alternative hypothesis (H_1) and this is actually the second option that we consider if the zero hypothesis does not apply:

H_0: "For the year 2017, more than 100,000 motor vehicles will be registered in Slovakia."
H_1: "For the year 2017, less than 100,000 motor vehicles will be registered in Slovakia."

- **Choice of materiality level**

Usually, the significance level is denoted by the Greek symbol (α). This is the probability that the zero hypothesis (H0) will be rejected as it is true. Of course, this value is very small, most often 0.05 or 0.01:

$$\alpha = 0.05$$

- **Determining Critical Area**

First, we have to calculate the degree of freedom (k), where we put the number of years for which we have statistical data, according to the relationship:

$$k = n - 1 \rightarrow 13 - 1 = 12$$

Then, according to the level of significance and degree of freedom, we find in the statistical tables the appropriate value:

$$K_{1-\alpha} = 2.2622$$

- **Calculating test value G**

Since the number of additions of the registrations of registered motor vehicles was less than 30, we used the student's distribution rather than the normal distribution to test the statistical hypothesis:

$$s = \sqrt{s^2} = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n}} \doteq 49\ 466.74$$

where *n=13* (number of values), $\bar{x}$*=111 687* (mean value), s^2 = is it standard deviation

Based on the calculated and entered values, we can calculate the test criterion (G) for deciding on the validity of the zero hypothesis at the specified significance level:

$$G = \frac{\bar{x} - Q_0}{s}\sqrt{n-1} \rightarrow \frac{111\ 687 - 100\ 000}{49\ 466{,}74}\sqrt{12} \doteq 0{,}82$$

- **Test evaluation**

Comparing the value of the test criterion with the appropriate value from the statistical tables and evaluate the tests according to the established rules.

$$G > -K_{1-\alpha}$$
$$0{,}82 > -2{,}26$$

The result of the test is correct and therefore we accept the hypothesis H_0:

H_0: "For the year 2017, at least 100,000 motor vehicles will be registered in the Slovakia."

Quantitative Forecasting Using Excel Functions

As our hypothesis was confirmed, we attempted to estimate the growth of motor vehicles in 2017. We used Quantitative Forecasting using Excel Functions:

Moving Averages

Nadler and Kros (2007) claims that moving averages are considered to be the easiest method of quantitative forecasting to develop. This particular method of forecasting is essentially a smoothing model, which makes forecasts more accurate. The basic premise behind the use of moving averages is to take data averages from x periods in order to forecast demand for the upcoming period. Most businesses use either a 3 month (quarterly) or 6 month (biannual) moving average because sales data is recorded on a monthly basis. The longer a moving average is, the smoother the data set becomes. In fact, one can control the effect of smoothing on the time series data by using a longer or shorter averaging time period. The formula for calculating a moving average is as follows:

$$MA_n = \frac{\sum_{t=1}^{n} D_t}{n}$$

where *n* = number of periods in moving average and D_t = data in period *t*.

The mathematical equation for the three-year moving average is expressed as:

$$MA(3) = M_{t+1} = \frac{(D_t + D_{t-1} + D_{t-2})}{3}$$

whereas the five-year moving average is

$$MA(5) = M_{t+1} = \frac{(D_t + D_{t-1} + D_{t-2} + D_{t-3} + D_{t-4})}{5}$$

where *MA(3)* is the moving average using 3 periods of data, *MA(5)* is the moving average using 5 periods of data and D is demand and *t* is time.

In Table 1 we can see figures MA(3) and MA(5) for the individual years calculated on the basis of annual incremental growth of motor vehicles. The most important for us is the figure for year 2017.

Table 1: Moving Average

Year	Number of registered vehicles	Increase in the number of vehicles per year	3-Year Moving average	5-Year Moving average
2003	1 497 077	-	-	-
2004	1 583 333	86 256	-	-
2005	1 609 472	26 139	-	-
2006	1 841 275	231 803	-	-
2007	1 989 824	148 549	114 733	-
2008	2 158 181	168 357	135 497	-
2009	2 236 608	78 427	182 903	132 221
2010	2 339 358	102 750	131 778	130 655
2011	2 442 231	102 873	116 511	145 977
2012	2 537 976	95 745	94 683	120 191
2013	2 622 939	84 963	100 456	109 630
2014	2 725 538	102 599	94 527	92 952
2015	2 843 809	118 271	94 436	97 786
2016	2 949 007	105 198	101 944	100 890
2017	**?**	**?**	**108 689**	**101 355**

Source: Author

Forecast function

Jureckova and Molnarova (2005) claims that when we use forecasting functions, based on existing values, they calculats or estimate the future value. The predicted value is the value of the dependent variable (y) for a given value independently of the variable (x). Known values are the pairs of numbers x and y, the new value being estimated using linear regression.

- The syntax of FORECAST ***(x, known_y's, known_x's)*** has the following arguments:
  - X Required. The data point for which you want to predict a value.
  - Known_y's Required. The dependent array or range of data.
  - Known_x's Required. The independent array or range of data.
- The equation for FORECAST is $a+b_x$, where:
  - $a = \bar{y} - b\bar{x}$
  - $b = \frac{\sum(x-\bar{x})\cdot(y-\bar{y})}{\sum(x-\bar{x})^2}$
  - and where x and y are the sample means AVERAGE(known_x's) and AVERAGE(known y's).

Figure 3 shows the calculation of an estimated future value, the same one as the previous example, on the basis of annual incremental growth of motor vehicles.

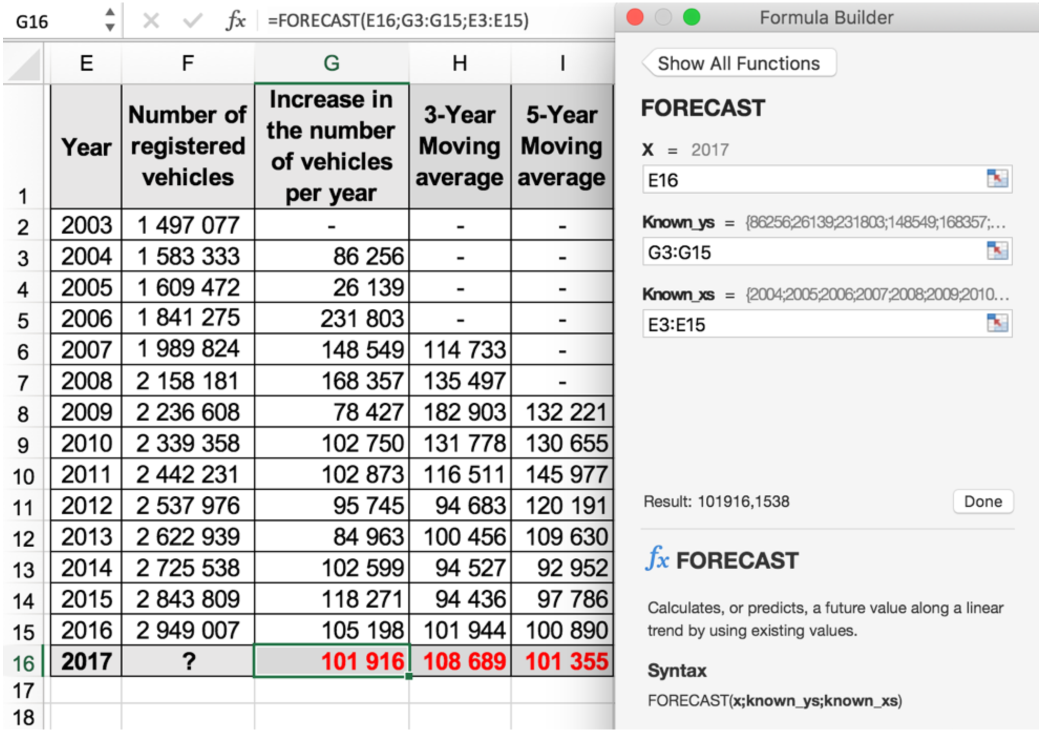
Linear Trend Analysis

Nadler and Kros (2007) claims that the TREND function is a Statistical function, that will calculate the linear trend line to the arrays of known y and known x. The difference in the previous functions is that the trend at the end of the syntax includes a constant.

- The syntax of **TREND *(x, known_y's, known_x's, const)*** has the following arguments:
  - Const (optional argument) – It specifies whether to force the constant b to equal 0. If const is TRUE or omitted, b is calculated normally. If false, b is set equal to 0 (zero) and the m-values are adjusted so that y = mx.

Figure 4 shows the calculation of an estimated future value calculated on the basis of annual incremental growth of motor vehicles.

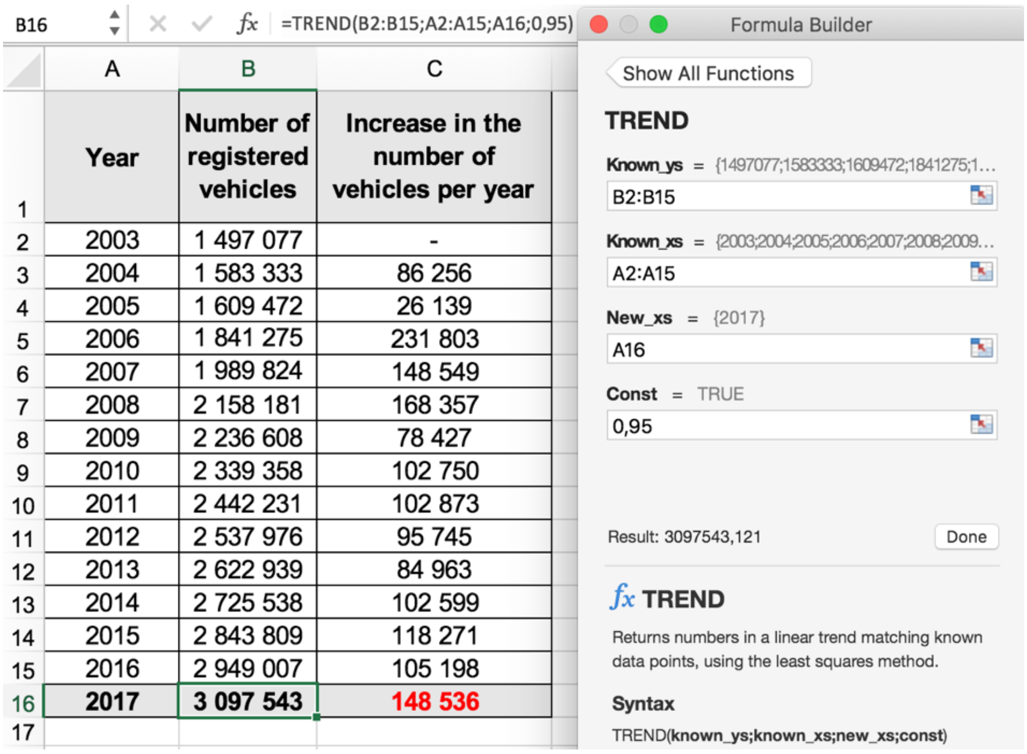
Figure 3: Forecast function in Microsoft Excel for Mac



	Year	Number of registered vehicles	Increase in the number of vehicles per year	3-Year Moving average	5-Year Moving average
2	2003	1 497 077	-	-	-
3	2004	1 583 333	86 256	-	-
4	2005	1 609 472	26 139	-	-
5	2006	1 841 275	231 803	-	-
6	2007	1 989 824	148 549	114 733	-
7	2008	2 158 181	168 357	135 497	-
8	2009	2 236 608	78 427	182 903	132 221
9	2010	2 339 358	102 750	131 778	130 655
10	2011	2 442 231	102 873	116 511	145 977
11	2012	2 537 976	95 745	94 683	120 191
12	2013	2 622 939	84 963	100 456	109 630
13	2014	2 725 538	102 599	94 527	92 952
14	2015	2 843 809	118 271	94 436	97 786
15	2016	2 949 007	105 198	101 944	100 890
16	2017	?	101 916	108 689	101 355

Source: Authors

Figure 4: Trend function in Microsoft Excel for Mac



	Year	Number of registered vehicles	Increase in the number of vehicles per year
2	2003	1 497 077	-
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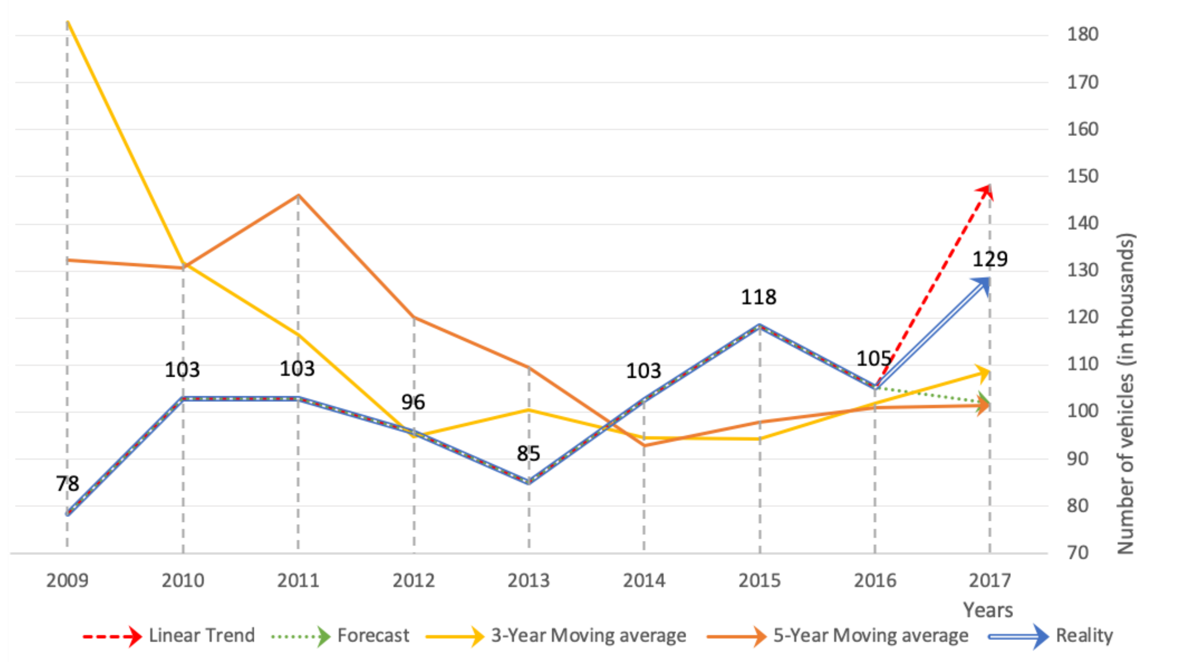
12	2013	2 622 939	84 963
13	2014	2 725 538	102 599
14	2015	2 843 809	118 271
15	2016	2 949 007	105 198
16	2017	3 097 543	148 536

Source: Authors

Figure 5 shows the comparison with reality of the Quantitative Forecasting using Excel Functions. The Linear Trend Analysis method was the closest to real growth in motor vehicles in the Slovak Republic.

Figure 5: Comparison with reality of Quantitative Forecasting using Excel Functions

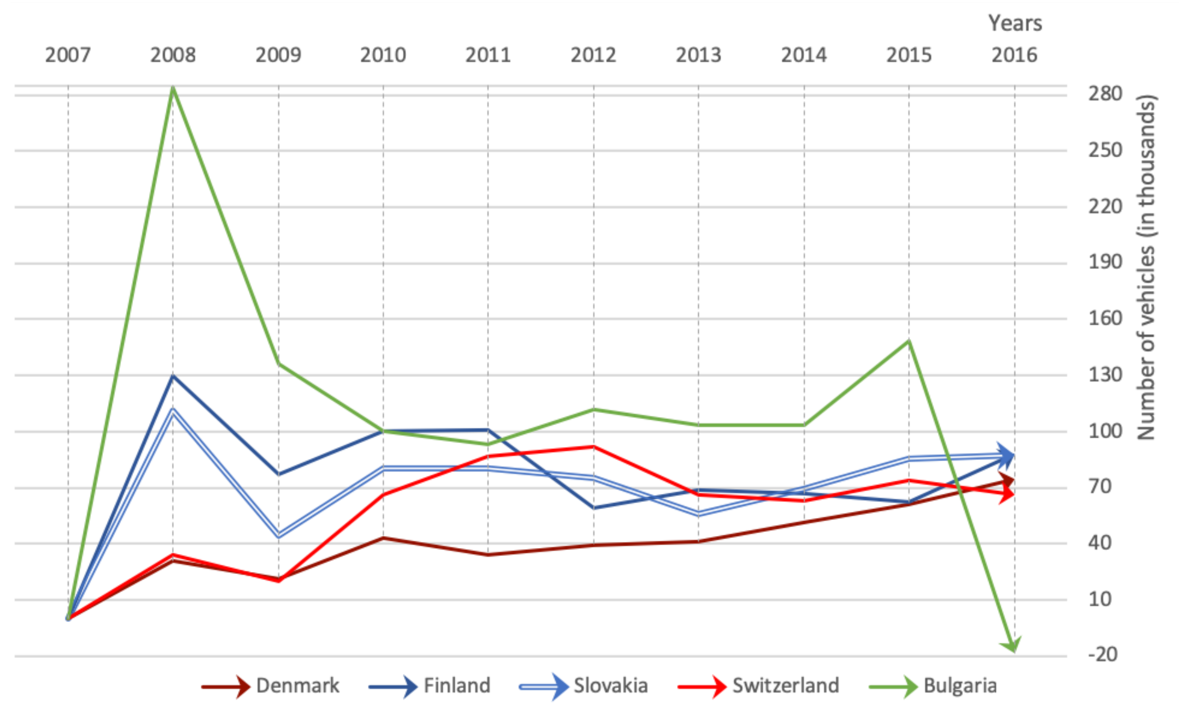


Source: Authors

Comparison with other member states of the European Union.

Our research focuses on the year-on-year growth of cars in the Slovak Republic. Since Slovakia has about 5.4 million inhabitants, we decided to choose 5 European Union countries with the same or somewhat larger number of inhabitants.

Figure 6: The total population of the country ranging from 5.4 to 8.3 million inhabitants

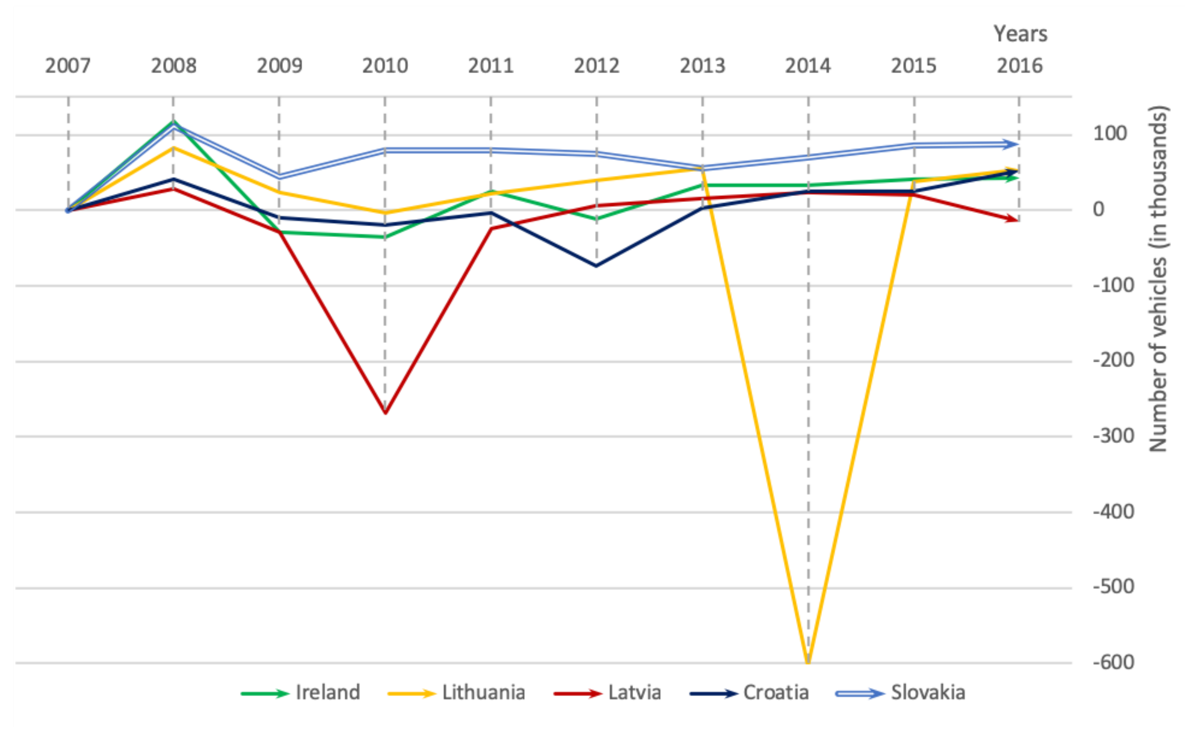


Source:
Statbank.dk (2018). Stock of vehicles per 1 January by region and type of vehicle.
Europa.eu (2018). Population change - Demographic balance and crude rates at national level.
Europa.eu (2018). Passenger cars, by type of motor energy and size of engine.

Figure 6 shows that among those countries where Slovakia has the smallest number of inhabitants (5.4 million) it still has the highest annual growth in motor vehicles in 2016.

We then made a comparison based on the size of the country. Since Slovakia has an area of about 49 thousand square kilometers we chose 5 European Union countries which have the same or somewhat larger area.

Figure 7: The land area ranging from 49 to 70 thousand square kilometers



Source:
Worldatlas.com (2017). The Countries Of Europe By Area.
Europa.eu (2018). Passenger cars, by type of motor energy and size of engine.

Figure 7 shows that among those countries where Slovakia has the smallest area (49 thousand km^2), it has the largest year-on-year increase in motor vehicles.

Conclusion

At the beginning, we set a hypothesis: "For the year 2017, at least 100,000 motor vehicles will be registered in the Slovak Republic.", which was confirmed by the students' distribution. Consequently, using moving averages, Forecast and Trend functions, we attempted to estimate the future value of annual incremental growth of motor vehicles in the Slovak Republic.

The year 2017 already passed and we had the opportunity to compare the forecasted data with the real data from the Slovak Transport Office. We have completed the statistical data for 2017 and we found that in the Slovak Republic there were 3,077,648 registered motor vehicles by 31 December 2017, resulting in an annual increase of 128,641 vehicles.

This means that our estimated calculations were predicted closest using a Trend function. As an interesting fact we would like to mention that the population of the Slovak Republic as of 31 December 2016 was 5 435 343. This means, in comparison with the number of registered motor vehicles in the territory of the Slovak Republic, that each other inhabitant owns at least one motor vehicle.

We also made a comparison with 5 members states of the European Union, whose size or population was the same or slightly larger than the Slovak Republic.

The comparison showed that even though Slovakia had the smallest area and the smallest number of inhabitants, it had the largest annual increase in motor vehicles. This is a worrying situation whose unpleasant effects can be observed especially in major towns during traffic peaks. At long junctions, long queues are formed, passing by the city takes several minutes longer than usual. Not to mention irregular occurrences such as different reconstructions or traffic accidents.

Kapusta et al., (2008) claims that the globally observed increase in the number of motor vehicles in road transport has created a top issue for the present. Increased motorization immediately leads to the deterioration of air quality in the streets, causes increased exposure of the population to noise from the road, threatens the health and life of the population itself, takes up territory for the construction of road infrastructure, contributes to the enhancement of the effects of climate change.

It is time to look for a new, more efficient way of delivering shipments. Hence, there is an opportunity to use airspace, in particular using unmanned aerial vehicles.

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