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FORECASTING THE ROAD ACCIDENT RATE AND THE IMPACT OF THE COVID 19 ON ITS FREQUENCY IN THE POLISH PROVINCES

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Resume

The COVID-19 pandemic has significantly affected the development of road transport, not only in Poland, but also worldwide. Limited mobility, especially at the beginning of the pandemic, had a large impact on the number of road accidents. The aim of the present study is to predict the number of road accidents in Poland and to assess the impact of the COVID-19 pandemic on variability of the number of road accidents. To attain the objective, annual data on the road accidents for every province in Poland were collected and analysed. Based on historical crash data, obtained from the police, the number of road accidents was forecasted for both pandemic and non-pandemic scenarios. Selected time series models and exponential models were used to forecast the number of accidents.

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1 Introduction and literature review

The road traffic accidents are events that cause not only injuries or death to road users, but the damage to property, as well. According to the WHO, approximately 1.3 million people die each year as a result of traffic accidents. Traffic accidents account for around 3% of their GDP for most of the countries in the world. Road traffic accidents are the leading cause of death for minors and young people aged 5-29 [1]. One of the most frequent causes of traffic accidents is the young age of drivers. Hudec et al. (2021) dealt with the fatal traffic accidents in the period 2017-2019, caused by drivers who have held driving licenses for less than five years [2]. The UN General Assembly has set an ambitious goal of halving the number of road deaths and injuries by 2030.

Traffic forecasting has always been important, considering the long-term strategy or design and therefore has been a field, which has attracted a lot of researchers around the world. Few of the important studies are described in the following part of this section.

Szumiska et al. (2020) presented the road safety issues in Poland over the years 2009-2019, with

a detailed consideration of the data on side, front and rear accidents, as well as the characteristics of perpetrators of road accidents in terms of gender and age of drivers [3].

Okutani et al. (1984) used Kalman filtering theory to forecast the traffic volume [4]. The authors using the Kalman theory computed 3 error indices (a) mean relative error, which indicates the expected error as a fraction of the measurement, (b) root relative square error and (c) maximum relative error and compared it to UTCS-2, which was previously determined as the best of the most widely used algorithms. They also found that all the new prediction models perform substantially (up to 80%) better than UTCS-2. Davis and Nihan (1991) reviewed the problem of the short-term traffic forecasting as a non-parametric regression method, by utilising the nearest neighbor (k-NN) approach [5]. According to the authors, this technique might sidestep some of the problems inherent in parametric forecasting approaches. Lavrenz et al. (2018) stated that last two decades have led to growing need for the short-term prediction of traffic parameters [6]. According to them, prediction models should be embedded in a real-time

intelligent transportation systems environment. The authors examined various forecasting models and their findings showed significant sensitivity of ARIMA models in dealing with missing values. Kashyap et al. (2022) reviewed various traffic forecasting models related to deep learning techniques [7]. Their article reviewed some of the latest works in deep learning for the traffic flow prediction. They talked about the rising popularity of hybrid methods. Lana et al. (2018) aimed to summarize the efforts to date towards extracting the main comparing criteria in traffic forecasting and challenges in this field [8]. Williams and Hoel (2003) used a seasonal ARIMA process to model and forecast vehicular traffic flow [9]. This article presents the theoretical basis for modelling univariate traffic condition data streams as seasonal auto regressive integrated moving average processes. Demissie et al. (2013) focused on study of the smart urban mobility in Oporto, Portugal, leveraging on the existing sensing capabilities to collect historical traffic sensing data through traffic counters [10]. The program used by authors is Porto LivingLab, which is a smart city initiative that aims to study urban dynamics. More specifically, this study analyses urban mobility by using historical data from road-mounted traffic counters to predict future vehicular traffic behaviour. Ali et al. (2021) used the machine learning to forecast and predict traffic crashes and their associated injuries and fatalities from a traffic safety standpoint [11]. The model consists of four terms: trend component, cyclical, seasonal and irregular components. The trend component was natural due to increase in population, which was directly proportional to traffic accidents. The cyclical component demonstrated an increase in the number of accidents, with the highest increase (28.9%) in February 2011 and then it showed a decline in accident number per month. The decrement of accidents happened because the fixed speed camera system was widely applied on major roads. The seasonal component showed seasonal effects where more accidents occurred in July, August and September (summer season) and less accidents occurred in February, March and April (winter season). Many countries have their own guidelines to forecast the road accidents. For instance, in India, IRC 108 is a guideline by Indian Roads Congress for traffic forecasting on highways. The various methodologies discussed in the guideline are forecasting techniques like ADT, AADT, ARIMA, linear regression etc. Salisu and Oyesiku (2020) examined traffic survey analysis on major highways in Ogun State, Nigeria using manual traffic count method for estimation of traffic volume and flow pattern [12].

Time series forecasting and decision trees have been used extensively in the field of accident forecasts by various researchers [13-17]. The three widely used time series methods are Exponential smoothening technique, Holt-Winters method and seasonal ARIMA. According to Wu et al. (2017), Winters method has the highest forecasting accuracy, as compared to other

methods [18]. According to Dutta et al. (2022), empirical results from exponential smoothening models assert the importance of their application in accident forecasting [16]. Yadav and Nath (2017) reported that MAPE values for exponential smoothening technique is much lesser than ARIMA techniques and hence provides better fit for forecasted data [19]. Along with these time series analyses, Artificial Neural Networks (ANN) and its various types are used a lot for traffic forecasting. Yang et al. (2022) proposed a multi-node Deep Neutral Network (DNN) to predict different levels of severity of injury, death and property loss with great accuracy [20]. Similarly, study by Biswas et al. (2019) used the Random Forest regression to predict the number of road accidents, where the authors opined the smaller groups to be favored over larger groups [21]. Chudy-Laskowska and Pisula (2014) used an autoregressive model with quadratic trend for forecasting the road incidents [22]. According to Kashpruk (2010), moving average techniques can also be used for accident forecasting; however, the prediction accuracy is too low [23]. As discussed earlier, time series analyses like ARIMA or SARIMA are also used for forecasting [24-27]. A limitation to ARIMA is the linear nature of the model by Dudek (2013) [28]. Hadoop is a new prediction technique, which was used by Kumar et al. (2019) [29]. The disadvantage of this method is its inability to work with small data files. Karlaftis and Vlahogianni (2009) used the Garch model for prediction [24]. However, they found the method to be very complex and complicated [30-31]. Various researchers [32-33] have also used the Data-Mining techniques for forecasting, which usually have the disadvantage of huge sets of general descriptions [34]. One also encounters the combination of models proposed by Sebege et al. as a combination of different models [35]. Parametric models were also proposed in the work of Bloomfield (1973) [36]. From the literature, it can be safely assumed that Time-series analyses and neural networks are better forecasting methods. Between them, time series analyses have more dynamics and types to choose from based on the type of data one is dealing with.

Regarding the sources of accident data, the most commonly, they are collected and analyzed by government authorities through relevant government agencies. Data are collected through police reports, insurance databases or hospital records. Partial information on the road accidents is then processed for the transport sector on a larger scale [37]. Another important source of data collection in today's era is the use of Intelligent transport systems (ITS). The GPS devices in vehicles are used for the collection of such data [38]. Vehicle number plate recognition system also helps in collecting large amounts of traffic data over a monitored period of time, which however is a tedious job [39]. In the present study, different data sources have been combined with major inputs from the police data since they provide the most trustworthy information.

Table 1 Area and population by province in Poland in 2020

Provinces	Area		Population	
	in ha	in km ²	total	per 1 km ²
Poland	31,270,525	312,705	38,265,013	122
Lower Silesia	1,994,670	19,947	2,891,321	145
Kuyavia-Pomerania	1,797,134	17,971	2,061,942	115
Lublin Province	2,512,246	25,123	2,095,258	83
Lubusz Province	1,398,793	13,988	1,007,145	72
Lodz Province	1,821,895	18,219	2,437,970	134
Lesser Poland	1,518,279	15,183	3,410,441	225
Masovia	3,555,847	35,559	5,425,028	153
Opole Province	941,187	9,412	976,774	104
Subcarpathia	1,784,576	17,846	2,121,229	119
Podlasie Province	2,018,702	20,187	1,173,286	58
Pomerania	1,832,368	18,323	2,346,671	128
Silesia	1,233,309	12,333	4,492,330	364
Holy Cross	1,171,050	11,710	1,224,626	105
Warmia-Masuria	2,417,347	24,173	1,416,495	59
Greater Poland	2,982,650	29,826	3,496,450	117
West Pomerania	2,290,472	22,905	1,688,047	74

2 Materials and methods

Poland is inhabited by over 38 million people. Poland covers an area of 312 705 km² and is divided into 16 provinces (Table 1, Figure 1). Based on the police road crash data, it may be stated that the number of road accidents on Polish roads is decreasing year by year. For all the studied provinces in the analysed period 2001-2021 the average decrease is more than 56%. This is most visible in Kuyavia-Pomerania province (70%) and Podlasie province (69%, and least in the Lubusz province (32%). The number of road accidents depends on the number of inhabitants in each province [40].

In some provinces there are fluctuations in the number of accidents, with a downward trend. In comparison with the European Union the number of accidents in Poland is still very high.

During the pandemic, a decrease in the number of road accidents is observed. Compared to 2019, there were on average 21% fewer road accidents in 2020 and comparing the statistics of 2021 compared to 2019, the decrease is more than 23%. Figure 2 graphically shows the trend of road accidents in Poland between 2001 and 2021 for the analysed provinces. The number of road accidents depends on the province. The rate of accidents per 100,000 inhabitants in 2021 is presented in Figure 3. The highest number of accidents per 100,000 inhabitants can be observed in the Lodz (95) and Masovia (79.3) provinces and the lowest in the Podlasie (37) and Kuyavia-Pomerania (38.8) provinces [41].

Selected exponential equalization models were used to forecast the number of road accidents for each

province in Poland. The essence of these methods is that the time series of the forecast variable is pronounced with a weighted moving average and the weights are determined according to the exponential function. These weights were optimally selected by Statistica software, in which the applied analyses were performed.

The forecast of the number of accidents for the analysed provinces was based on the weighted average of the current and historical series. The obtained results of the forecast using these methods depend on the choice of a model and its optimal values of parameters. Forecasting the number of accidents in Poland by provinces was carried out using the selected time series models.

The following errors of expired forecasts determined from Equations (1) to (5) were used to calculate measures of analytical forecasting perfection:

- ME - mean error

$$ME = \frac{1}{n} \sum_{i=1}^n (Y_i - Y_p), \quad (1)$$

- MAE -mean average error

$$MAE = \frac{1}{n} \sum_{i=1}^n |Y_i - Y_p|, \quad (2)$$

- MPE -mean percentage error

$$MPE = \frac{1}{n} \sum_{i=1}^n \frac{Y_i - Y_p}{Y_i}, \quad (3)$$

- MAPE - mean absolute percentage error

$$MAPE = \frac{1}{n} \sum_{i=1}^n \frac{|Y_i - Y_p|}{Y_i}, \quad (4)$$



Figure 1 Location of provinces in Poland (Division of Poland, 2022)

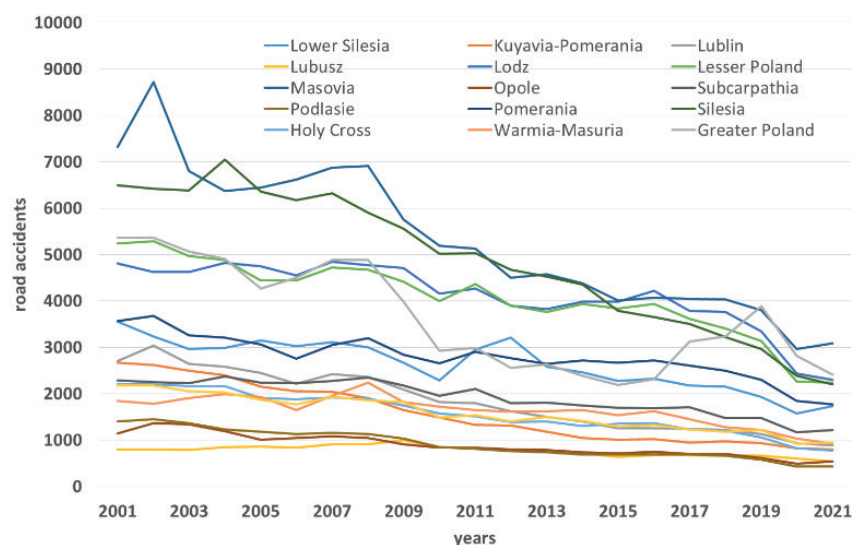


Figure 2 Comparison of the number of accidents in Poland between 2001 and 2021

- SSE - mean square error

$$SSE = \sqrt{\frac{1}{n} \sum_{i=1}^n (Y_i - Y_p)^2}, \quad (5)$$

where:

n - the length of the forecast horizon,

Y - observed value of the road accidents,

Y_p - forecasted value of the road accidents.

In order to compare the number of accidents in case

of pandemic and if it did not exist, the mean percentage error was minimized.

3 Research results

The variability of the number of road accidents per day was examined by the Kruskal - Wallis test. The value of the test statistic is 14.4 with a test probability of $p < 0.05$. This value indicates that, according to

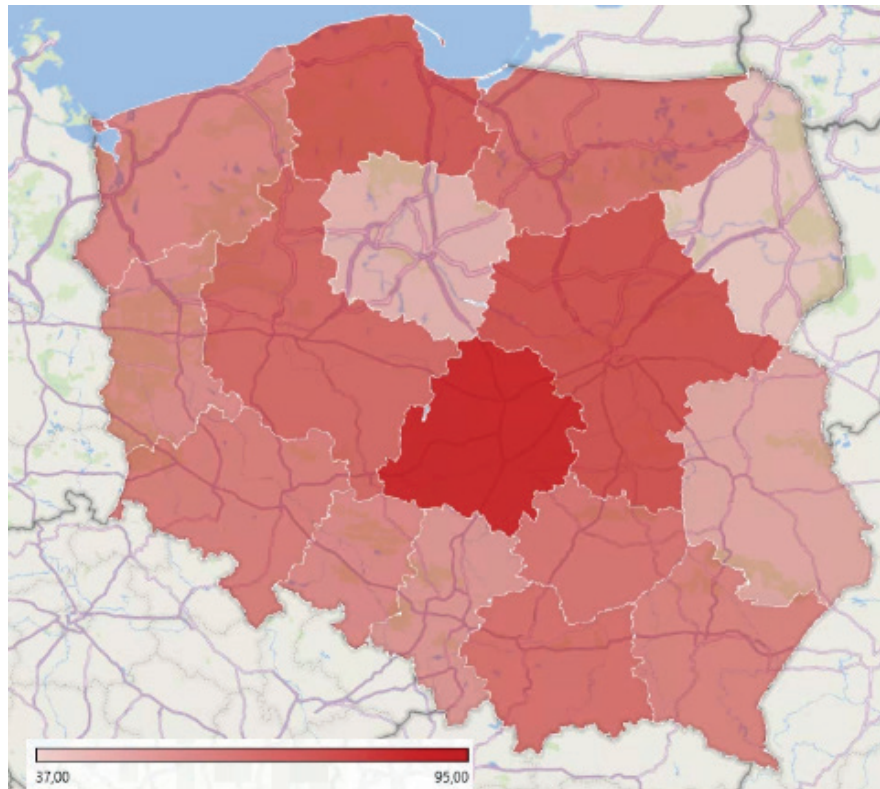
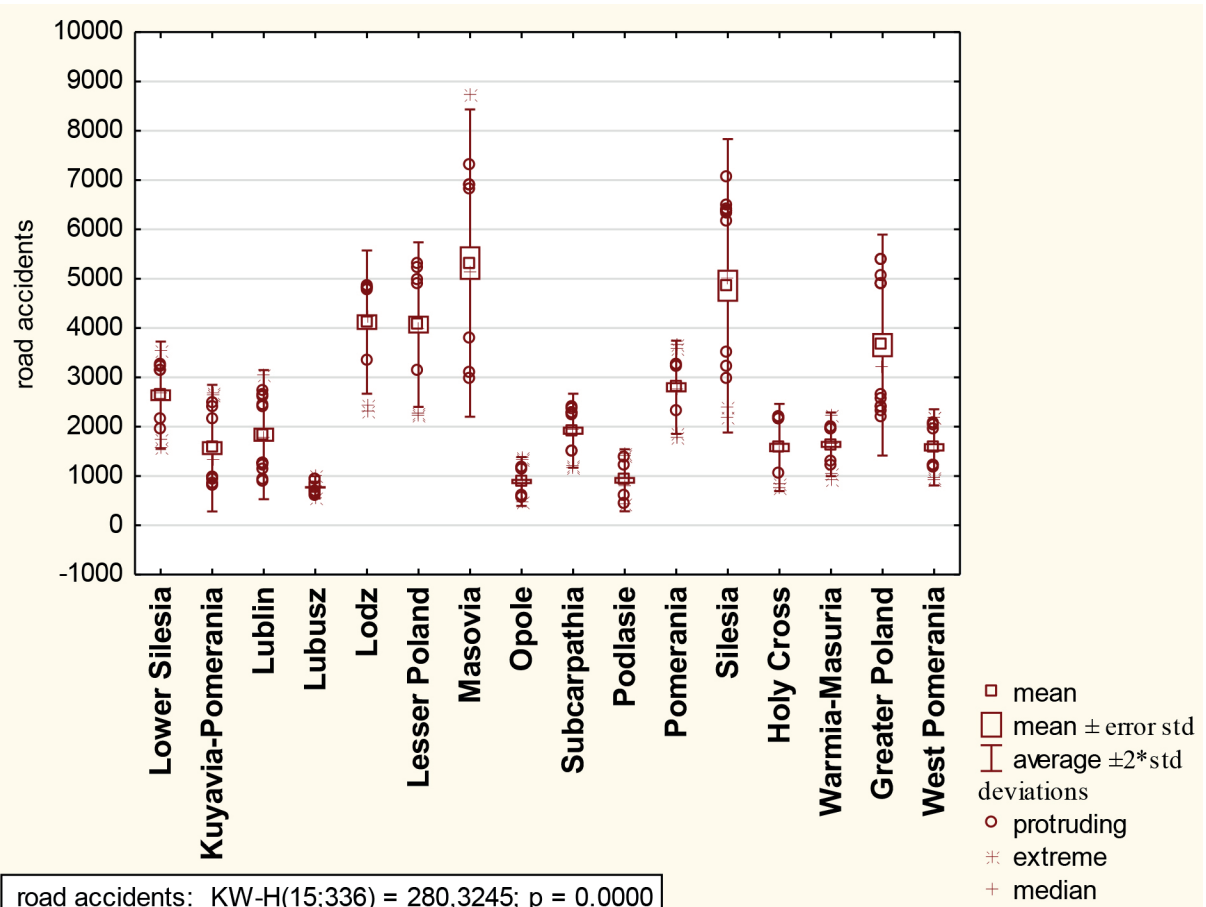


Figure 3 Accident rate per 100,000 inhabitants in 2021 (Statistice Police, 2022)



the hypothesis, the equality of the average level of road accidents should be rejected. This means that the number of accidents in Poland show a systematic decrease in the average level of accidents over the years. Furthermore, there is a clear variation in the number of accidents per day, as shown in Figure 4.

Figure 4 clearly shows that the highest number of road accidents occurs at weekends, on Fridays and Saturdays. This is due to the increased traffic at weekends, which causes a high number of road accidents. The least number of road accidents occur on Sundays because workplaces are closed on this day, resulting in less traffic on the roads.

Based on the analysis of the number of road accidents, it can be concluded that they have a seasonal character. Therefore, the selected time series models for forecasting the number of road accidents were used for further analysis.

3.1 Forecasting road accidents in the province

To forecast the number of accidents in each province, data from the Polish Police from 2001 to 2021 were used. To examine the impact of the pandemic on the number of road accidents in the analysed provinces, the study was divided into two-time frames:

- From 2001 to 2021 (considering the occurrence of

pandemic) and

- From 2001 to 2019 (considering that there were no pandemic).

The study assumes that the start of the pandemic is in 2020, due to the lack of police statistics on the number of road accidents by province and month. The forecast results for each province with pandemic impact (up to 2021) are shown in Figures 5-20. Similarly, accident forecasts for each province without pandemic data (up to 2019) are shown in Figures 21-36. The individual forecasting methods used in the study are coded M1, M2,, Mn. The individual forecasting techniques used in the study are as follows:

M1 - moving average method 2-points,

M2 - moving average method 3-points,

M3 - moving average method 4-points,

M4 - exponential smoothing no trend seasonal component: none,

M5 - exponential smoothing no trend seasonal component: additive,

M6 - exponential smoothing no trend seasonal component: multiplicative,

M7 - exponential smoothing linear trend seasonal component: none HOLTA,

M8 - exponential smoothing linear trend seasonal component: additive,

M9 - exponential smoothing linear trend seasonal component: multiplicative WINTERSA,

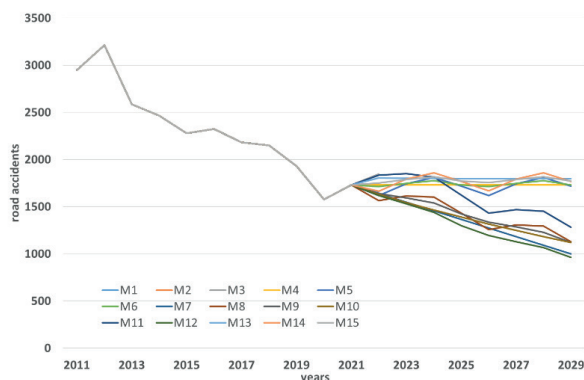


Figure 5 Forecasting the number of road accidents in the Lower Silesian Province in 2022-2029

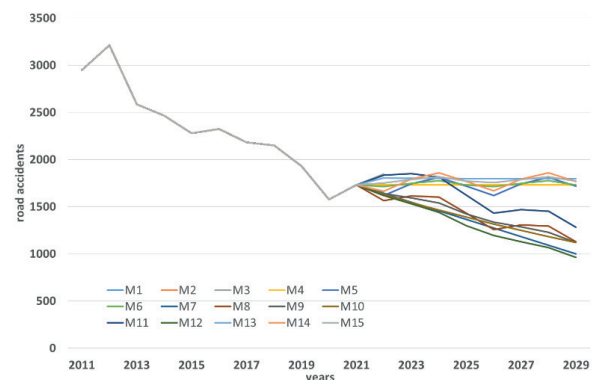


Figure 5 Forecasting the number of road accidents in the Lower Silesian Province in 2022-2029

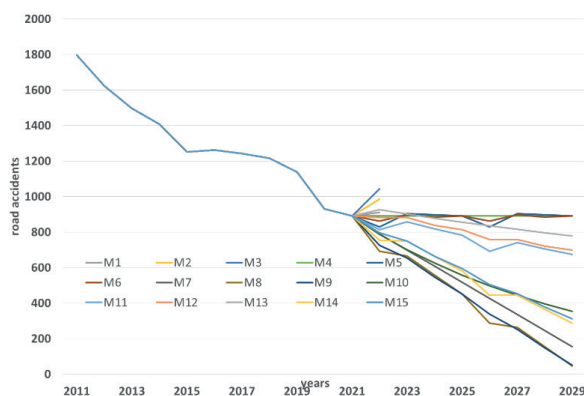


Figure 6 Forecasting the number of road accidents in Lublin Province in 2022-2029

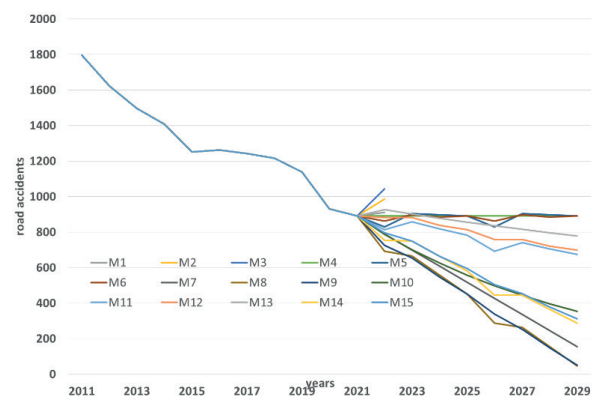


Figure 6 Forecasting the number of road accidents in Lublin Province in 2022-2029

M10 - exponential smoothing exponential seasonal component: none,
 M11 - exponential smoothing exponential seasonal component: additive,
 M12 - exponential smoothing exponential seasonal component: multiplicative,

M13 - exponential smoothing fading trend seasonal component: none,
 M14 - exponential smoothing fading trend seasonal component: additive,
 M15 - exponential smoothing fading trend seasonal component: multiplicative)

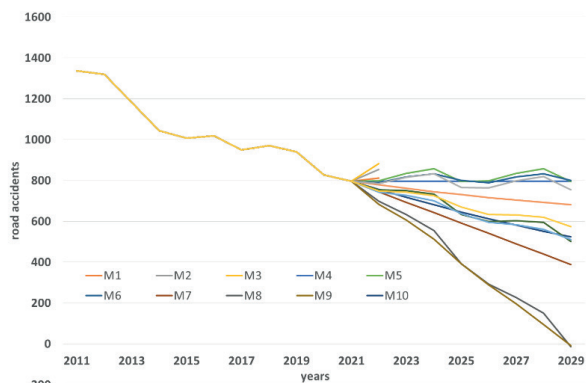


Figure 7 Forecasting the number of road accidents in Kuyavia-Pomerania Province in 2022-2029

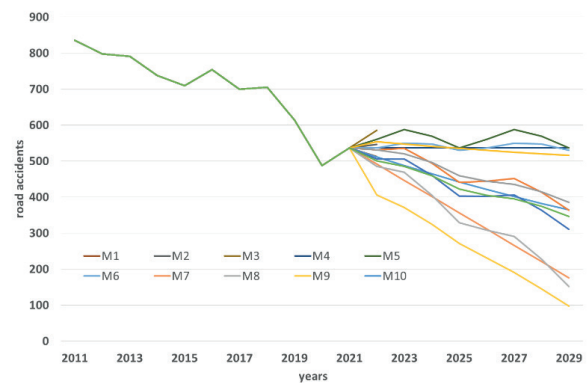


Figure 10 Forecasting the number of road accidents in Opole Province in 2022-2029

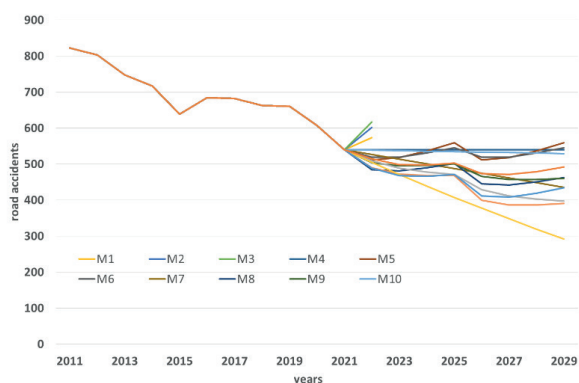


Figure 8 Forecasting the number of road accidents in Lubusz Province in 2022-2029

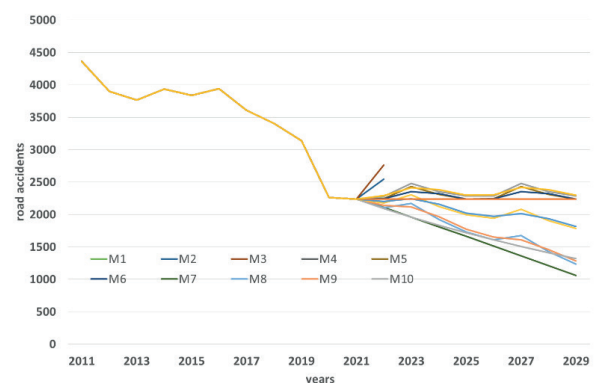


Figure 11 Forecasting the number of road accidents in the Lesser Poland in the years 2022-2029

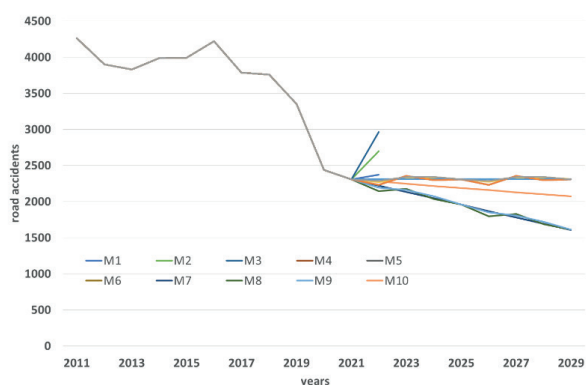


Figure 9 Forecasting the number of road accidents in the Lodz Province in the years 2022-2029

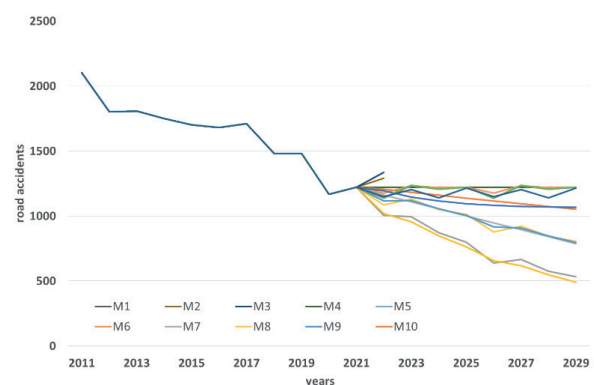


Figure 12 Forecasting the number of road accidents in Subcarpathia Province in 2022-2029

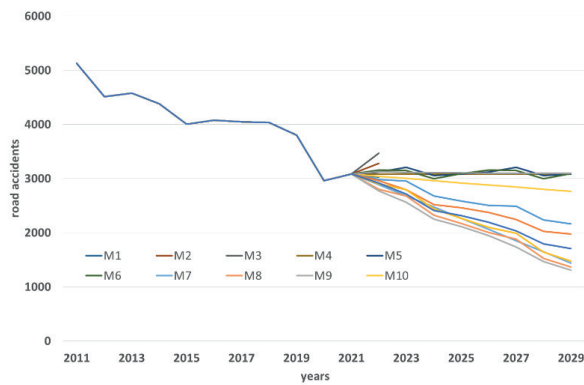


Figure 13 Forecasting the number of road accidents in Masovia Province in 2022-2029

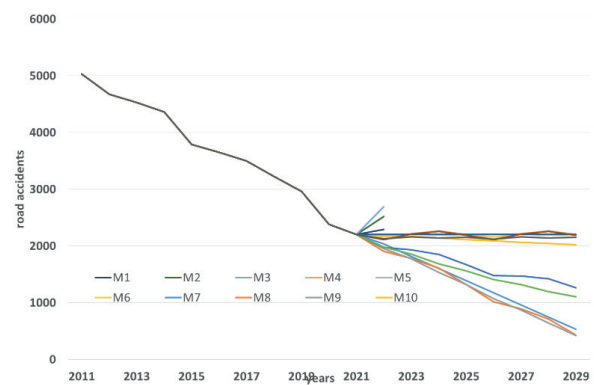


Figure 17 Forecasting the number of road accidents in Silesia Province in 2022-2029

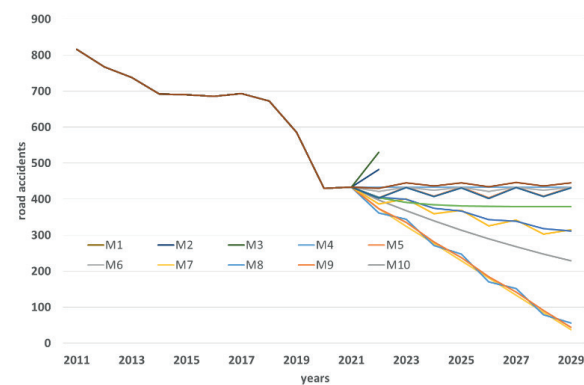


Figure 14 Forecasting the number of road accidents in Podlasie Province in 2022-2029

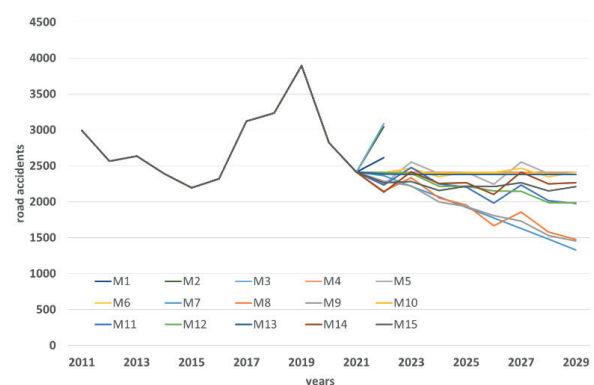


Figure 18 Forecasting the number of road accidents in Greater Poland Province in 2022-2029

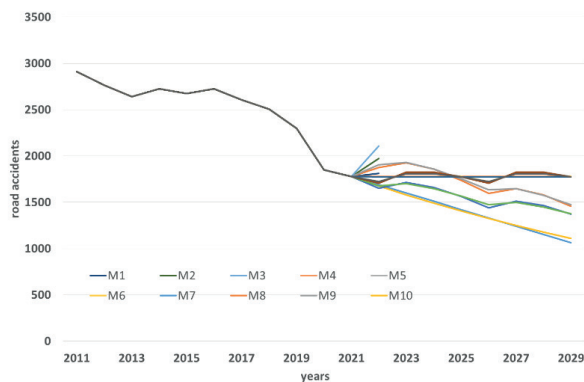


Figure 15 Forecasting the number of road accidents in Pomerania Province in 2022-2029

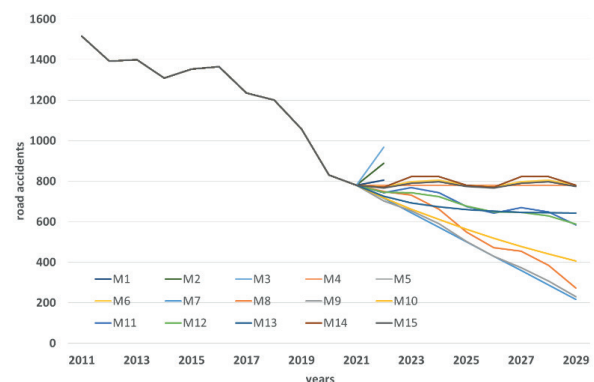


Figure 19 Forecasting the number of road accidents in the Holy Cross Province in 2022-2029

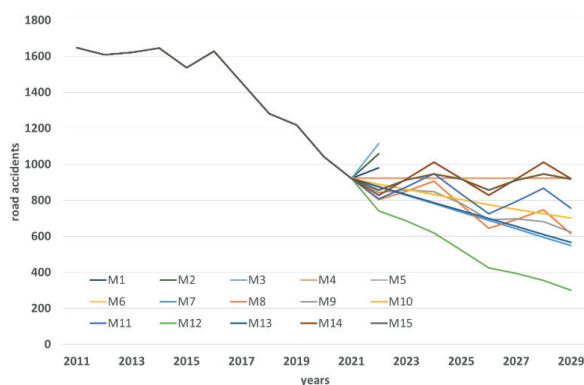


Figure 16 Forecasting the number of road accidents in Warmia-Masuria Province in 2022-2029

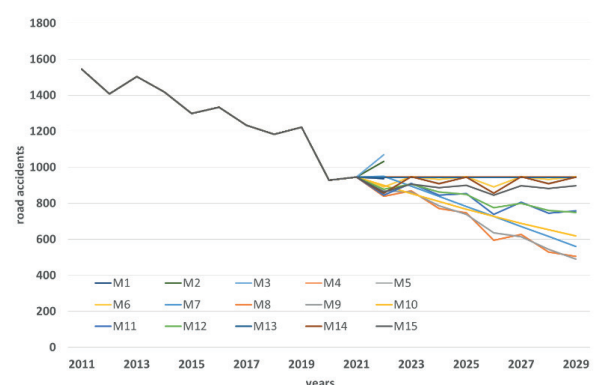


Figure 20 Forecasting the number of road accidents in the West Pomeranian Province in the years 2022-2029

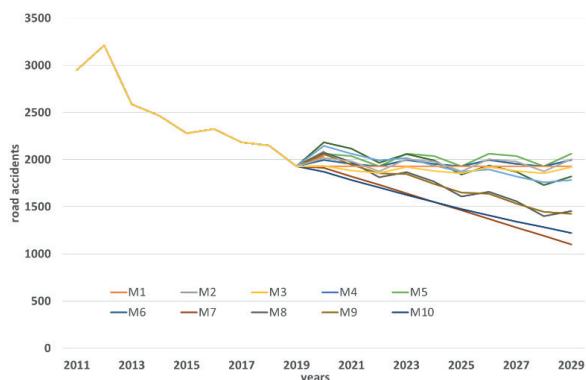


Figure 21 Forecasting the number of road accidents in the Lower Silesian Province in 2020-2029 if there were no pandemic

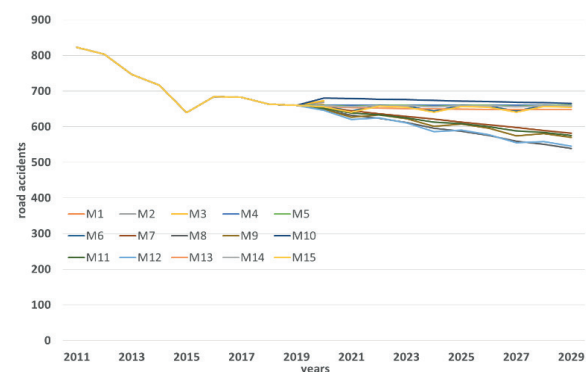


Figure 22 Forecasting the number of road accidents in Lubusz Province in 2020-2029 if there was no pandemic

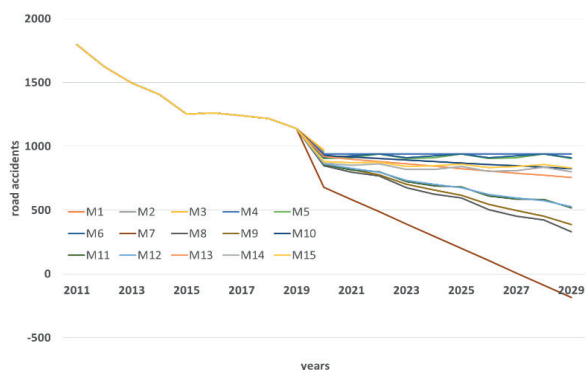


Figure 23 Forecasting the number of road accidents in Kuyavia-Pomerania province in 2020-2029 if there was no pandemic

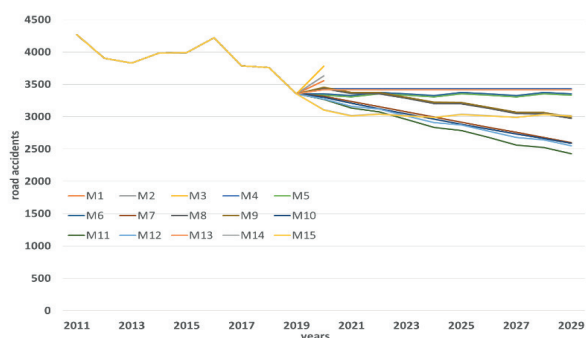


Figure 24 Forecasting the number of road accidents in Lodz Region in the years 2020-2029 if there was no pandemic

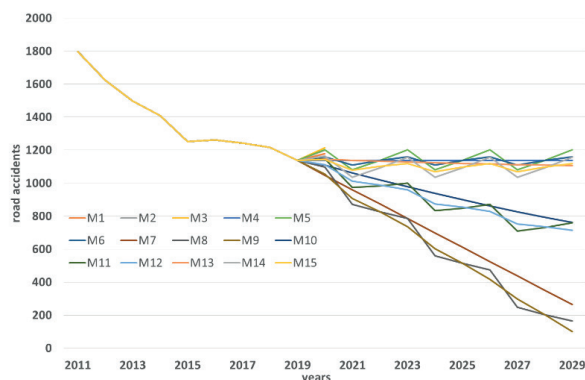


Figure 25 Forecasting the number of road accidents in Lublin province in 2020-2029 if there was no pandemic

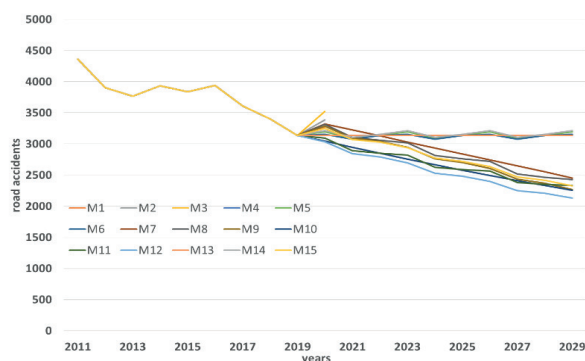


Figure 26 Forecasting the number of road accidents in Lesser Poland province in 2020-2029 if there was no pandemic

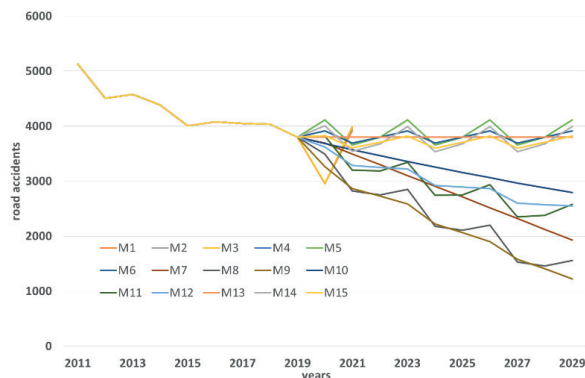


Figure 27 Forecasting the number of road accidents in Masovia province in 2020-2029 if there was no pandemic

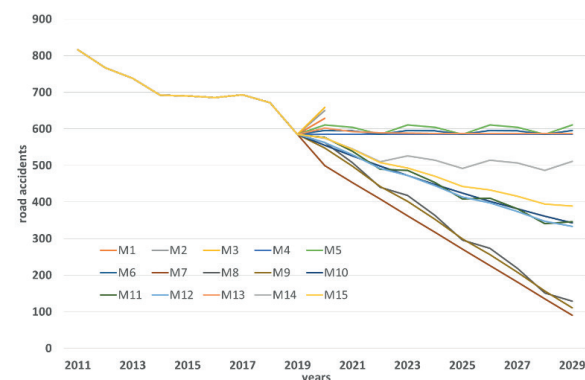


Figure 28 Forecasting the number of road accidents in Podlasie Province in 2020-2029 if there was no pandemic

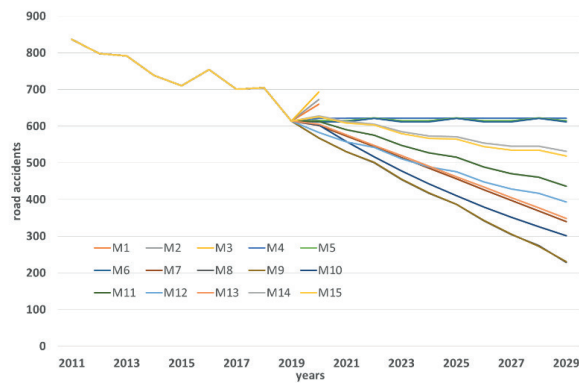


Figure 29 Forecasting the number of road accidents in Opole Province in 2020-2029 if there was no pandemic

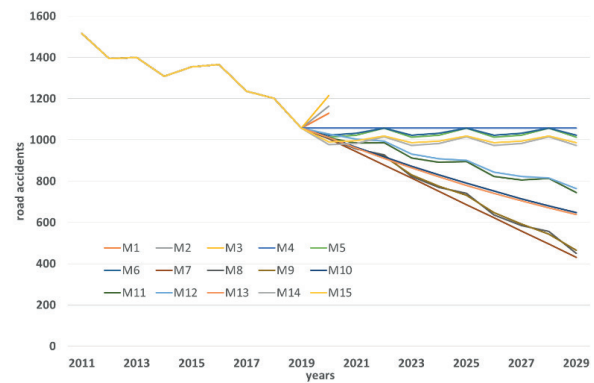


Figure 33 Forecasting the number of road accidents in Holy Cross Province in 2020-2029 if there was no pandemic

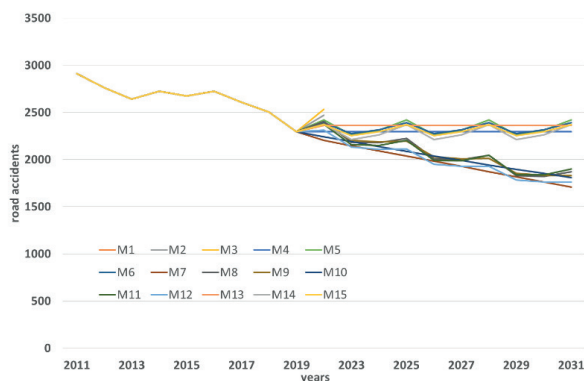


Figure 30 Forecasting the number of road accidents in Pomerania Province in 2020-2029 if there was no pandemic

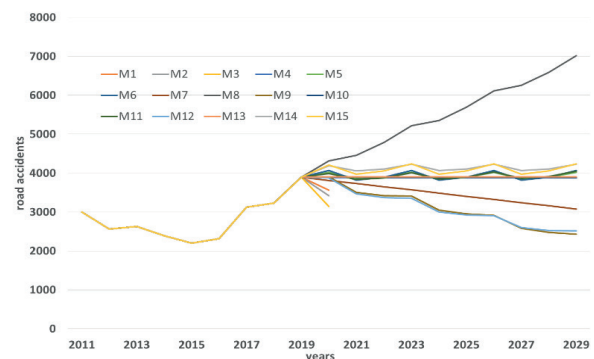


Figure 34 Forecasting the number of road accidents in Greater Poland Province in 2020-2029 if there was no pandemic

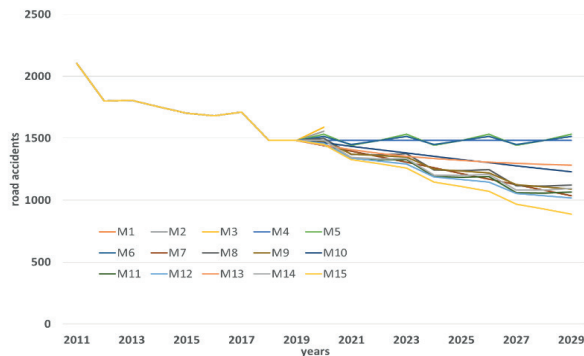


Figure 31 Forecasting the number of road accidents in Subcarpathia province in 2020-2029 if there was no pandemic

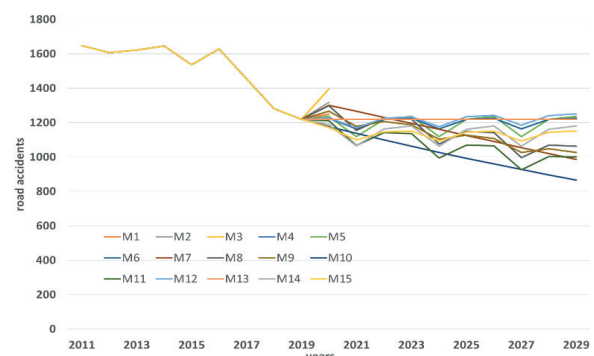


Figure 35 Forecasting the number of road accidents in Warmia-Masuria Province in 2020-2029 if there was no pandemic

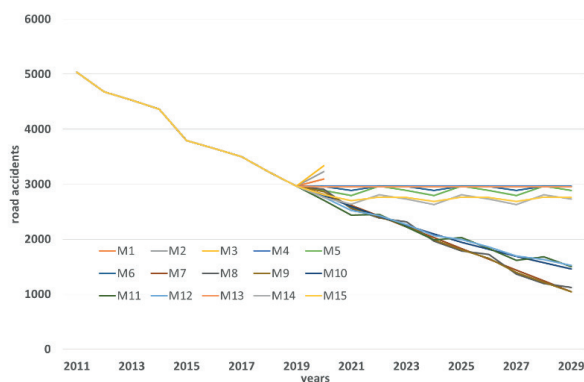


Figure 32 Forecasting the number of road accidents in Silesia Province in 2020-2029 if there was no pandemic

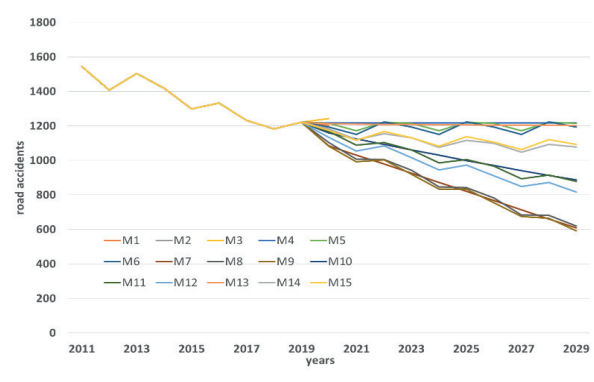


Figure 36 Forecasting the number of road accidents in the West Pomerania Province in 2020-2029 if there were no pandemic

Based on the results of the pandemic study, the number of road accidents projected at the end of the analysed period 2029 ranges from 44 to 2313 depending on the province and the forecasting technique used. This confirms the fact that the number of road accidents in the studied provinces will decrease year over year.

To compare the number of road accidents depending on the studied province during the pandemic and in the absence of pandemic, the forecast of the number of road accidents was made based on different forecasting techniques, for which the average percentage error is the smallest. The following methods were selected as the best forecasting methods for each province:

- The occurrence of a pandemic: Lower Silesia - M8, Kuyavia-Pomerania - M11, Lublin - M7, Lubusz - M7, Lodz - M12, Lesser Poland - M7, Masovia - M7, Opole - M7, Subcarpathia - M7, Podlasie - M9, Pomerania - M11, Silesia - M9, Holy Cross - M8, Warmia-Masuria - M10, Greater Poland - M7, West Pomerania - M8,
- No pandemic: Lower Silesia - M11, Kuyavia-Pomerania - M12, Lublin - M11, Lubusz - M8, Lodz - M7, Lesser Poland - M11, Masovia - M8, Opole - M12, Subcarpathia - M7, Podlasie - M7, Pomerania - M12, Silesia - M9, Holy Cross - M7,

Warmia-Masuria - M7, Greater Poland - M7, West Pomerania - M11,

In the next step the forecast of the number of road accidents for the following years was made in each province in the case no pandemic was there. The research was conducted to answer the question how the pandemic influenced the number of road accidents in the analysed provinces. In order to do so, the Police data containing the number of road accidents in the years 2001-2019 were used [41].

Based on the conducted research, it can be concluded that the estimated number of road accidents by province for the year 2029 ranges from 89 to 3077 depending on the method used and the province. Based on the obtained results of the research, it can be concluded that the number of road accidents in Poland will decrease from year to year in individual provinces.

4 Discussion

The projected number of road accidents in 2020 and 2021 in each province was compared to the actual number of road accidents reported by the police (black line in Figures 37 to 52) [41]. Those data are presented in Figures 37 to 52.

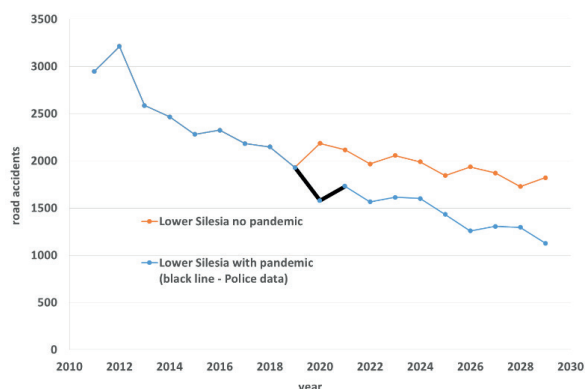


Figure 37 Comparison of the number of road accidents in the Lower Silesian Province with and without the pandemic

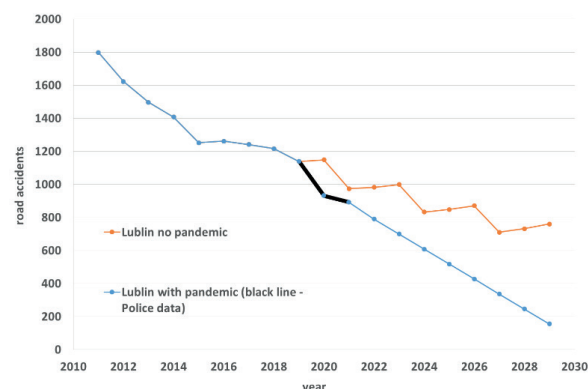


Figure 39 Comparison of the number of road accidents in Lublin Province with and without the pandemic

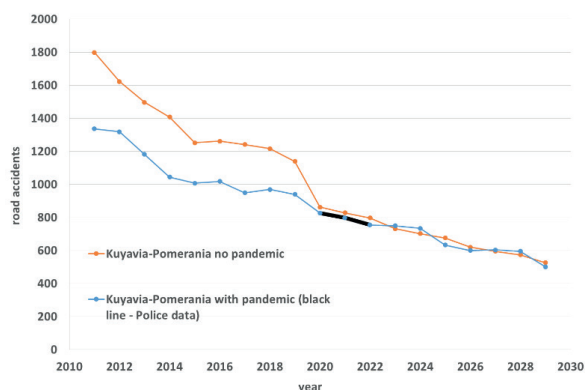


Figure 38 Comparison of the number of road accidents in Kuyavia-Pomerania province with and without the pandemic

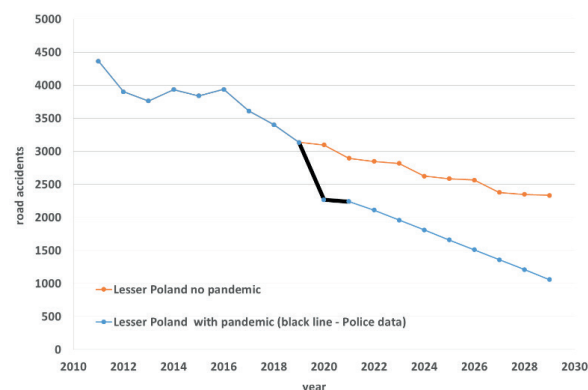


Figure 40 Comparison of the number of road accidents in Lesser Poland province with and without the pandemic

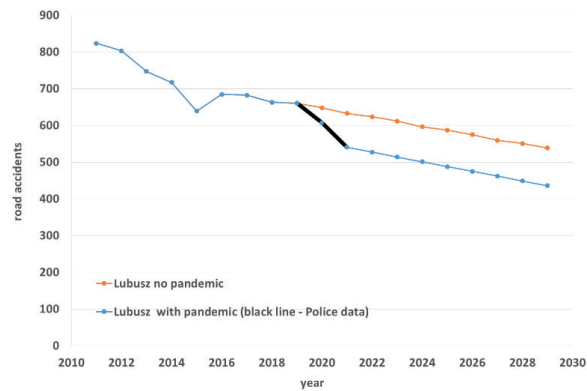


Figure 41 Comparison of the number of road accidents in Lubusz province with and without the pandemic

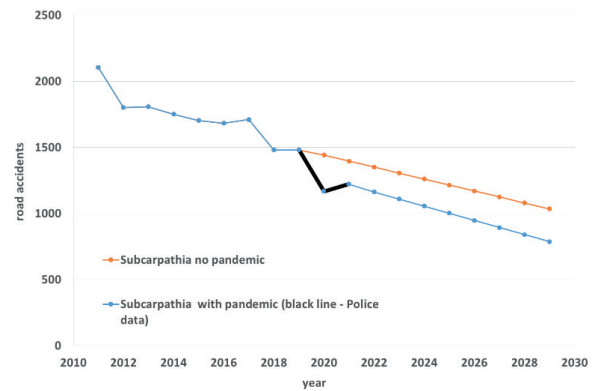


Figure 45 Comparison of the number of road accidents in Subcarpathia province with and without the pandemic

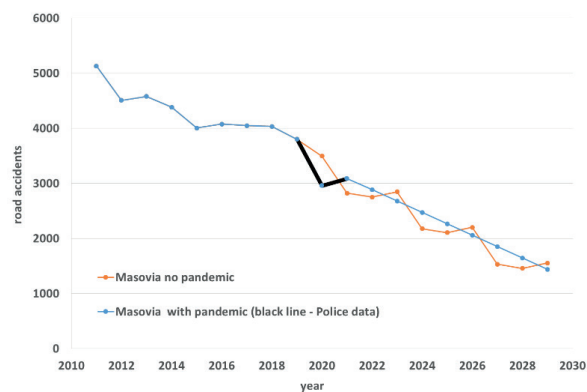


Figure 42 Comparison of the number of road accidents in Masovia province with and without the pandemic

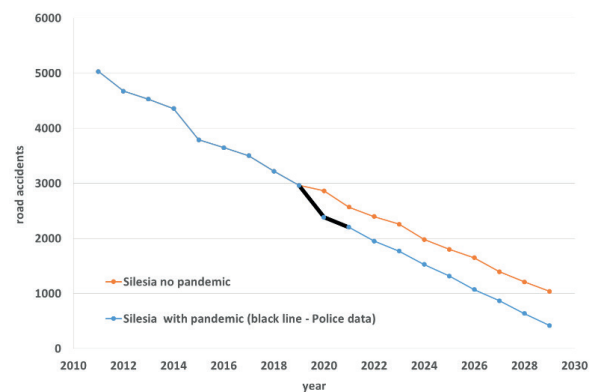


Figure 46 Comparison of number of road accidents in Silesia with and without the pandemic

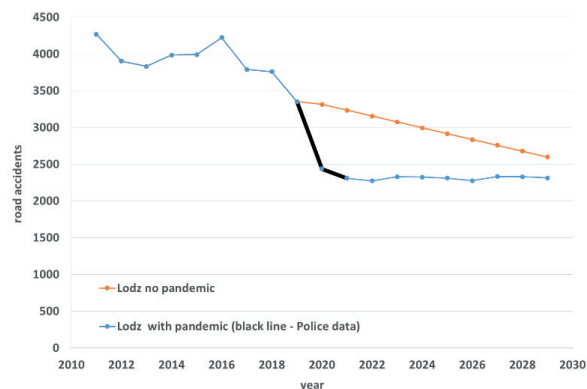


Figure 43 Comparison of the number of road accidents in Lodz Province with and without the pandemic

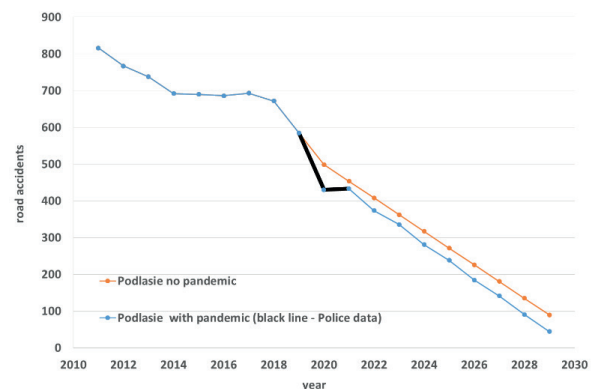


Figure 47 Comparison of the number of road accidents in Podlasie province with and without the pandemic

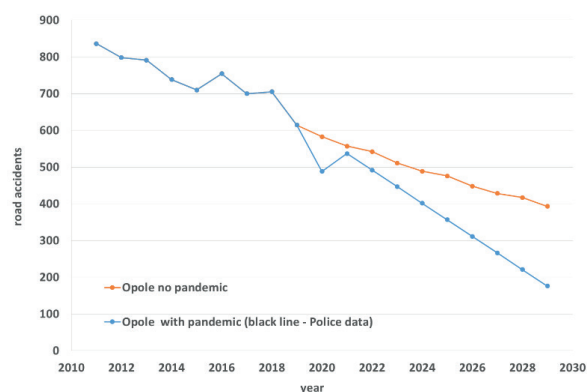


Figure 44 Comparison of the number of road accidents in the Opole Province with and without the pandemic

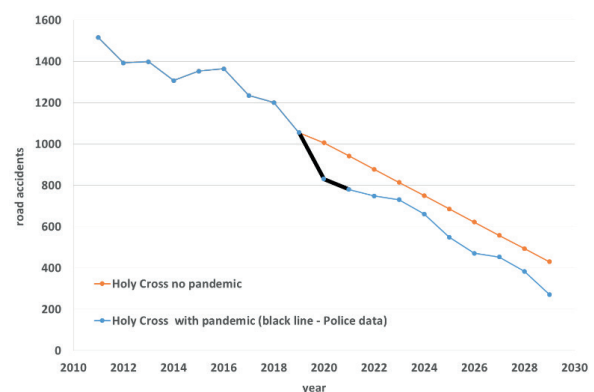


Figure 48 Comparison of the number of road accidents in the Holy Cross Province with and without the pandemic

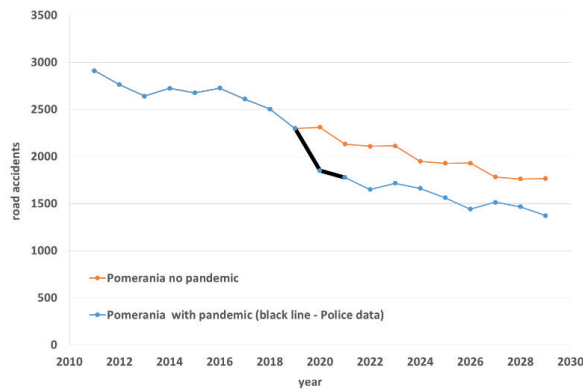


Figure 49 Comparison of the number of road accidents in Pomerania Province with and without the pandemic

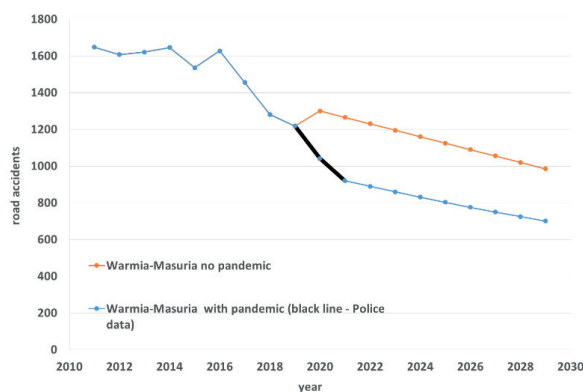


Figure 50 Comparison of the number of road accidents in Warmia-Masuria Province with and without the pandemic

Based on the obtained data, it can be concluded that the pandemic caused a decrease in the number of road accidents in Poland by 21% on average. The ranges depending on the province narrow in the range: 10% for Lubusz province to almost 53% for Lublin province. The most visible decrease is observed in Lublin, Greater Poland and Lesser Poland Provinces. Moreover, the forecasts show, that in the current situation further decrease in the number of road accidents in Poland can be expected.

5 Conclusion

The forecasted number of accidents in Poland in individual provinces was determined by the exponential equalization method using the Statistica software. The applied weights were estimated by the program in such a way to minimize the mean absolute error and mean absolute percentage error.

To forecast the number of accidents in individual provinces, Polish Police data from 2001-2021 were used. To examine the impact of the pandemic on the number of road accidents in the analysed provinces, the study was divided into two time frames: 2001- 2021 (with pandemic) and 2001-2019 (without pandemic).

Based on the forecast considering the pandemic,

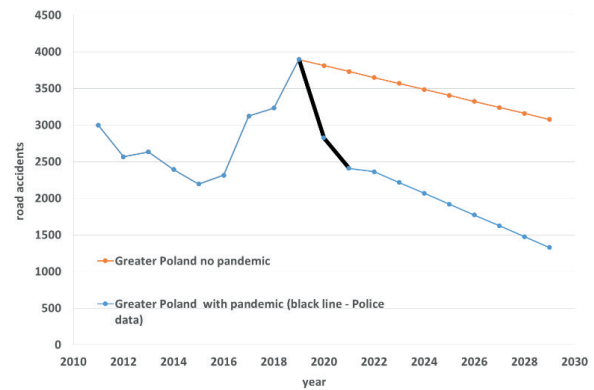


Figure 51 Comparison of the number of road accidents in Greater Poland Province with and without the pandemic

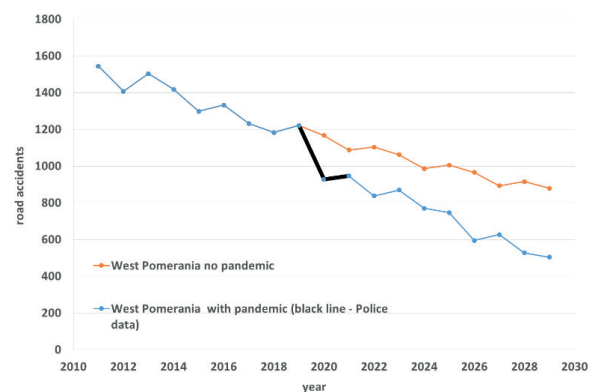


Figure 52 Comparison of the number of road accidents in the West Pomeranian Province with and without the pandemic

it can be concluded that the forecasted number of road accidents at the end of the analysis period 2029, varies from 44 to 2313 depending on the province and on the forecasting technique used. The forecasted data also confirms the fact that the number of the road accidents in the studied provinces will decrease year by year.

In the next step, the prognosis of the number of road accidents for the following years in each province in the absence of the pandemic was forecasted. The aim of this forecasting analysis was to understand the actual effect of pandemic and its influence on the number of road accidents in the studied provinces. In order to do this, the Police statistics defining the number of road accidents in the years 2001-2019 were used.

Based on the research, it can be concluded that the estimated number of road accidents in each province for 2029 ranges from 89 to 3077, depending on the method used and the province. Based on the presented results of the research it can be concluded that the number of road accidents in Poland will decrease year by year in each province. However, the forecast without the pandemic gives a higher value of crashes as compared to forecasted values with effect of pandemic.

Based on obtained data, it may be stated that the pandemic caused decrease in the number of road accidents in Poland by 21% on average. The variation and spread varies across voivodship areas in the range:

10% for Lubuskie Province to almost 53% for Lubelskie Province. The most visible decrease is observed in the voivodships: Lubelskie, Wielkopolskie and Małopolskie. Moreover, the forecasts indicate that in the current situation further decrease in the number of road accidents in Poland can be expected.

Furthermore, based on analysis of the obtained results it may be stated, that the forecasts of the number of road accidents in Poland for the next year's show a downward tendency, especially in relation to the arrival of Covid-19 virus pandemic. Comparison of forecast to the actual data proved accuracy of the used models. Another important conclusion from the analysis is that there is a significant variation in the number of accidents in individual provinces. Moreover, depending

on the voivodeship for which the forecasting is carried out, certain types of forecasting techniques turn out to be more accurate.

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