Traffic safety developments in Poland

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D-2001-8

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A research note

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Leidschendam, 2001
SWOV Institute for Road Safety Research, The Netherlands

Report documentation

Number:	D-2001-8
Title:	Traffic safety developments in Poland
Subtitle:	A research note
Author(s):	Siem Oppe
Research theme:	Road safety analysis
Theme leader:	Ingrid van Schagen
Project number SWOV:	37.410
Keywords:	Traffic, safety, fatality, mathematical model, development, trend (stat), risk, forecast, growth rate, statistics, Poland.
Contents of the project:	The rapid growth of traffic in Poland has led to increased interest in traffic safety. Additional safety measures are therefore felt to be necessary. In order to set realistic safety targets, the expected safety trends are investigated and forecasts are made.
Number of pages:	17 pp.
Price:	Dfl. 15.-
Published by:	SWOV, Leidschendam, 2001

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Abstract

Recently there has been an increased interest in traffic safety in Poland. There is a feeling that the rapid growth of traffic should be accompanied by additional efforts to improve traffic safety, in order to stop the corresponding increase in fatalities and serious accidents. To set realistic safety targets, it is important to have some idea of the expected safety trends, if no extra measures are taken.

In this study the developments of traffic and traffic safety are investigated and forecasts are made. This is done by extrapolation of smoothed trends (preliminary analysis) and by applying models that proved to be useful in the past for the description of safety developments in developed countries. The underlying assumption of these models is that the outcome of safety trends in terms of accidents, casualties and fatalities is the product of two more basic developments. These basic developments are the trends in traffic growth, measured by the growth of the car park and the use of cars, and the risk of having a(n) (serious) accident per travelled kilometre. If there is a strong increase in traffic, risk increases as well, and as a result the influence of accidents on safety trends will be considerable. Extra safety measures are then necessary to reduce the risk and consequently the number of accidents. Society seems to work this way: unexpected increases in traffic are usually followed, with some delay, by extra safety measures, resulting in stronger decreases of risk in order to annihilate negative safety effects. Estimates based on the period from 1990 to 1998, compared to estimates based on the period from 1980 onwards, show that such a change did indeed occur in Poland.

Because the series of available data is relatively short and the development of traffic and safety in Poland shows large fluctuations, forecasts will not be very reliable and only indications can be given. From the preliminary analysis it follows that, if the considerable increase in traffic continues, a corresponding increase is to be expected for the number of fatalities. A similar effect was noticeable around 1991.
Forecasts based on the model assumptions show for the near future a more rapid decrease in risk than before. The result of this will be that, in the near future, the number of fatalities will decrease as well. A more rapid decrease in risk, than observed over the period from 1980 to 1998, however, is only possible if the intended additional safety programmes are actually implemented.

Continuous monitoring of traffic and safety trends is necessary to detect deviations from trends. The outcomes can be used to evaluate the effectiveness of safety programmes and the extent to which the safety targets will be reached.

Contents

1. Introduction

Recently an increased interest in traffic safety can be noted in Poland. There is a feeling that an extra effort for the improvement of safety is necessary, given the accelerating increase in the amount of traffic on the road and the large number of fatal and serious accidents. To make ambitious but realistic plans for such extra efforts, it was found necessary to have an indication of the expected development of traffic safety in the future, given the (recent) developments in traffic, safety and safety policies. In the context of the Memorandum of Understanding (MOU) between the Dutch and Polish Governments SWOV has regularly advised the Polish Government and Road Safety Institutes regarding safety policies to be implemented. This has led to close contacts between researchers from SWOV and Polish researchers, in particular researchers of the University in Gdansk. This research note is an example of this close co-operation.

In order to forecast safety developments on the basis of past experience, it is necessary to apply models that are based on realistic assumptions and applied to relevant and available data of good quality. One major assumption is, that the future developments in traffic and traffic safety will have the same socio-economic basis as they had in the past, i.e., it is assumed that no sudden changes in the developmental process will appear. In addition to measures resulting from current safety programmes, the implementation of extra safety measures is necessary in order to reach newly stated safety targets. The safety forecasts based on developments in the recent past may be used to evaluate the effect of such additional measures. If safety targets are set at a lower level than the expected trends, the process may be monitored later, to see whether the additional measures were effective or should be supplemented.

2. Situation in Poland

This note describes the present situation in Poland on the basis of existing data and assumptions about the underlying processes. The most important model assumption is that the development of traffic safety cannot be investigated without knowledge of the traffic developments. We might look at safety as the result of a ‘production process’: the societal need for travel expressed in units of vehicle kilometres (vkm’s, the measure of exposure) is the product; the probability of an accident or casualty per vehicle kilometre (the traffic risk) is one of the cost factors of the production process. Society as a whole (road users, administrators, road constructors, car builders etc.) learn through time how to manage traffic risk. The amount of societal costs regarding safety, expressed in the total amount of fatalities, injuries and material damage, will determine what effort society will put in decreasing risks. As a result of this decrease, the total number of accidents or casualties will automatically decrease as well. In order to improve the system, society can only act on risk factors and not on accidents or casualties themselves. As long as traffic grows more rapidly than risk decreases, the total number of accidents and casualties will rise. Therefore, the development of traffic safety is seen as the result of two other basic developments: the development of traffic (expressed in vkm’s) and the development of risk (expressed in accidents or casualties per vkm). The product of these two developments of exposure and risk determine the development of safety. For a detailed description and application of this viewpoint to traffic safety, see Oppe and Koornstra (1990), Oppe (1991a and b) and Koornstra (1992). Previous analyses of safety trends in Poland have been made by Oppe and Koornstra (1992) and Koornstra (1996). The last study is based on data from 1953-1995. Because the Polish traffic system is still changing rapidly, an update from 1980 onwards, based on newly acquired data was suggested.

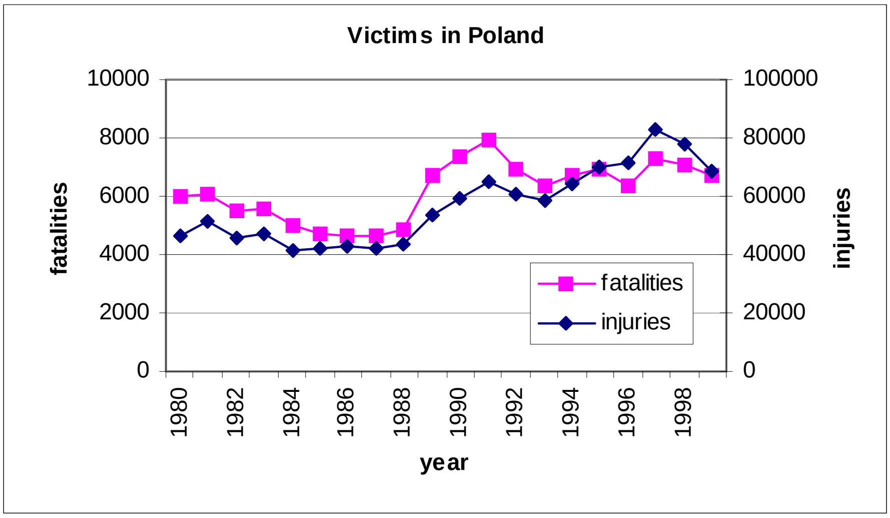


Figure 1. *Number of fatalities and injuries in Poland from 1980 to 1999.*

The data that will be used are annual numbers of fatalities in Poland and annual figures concerning the national vehicle park from 1980 to 1998. The most commonly used indicator for the traffic volume for a nation is expressed in the total number of motor vehicle kilometres per year. However, only scarce and incomplete data is available about vehicle use measured in vkm's, therefore vehicle park is used as a surrogate measure for traffic performance.

The first obvious, but most important observation for Poland is that for the last ten to fifteen years there has not been a stable situation in traffic and safety. The sudden change in safety after 1988 and again in recent years makes forecasts unreliable (see *Figure 1*). Therefore, in this study it is only possible to give a rough estimation of future safety developments, on the basis of general trends and recent changes in these trends, combined with the use of scenarios regarding future changes.

3. Model

There are a number of possibilities to analyse the Polish safety trends. The first is to use ARIMA modelling (AutoRegression and Moving Average Models with Integration techniques), directly to the number of fatalities as applied in Spain (European Co-operation in the Field of Scientific and Technical Research, 1999). This is only possible if monthly fatality data are available over a number of years (five or six years at least). This will make forecasts for one year possible and will primarily show the monthly deviations, but these forecasts give unreliable estimates for long-range trends. More refined exploratory techniques, such as ‘structural time-series analysis’ (Harvey, 1994) might give more insight in the underlying factors. Both the ARIMA model and Harvey’s model are generally applied directly to accident or casualty numbers. In this way they do not take into account the two underlying components, i.e. risk and exposure. Therefore, the best way to look at the problem is to start from a conceptual model in which safety is regarded as a function of exposure and risk. Exposure is best expressed in number of motor vehicle kilometres, but because of a lack of such data in Poland, it will be approximated by number of vehicles. This figure includes passenger cars, trucks, trailers and agricultural vehicles.
It should be realised that if the number of vehicle kilometres grows much faster than the number of vehicles, estimates based on vehicle park figures will be less accurate. In that case it is expected that the number of fatalities is under-estimated in the near future and over-estimated in the more distant future. After all, it will take time for society to adapt to the new situation, in which traffic growth is much higher than expected from the growth of the vehicle park. Therefore, if stronger safety measures are necessary in the near future, they will be even more effective in the distant future. Empirical evidence suggests that it takes an average of ten years for large scale safety programmes to become implemented and effective: the safety problems must be realised first, measures should be decided on, planned and financed, before implementation can take place.

In order to have some idea about the possible effect of the increase in vehicle use per vehicle, estimates of the development of the total number of vehicle kilometres are also used to make forecasts.
Especially if only short time-series are available, a simple parsimonious model should be used to describe the developments. Oppe (1991a) used a simple exponential decay function to describe the general trend in fatality rates. This so-called exponential ‘societal learning curve’ was borrowed from psychological learning theory, where the function was used to describe individual learning. For many countries it described the general decrease in risk surprisingly well, although deviations from the trend are apparent for shorter periods. The exponential decay function is defined as follows:

$$\frac{F_t}{V_t} = e^{\alpha t + \beta} \qquad (1)$$

where t is an index for time, and α and β parameters to be estimated. If α is negative, the fatality rate F_t/V_t will steadily decrease each year by a fixed percentage, finally to zero for t approaching infinity.

For the development of vkm's a simple logistic growth function was used:

$$V_t \quad = \quad \frac{V_{\max}}{1+e^{at+b}} \qquad (2)$$

where t is the index for time, V_{max} the saturation level for traffic in vkm's, and a and b are parameters. According to this function the amount of traffic will first grow quickly and level off later; the amount of traffic will finally reach its saturation level. This function therefore has a sigmoid shape.

The expected number of fatalities results from the product of these two equations. The combination of these two functions describes the rise and fall of the number of fatalities over time: at the initial accelerated part of the logistic function the number of fatalities rises (because the risk reduction cannot compensate for the accelerating increase in exposure); when traffic growth levels off, the steady risk reduction will finally bring the total number of fatalities down. This model was also used for Poland, with V (vkm's) in some analyses replaced by the number of vehicles.

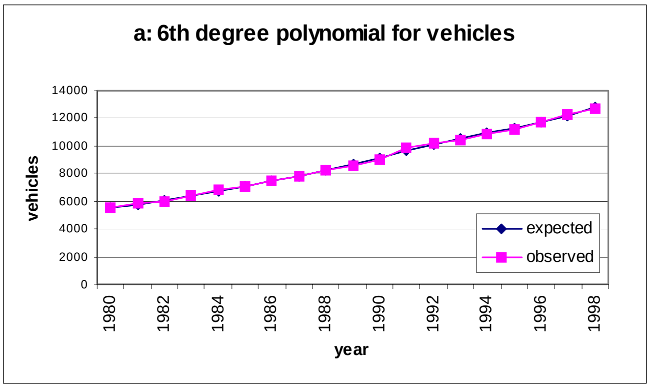
4. Results

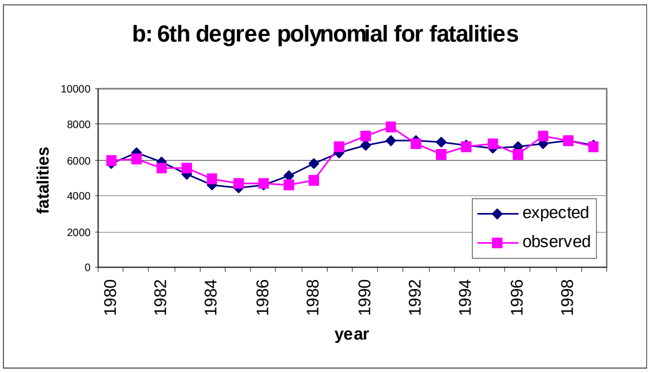
The data that was used is given in *Table 1*, together with the model predictions. The fifth column shows the risk: the observed numbers of fatalities (column 3) per 1000 vehicles (column 4). Column six, seven and eight show the expected values, based on the observed fatalities and the observed vehicle numbers. Columns eleven through thirteen show the same figures for the vehicle kilometres (shown in millions in *Table 1*).

Year	Obsv. casualt.	Obsv. fatalit.	Vehicle data 1980-1998					Vehicle kilometres 1985-1998				
			Observed		Expected values			Observed		Expected values		
			Vehicles	Risk	Vehicles	Risk	Fatalities	Vkm's	Risk	Vkm's	Risk	Fatalities
1980	46245	6002	5496	1.09	4007.93	0.91	3660.49			23.9	144.68	3458.38
1981	51365	6107	5853	1.04	4604.99	0.89	4087.93			26.9	137.30	3693.73
1982	45693	5535	5996	0.92	5238.07	0.86	4519.61			30.23	130.31	3938.56
1983	47463	5561	6417	0.87	5895.67	0.84	4944.45			33.9	123.66	4191.89
1984	41325	4980	6850	0.73	6564.27	0.82	5350.90			37.94	117.36	4452.48
1985	42290	4688	7089	0.66	7229.44	0.79	5727.96	47.5	98.69	42.37	111.38	4718.75
1986	43150	4667	7476	0.62	7877.04	0.77	6066.14	50.9	91.69	47.2	105.70	4988.79
1987	42272	4625	7795	0.59	8494.37	0.75	6358.23	53.8	85.97	52.44	100.32	5260.33
1988	43626	4851	8214	0.59	9071.16	0.73	6599.68	57.5	84.37	58.09	95.20	5530.77
1989	53639	6724	8596	0.78	9600.02	0.71	6788.71	61.1	110.05	64.16	90.35	5797.21
1990	59611	7333	9041	0.81	10076.67	0.69	6926.07	66.4	110.44	70.63	85.75	6056.48
1991	65242	7901	9860	0.80	10499.62	0.67	7014.53	74.9	105.49	77.48	81.37	6305.21
1992	61046	6946	10207	0.68	10869.78	0.65	7058.31	80.7	86.07	84.68	77.23	6539.93
1993	58812	6341	10438	0.61	11189.83	0.63	7062.51	85.6	74.08	92.20	73.29	6757.18
1994	64573	6744	10858	0.62	11463.69	0.61	7032.58	93.4	72.21	99.97	69.56	6953.62
1995	70226	6900	11186	0.62	11695.93	0.60	6973.97	101.8	67.78	107.95	66.01	7126.15
1996	71419	6359	11766	0.54	11891.38	0.58	6891.79	115.3	55.15	116.08	62.65	7272.07
1997	83169	7310	12284	0.60	12054.81	0.56	6790.72	130.2	56.14	124.29	59.45	7389.15
1998	77560	7080	12710	0.56	12190.75	0.55	6674.84	148.7	47.61	132.49	56.42	7475.75
1999	68449	6730			12303.31	0.53	6547.68			140.64	53.55	7530.88
2000					12396.18	0.52	6412.21			148.65	50.82	7554.23
2001					12472.55	0.50	6270.91			156.47	48.23	7546.15
2002					12535.22	0.49	6125.79			164.03	45.77	7507.64
2003					12586.52	0.47	5978.48			171.29	43.44	7440.25
2004					12628.45	0.46	5830.30			178.20	41.22	7346.02
2005					12662.68	0.45	5682.26			184.74	39.12	7227.37
2006					12690.59	0.44	5535.19			190.88	37.13	7086.96
2007					12713.32	0.42	5389.70			196.61	35.24	6927.62
2008					12731.82	0.41	5246.27			201.92	33.44	6752.23
2009					12746.87	0.40	5105.28			206.82	31.74	6563.61
2010					12759.11	0.39	4966.96			211.32	30.12	6364.52

Table 1. *Observed data from 1980 – 1999 and expected data up to 2010 from model (1) and (2) applied to vehicle park data (vehicle numbers in thousands) and vehicle kilometres (in millions).*

First a preliminary analysis was carried out, to get a rough indication about developments in the total number of vehicles, fatalities and fatalities/ vehicles. 6th degree polynomials were used to find ‘smoothed’ curves for these three series. The results are given in *Figures 2a-2c*.
Looking at the derivatives of these polynomials, one may get a rough idea about the rate of change of the three developments (see *Figures 3a-3c*).





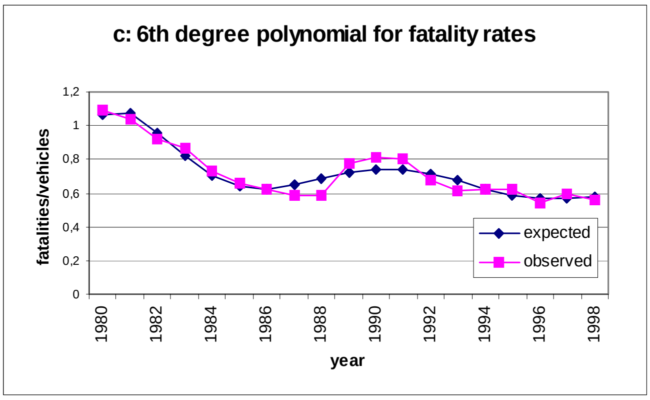


Figure 2a-2c. *6th degree polynomial smoothing for the number of vehicles (x1,000), fatalities and fatality rates (fatalities per 1,000 vehicles).*

For the number of vehicles there is a much clearer change in the growth rate now than seen from the raw data. Of course, this change will be more pronounced for the number of passenger cars and particularly for the number of vehicle kilometres.

This clear increase in the rate of growth of exposure up to 1991, as seen in *Figure 3a*, had a direct effect on the total number of fatalities as seen in *Figure 2b*. The decrease in growth rate is followed by a decreasing trend in the number of fatalities up to 1996. After that period we see a steep increase again in the growth rate of vehicles together with a negative effect on the number of fatalities. If this trend continues, then the number of fatalities will not decrease for a number of years.

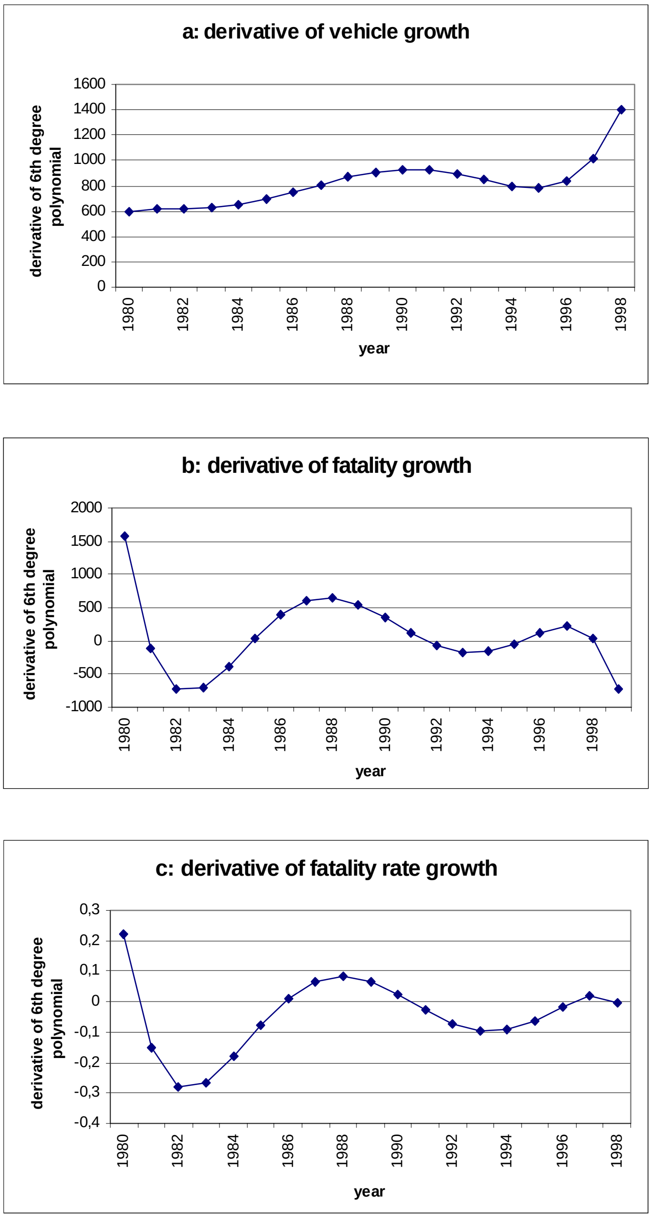


Figure 3a-3c. *Derivatives of 6th degree polynomial on vehicles, fatalities and fatality rates.*

For the fatalities and fatality rates we see similar trends for the derivatives, although the zero points differ. This means that, on average, the fatality rates decrease more rapidly than the fatalities. For both curves there seems to be a positive development at the end of the scale, as can be seen from the raw data as well. However, it is important to know what can be expected from the vehicle development in the near future.

The preliminary analysis was followed by a joint analysis of volume and risk as described in the model section. In *Model 1* risk data defined as the fatality rate per 1000 vehicles from 1980 onwards was used. If the data from 1980 to 1990 were left out of the model, a considerably steeper decay function for risk would be found. This again indicates the change in risk development in the last decade.

Model 2 applied to the development of vkm’s is not well-defined. A conservative saturation level just over 1.3 million vehicles was found. Leaving out the data from 1980 to 1990 again resulted in a considerable change in development. Both predictions were used in the estimation of the number of fatalities. The results are given in *Figure 4*. The data based on the whole period from 1980 onwards pictures a development at a lower pace, leading to an estimated number of 5000 fatalities in 2010. The estimation based on data from 1990 onwards shows a more rapid development, resulting in less than 4000 fatalities in 2010. A scenario approach has been applied to get rough estimates of vkm’s. The outcome of this approach shows a very rapidly growing number of vkm’s.

If the outcomes of an analysis with this data are compared with the outcomes based on the rough estimates of vehicle kilometres (x 10^9) from 1985 onwards, then it turns out that for the near future a further increase in fatalities is to be expected, followed by a decrease that still results in more than 6000 fatalities in 2010 (see *Figure 5*).

If more realistic scenarios are available for the growth of the vehicle park or the number of vehicle kilometres, starting from 1998, then the predictions for the total number of fatalities from 1999 to 2010 could be improved, using these figures combined with the given forecasts for the corresponding risks over that period.

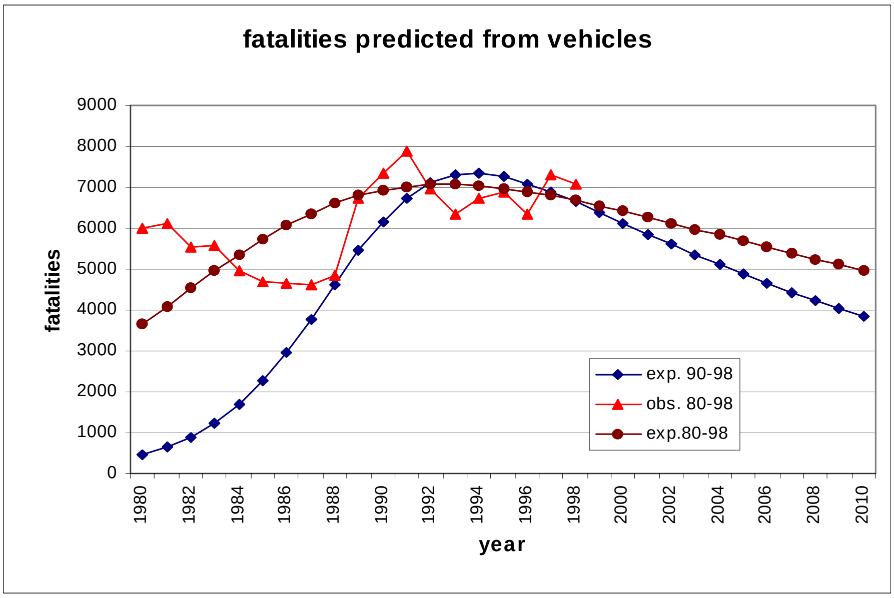


Figure 4. *Development of fatalities predicted from numbers of vehicles and related risk data from 1980 onwards, and from the same data from 1990 onwards, using model (1) and (2).*

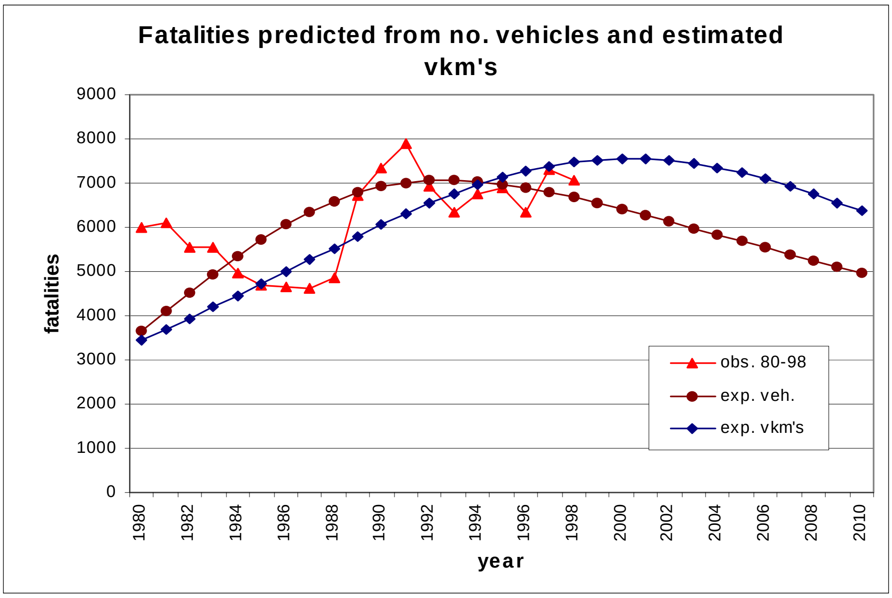


Figure 5. *Development of fatalities predicted from numbers of vehicles and related risk data from 1980 onwards, and from vkm's and related risk data from 1985 onwards, using model (1) and (2).*

5. Conclusions

It is clear that the rapidly changing situation in Poland over the last twelve years makes it difficult to give reliable forecasts for future developments. The level of safety, expressed in the total number of fatalities per year, is strongly dependent on the rate of change in the amount of traffic. If the indications based on the development of the number of vehicle kilometres are correct, a further increase in the number of fatalities is to be expected in the near future. If traffic growth is more conservative and fairly measured by the growth rate of the vehicle park, then coming years should show a drop in the number of fatalities.

What is clear from the developments so far is that such a positive change in the number of fatalities can only be reached, if a continuous effort is put into the reduction of risk that is equal to or larger than the reduction of risk that was found for the last ten years.
If the recent increase in vehicle park growth and probably an even steeper increase in the growth of the number of vehicle kilometres continue, then an intensified traffic safety programme will be necessary to annihilate the effect of this growth on the number of fatalities.
In order to initiate an increased effort in traffic safety, it has been shown that only realistic but ambitious safety targets will be effective.
Continuous monitoring of the traffic and safety developments are necessary to detect deviations from expected trends. The outcomes can be used to evaluate the effectiveness of the safety programme and the extent to which the safety targets will be reached.

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