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The comparison of number of deaths in accidents with the agriculture and forestry tractors among European countries

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ABSTRACT

Agricultural and forestry tractors are very often involved in accidents with overturning because of their construction with a high centre of gravity. Such accidents are caused by various factors such as drivers, vehicles, driving conditions, or landscape/terrain. The data related to the number of deaths in accidents with agriculture and forestry tractors was collected from several European countries. The landscapes (or terrain) of the countries for tractor traffic was assessed by the coefficient of the topography and the economic development level of the countries was evaluated in terms of the GDP. The correlation analysis among the factors showed us that neither the relief of the country landscape nor the economic development level of the countries have a significant influence on the number of deaths in such accidents. The essential influence is in the legislation for the tractors and drivers. The comparison of three countries (Austria, Slovenia, and Serbia) showed the implementation of legislation in this area and time are needed for reducing the number of deaths by half.

Key words: agriculture tractors, forestry tractors, accidents, deaths in traffic accidents, influence of factors

IZVLEČEK

PRIMERJAVA ŠTEVILA MRTVIH V NESREČAH S KMETIJSKIMI IN GOZDARSKIMI TRAKTORJI PO EVROPSKIH DRŽAVAH

Kmetijski in gozdarski traktorji so zelo pogosto vpleteni v nesreče s prevračanjem, saj imajo zaradi njihove konstrukcije zelo visoko težišče. Take nesreče se dogajajo zaradi različnih vplivov kot so vozniki, vozila, vozne razmere ali površina/teren. Zbrani so bili podatki o številu mrtvih v nesrečah s kmetijskimi in gozdarskimi traktorji za več evropskih držav. Oblika površine držav, po katerih poteka vožnja traktorja, je bila ocenjena s koeficientom topografije, stopnja gospodarskega razvoja držav pa je bila ocenjena z BDP. Korelacijska analiza med faktorji je pokazala, da niti oblika površine države niti stopnja gospodarskega razvoja držav nimata močnejšega vpliva na število mrtvih v tovrstnih nesrečah. Bistveni vpliv imajo predpisi za traktorje in voznike. Primerjava treh držav (Avstrije, Slovenije in Srbije) je pokazala, da sta potrebna implementacija predpisov na tem področju in čas, da se število mrtvih prepolovi.

Ključne besede: kmetijski traktorji, gozdarski traktorji, nesreče, mrtvi v prometnih nesrečah, vpliv faktorjev

1 INTRODUCTION

Agricultural and forestry tractors, so-called off-highway vehicles, have significantly impacted the safety and health on road and in working places as their numbers increase in rural areas. Because of their working nature and construction with a higher centre of gravity, tractors are often classified as a high-risk vehicle. The major cause of accidents related to agricultural and forestry tractors is overturning. Researchers have collected the number of deaths in accidents with agriculture and forestry tractors with the help of international authorities and organisations in other European countries since the year 1990.

The number of motor vehicles has been growing continuously due to industrialisation in the Republic of Slovenia just like in other developed countries. The traffic is increasingly dense, and our surroundings are polluted by toxic gases and noise. Consequently, many

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traffic accidents occur as well. Although the causes of accidents vary, in Slovenia the majority of them are due to unsuitable speed (19% of accidents) and the use of alcohol (15% of accidents) (Hribernik, 1995). In many other states in Europe the situation is very similar. It is impossible to prohibit selling alcohol and avoid speeding. Therefore, we must make changes in other fields. In addition to building better roads, we can also improve the safety of motor vehicles in terms of other strategies. For these reasons, experts all around the world carry out a large number of investigations, perform tests on vehicles and their parts, and then develop better technology and legislation to make improvements on motor vehicles. Besides the legislation, there are also the rules that regulate the implementation of equipment and specify vehicles' safety features in use.

In the European Union there are a lot of regulations and rules regulating the conditions and technical prescriptions for the producers of motor vehicles and their trailers and all types and variants of those vehicles have to be type-approved before selling in the market (The Acquis..., 2006). However, these regulations and rules are valid not only for road motor vehicles and their trailers, but also for agricultural and forestry tractors. These vehicles can be operated on roads, on fields, and in forests. Therefore, accidents with tractors happen very often for a variety of reasons.

Tractors are nowadays present on almost every farm in Slovenia and in the world. According to the statistical data (FAO, 2004), there are 116 tractors per 100 farms in Slovenia while there are different rates of tractor population in other developed states such as Portugal – 51, Italy – 59, Austria – 132, France – 158, and Great Britain – 205. Furthermore, there are 0.25 tractors / ha in Slovenia, which is ahead of some EU Member States such as France with 0.08 tractor/ha, and Austria with 0.10/ha).

A lot of drivers or their attendees are killed every year in tractor accidents in the agricultural and forestry industries. There were 821 fatalities related to tractor accidents in the Republic of Slovenia from 1981 to 2006 (Jerončič, 2008). Fortunately, the number of victims has been declining yearly. As the tractors are used on public roads, macadamised roads, and fields, these accidents could happen anywhere. Particularly, because a tractor is a slow vehicle, it is often in danger when it is on congested public roads. Even worse is that the tractors run mainly on rural roads where the driving conditions are rough and unpredictable.

We divide the accidents related to agriculture and forestry tractors into traffic accidents and working accidents. A traffic accident occurs when a tractor is on public roads, while a working accident occurs at the workplace on a farm, field, meadow, or forest etc (Hribernik, 1995).

2 THEORETICAL CONSIDERATIONS

There are many reasons that cause agricultural and forestry tractors accidents. We will divide them into those related to:

(1) the driver (inexperience, alcohol, incorrect reaction of the driver …),
(2) the tractor (technical conditions of the vehicle, maintenance …),
(3) the driving conditions (slippery driving surface, bad weather conditions …).

The most frequent cause of tractor accidents in agricultural and forestry industries is unprofessional operation, such as driving a tractor with inappropriate technique, speeding or overturning on a slope or incompetent maintenance and repairs, replacement of pneumatic tyres, or fuel filling.

Accidents resulting from overturning of tractors represent about 40% of all tractor related accidents in Slovenia (Hribernik, 1995). A tractor may be unstable on an uneven surface because the tractor has a relatively high centre of gravity, a short wheelbase, and a narrow track width. The stability of the tractor (static and dynamic) changes due to several reasons such as the slope and characteristic of the driving terrain, inappropriate speed in certain conditions, skidding of the driving wheels, the amount of the force on pulling rod, dramatic changes of movement of the tractor like standstill – driving, driving – inappropriate stopping.

Although tractor manufacturers build safer tractors, they cannot, presently, build a tractor that can "recognize" a dangerous situation. Implementation of ROPS, safety arcs, cabins, or safety belts reduces the number of victims, but the development of new tractors also continues to challenge safety structure capabilities. Overturning could still happen because of fast driving, sharp turning, sudden obstacles such as rocks and holes on the road, driving over canals, pushing by towing trailer, and inappropriate use of front loading devices (Ayers, 1992; Hoppe, 2005; Hunter, 1991).

In order to evaluate the influence of terrain on a tractor accident, the authors have developed a coefficient of the topography based on topography or on the mountain

area out of the country area (Jerončič, 2008). The topography is defined:

$$\text{Coefficient of the topography} = \begin{cases} 0; \text{when the terrain} \\ \text{is all of flat} \\ 1: \text{when the areas} \\ \text{are all in the mountain} \end{cases}$$

The diagrams below demonstrates the definition of the coefficient of the topography. For instance, if the coefficient of the topography is 0.4, this means that the approx. 40% of the country area is less than 200 meters high, and approx. 60% of the country area is over 200 meters high (above the sea level). The topography is included as a variable in this study. The average altitude of the Netherlands is very low, a few meters above sea level. In such case the coefficient of the topography is close to 0 (Fig. 1). The average altitude of Poland is medium, there are flat and low places and there are also mountains. In this case the coefficient of the topography depends of the percentage of the mountain area versus the flat and low areas (Fig. 2). The average altitude of the Switzerland is very high. There are a lot of mountains, therefore the coefficient of the topography is close to 1 (Fig. 3).

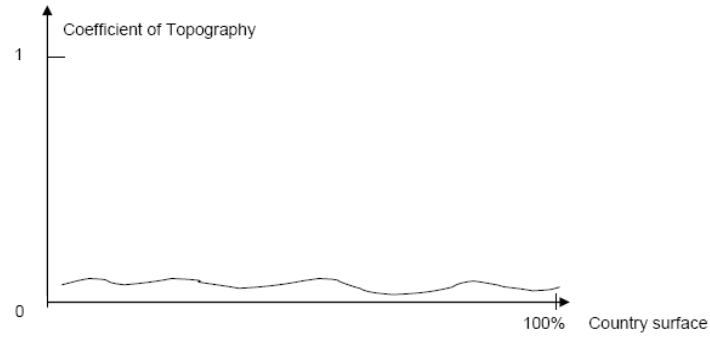

Figure 1: Example for a very flat country (i.e. the Netherlands)

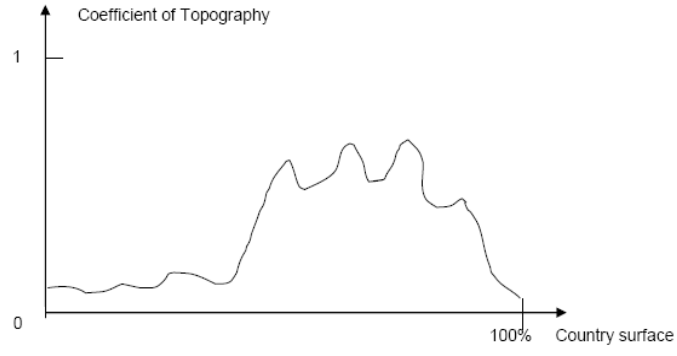

Figure 2: Example for a country with flat places and some mountains (i.e. Poland)

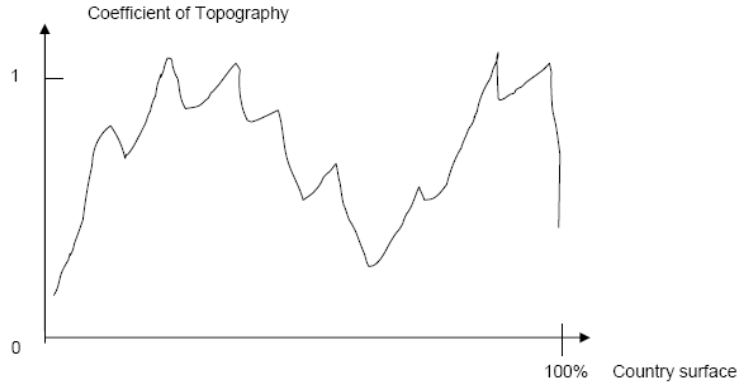

Figure 3: Example for a country with a lot of mountains (i.e. Switzerland)

3 MATERIALS AND METHODS

Most of the data about the number of deaths in accidents related to agricultural and forestry tractors was gathered with the inquiry, the others was acquired from the Web-based EU data base CARE (Jerončič, 2008). Questionnaires were sent to the authorities and/or statistical institutions in other EU Member States.

As mentioned before we have to estimate the topography of countries that the data of deaths in accidents related to agriculture and forestry tractors was gathered. We are able to estimate the coefficient of the topography. This may be a subjective estimation or presumption, but we took it into account as a real estimation of the form of the landscape. For this reason we took into account that the confidence of this data is only 90%. The coefficient has values between 0 and 1. For a country with a lot of mountains it is closer to 1, and for a very flat country it is closer to 0. Values were estimated and defined based on the maps of the countries (Table 2) (Jerončič, 2008). From the value of the GDP, we could make inferences about the economic development level of the country where technical characteristics of the tractors and qualification of the drivers are considered. The coefficient of the development of the country was calculated, relative to the biggest value for Luxemburg from selected countries (Table 3)..

Table 1: Deaths in traffic accidents with agricultural and forestry tractors

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
SLOVENIA	18	8	11	12	13	8	6	9	7	6
FINLAND	-	2	7	3	1	5	5	4	1	3
AUSTRIA	-	24	13	18	20	20	15	7	13	12
NETHERLANDS	-	7	1	5	3	1	2	2	2	4
SWEDEN	-	5	4	2	1	5	0	3	3	6
GERMANY	-	-	115	112	94	107	134	112	101	106
LUXEMBURG	-	-	-	-	-	-	-	1	1	0
GREAT BRITAIN	-	-	-	-	-	-	-	-	55	44
PORTUGAL	-	-	-	-	-	-	34	36	40	35
ESTONIA	32	23	12	14	17	9	4	4	9	1
LATVIA	-	-	-	-	-	14	7	12	15	10
POLAND	175	123	115	111	93	98	68	84	82	72
SWITZERLAND	-	-	-	-	-	-	27	26	26	24
SERBIA	107	94	80	69	74	66	72	106	81	55
BELGIUM	0	4	2	1	2	4	3	2	3	4
DANMARK	-	3	3	3	4	2	0	0	3	2
FRANCE	-	43	37	28	32	32	36	35	22	20
GREECE	-	114	93	79	99	81	44	80	61	71
ITALY	-	51	40	42	47	30	38	31	23	38
SPAIN	-	43	40	23	26	30	36	33	30	32
CROATIA	-	-	-	-	-	-	20	14	8	3
MACEDONIA	-	-	-	15	11	13	5	14	4	15

	2000	2001	2002	2003	2004	2005	2006	2007
SLOVENIA	5	10	4	4	9	4	2	-
FINLAND	4	2	2	3	1	0	2	0
AUSTRIA	19	15	12	10	7	8	8	9
NETHERLANDS	3	1	2	5	5	5	1	2
SWEDEN	4	0	3	2	5	1	3	1
GERMANY	95	96	104	110	87	-	-	-
LUXEMBURG	2	0	0	0	0	0	-	-
GREAT BRITAIN	53	4	38	51	7	0	-	-
PORTUGAL	42	38	38	27	35	33	41	32
ESTONIA	2	7	4	2	-	2	0	0
LATVIA	7	10	9	11	10	-	-	-
POLAND	72	62	47	61	57	67	-	-
SWITZERLAND	28	23	20	25	18	13	-	-
SERBIA	58	77	74	65	71	58	54	-
BELGIUM	5	0	1	2	3	1	2	-
DANMARK	3	1	0	0	0	3	2	1
FRANCE	26	12	20	25	13	12	12	11
GREECE	54	72	43	46	37	26	29	-
ITALY	28	24	23	24	23	23	-	-
SPAIN	35	28	16	23	40	26	32	-
CROATIA	10	13	14	8	10	13	-	-
MACEDONIA	7	7	10	2	-	-	-	-

Note: "-" in the table indicates no data available

Table 2: The coefficient of the topography (Jerončič, 2008)

Country	Coefficient of the topography – estimation (*)	Country	Coefficient of the topography – estimation (*)
Netherlands	0.05	Greece	0.5
Estonia	0.05	Germany	0.6
Denmark	0.05	Portugal	0.6
Latvia	0.1	France	0.6
Great Britain	0.2	Spain	0.6
Belgium	0.2	Croatia	0.6
Finland	0.3	Slovenia	0.7
Sweden	0.4	Italy	0.7
Luxemburg	0.4	Macedonia	0.8
Poland	0.4	Austria	0.8
Serbia	0.4	Switzerland	0.9

(*) the confidence of the data is 90%

Table 3: The GDP of the countries (Tosi et al., 2002)

Country	The development of the country		Country	The development of the country	
	GDP in USD	Coefficient		GDP in USD	Coefficient
Serbia	900	0.039	Italy	17180	0.753
Croatia	2640	0.116	Austria	17500	0.767
Latvia	4480	0.196	Netherlands	17940	0.786
Poland	4920	0.216	Great Britain	17980	0.788
Estonia	6460	0.283	Belgium	18040	0.79
Greece	8870	0.389	Sweden	18580	0.814
Slovenia	9352	0.41	France	18670	0.818
Portugal	10190	0.446	Denmark	19860	0.87
Spain	13120	0.575	Switzerland	22080	0.967
Finland	16140	0.707	Luxemburg	22830	1
Germany	16580	0.726			

4 RESULTS AND ANALYSIS

As already indicated, the data has been collected in several European countries. Ideally, a more reliable analysis could be performed if we could have information for every accident case and for the essential parameters such as type of tractor, age of tractor, condition of the driver, education of driver etc. As this study is hard to obtain and trace all of the accident information, the analysis was performed on the basis of certain assumptions.

Direct comparison based on statistics about accidents or deaths and injuries is not feasible. We had to take into consideration major factors that influence data comparison. Firstly, the number of tractors in use in the countries was considered, and therefore it is obvious that more tractors in operation consequently result in more accidents. Furthermore, it is also important that the data is based on the number of tractors per area. The data indicates that the density of tractors in an area results in a higher potential rate of accidents and deaths. For example, in Germany there are almost 1.2 million agricultural and forestry tractors in use and the number of deaths in accidents is every year more than 100 (Schauer, 2004; Schelo, 2005). On the other hand, in the Netherlands there are only about 150.000 agricultural and forestry tractors in use and there are only 5 deaths per year in accidents with those vehicles (Jeroničič, 2008). The comparison of the economic development level of the countries in terms of GDP can induce several other factors such as technical development of the vehicle fleet, the education of the drivers, the purpose for which the tractors are used, driving culture, and consciousness of the drivers.
Moreover, it is very important that the analysis is based on the number of accidents and deaths pertaining to a landscape in the country. It is clearly shown that flat countries such as The Netherlands and Denmark have a much lower number of tractor overturns than the countries with more mountain (Switzerland, Austria, etc…). Although the number of tractors in use varied with years, the number in a reference year was used for analysis because the change of number of tractors in percentage within a few years was so small that it does not mean a substantial calculating mistake.

4.1 INFLUENCE OF FACTORS

We could analyse the relationships from calculations for the purpose of correlations. If the value of the correlation is 1, then it indicates a full linear mathematical connection among variables. If the value of the correlation is 0, then it means that there is not a linear connection among variables.

Since we have the most complete mortality data for 2000, we can accurately calculate the correlation for this year. For the calculations of the correlation the software MATLAB has been used. The correlation for the number of deaths per area is at the coefficient of the topography 0.2735 and at the coefficient of GDP 0.1637. Furthermore, the decision was made to calculate also the correlation for a period of years. If we account the data for a period of 5 years (1996 – 2000), the correlation is at a coefficient of the topography 0.2654. It is unnecessary to calculate the correlation at the coefficient of GDP because the value of GDP changes within only a few years and this causes an additional impact on the calculation. They probably do not change much on a relative scale.

In the next step, calculations of the correlation at the coefficient of the topography were done. The correlation for the year 2000 between the number of deaths and number of tractors is for the coefficient of the topography 0.1762 and at the coefficient of GDP -0.0608. Also here we calculated the correlation for a longer period than one year. If we consider the data for a period of 5 years (1996 – 2000), the correlation will be for the coefficient of the topography 0.0924.

Based on these results, we can conclude that the relief of the surface and the value of GDP have almost no influence on the number of deaths with agricultural and forestry tractors. The significant influence on the number of deaths related to agricultural and forestry tractors are the tractor characteristics and the driver. Indirectly, this indicates the important influence of legislation on traffic safety and the reduction of the number of deaths.

According to these facts, we can now compare the number of deaths in different countries without multiplication of data with the coefficients of the relief and the GDP.

4.2 COMPARING OF COUNTRIES

Comparing Austria, Serbia and Slovenia, we can find considerable geographic similarities. In all countries, there is a rugged landscape and an extensive alpine area where the driving conditions for tractors are always very problematic. However, the situation regarding the legislation in these countries is very different. Namely, with legislation the safety elements to be fitted in the tractor are prescribed and therefore tractors are safer for drivers and other participants in road traffic. Austria had started to regulate agricultural and forestry tractors long ago. On the other hand, Serbia is geographically different because there are plains in Vojvodina in the North of Serbia and a very rugged surface in the central and southern regions. Serbia has had a substantial delay for legislation and does not follow the development of

legislation. We can compare this with all three types of reference data and divide the number of deaths in accidents with the agricultural and forestry tractors by the number of tractors, by the size of the area that is cultivated, and by the number of residents.

There is a difficulty in defining the correct number of agriculture and forestry tractors in Slovenia. According to the data from the Ministry of the Interior on 31.08.2005, there are 87,617 registered agricultural and forestry tractors in Slovenia (Jerončič, 2008); however, the experts who work in the agriculture field estimate there are actually 130,000 tractors in use (Hribernik, 1995). Therefore, we must compare the countries, take into account both data, and the area between these values.

5 DISCUSSION

All three diagrams *(Fig. 6, 7 and 8)* indicate that Austria has a lower death rate in accidents with agricultural and forestry tractors than Serbia does . If we look at the number of deaths divided by the number of tractors we could see Slovenia has an average from 1.82 to 2.69 times (depending on the number of the tractors being calculated) more deaths than Austria. The death rate in Serbia is 4.90 times more than in Austria. If the number of deaths is divided by the area, we could see Slovenia has an average 2.28 times more deaths than Austria, and Serbia is 3.39 times more than Austria. The death rate per citizen in Slovenia is an average 2.27 times more than in Austria, and Serbia is 4.91 times more than in Austria.

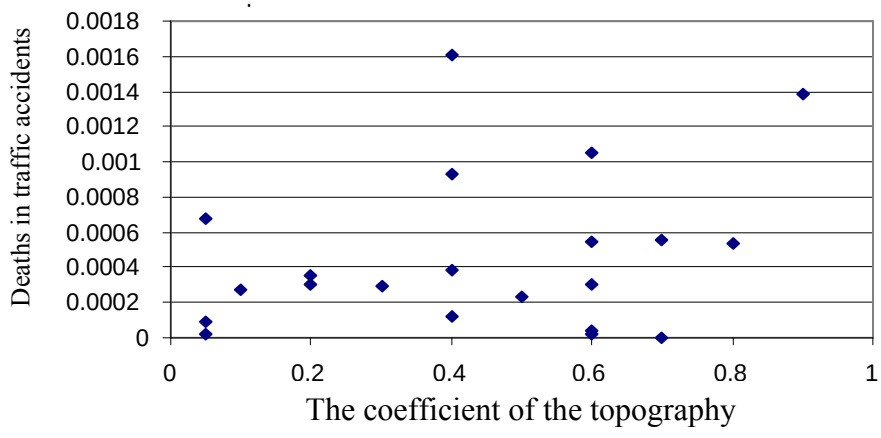

Figure 4: The graphical review of the regression between the data (topography)

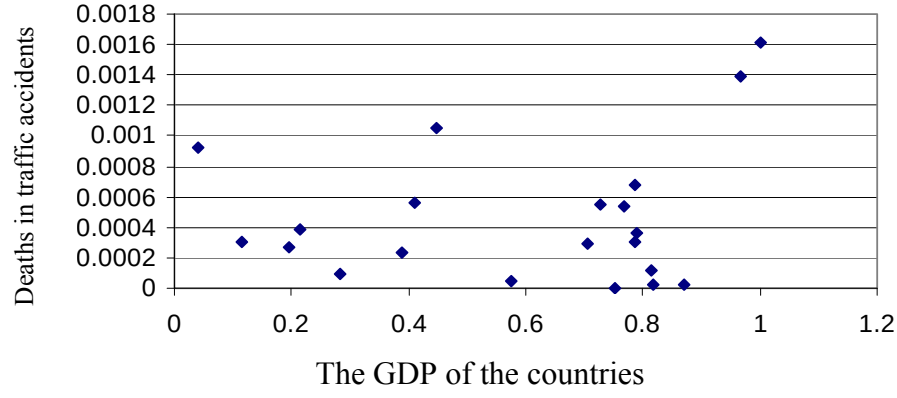

Figure 5: The graphical review of the regression between the data (GDP)

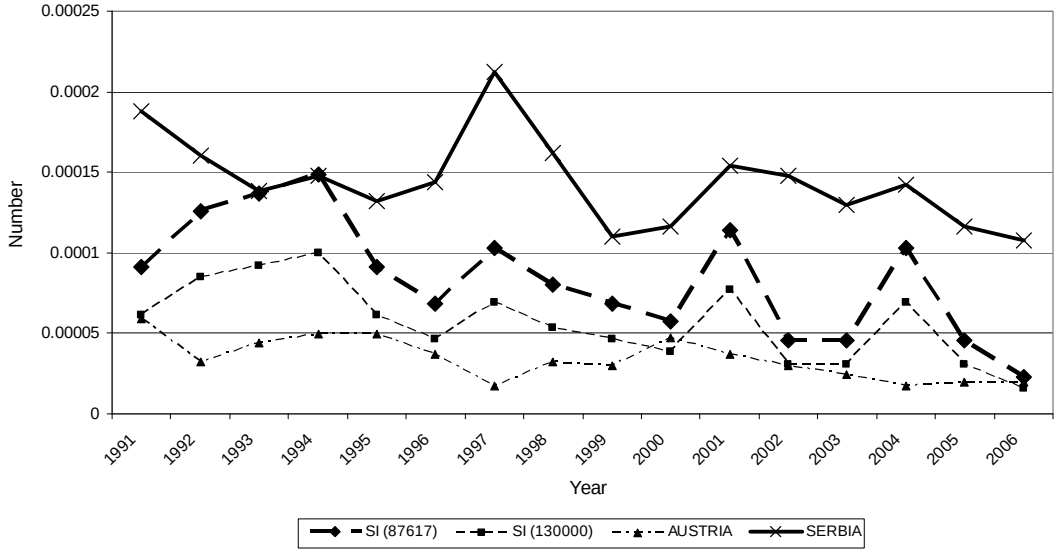

Figure 6: The comparison of reference data (deaths dividing by the number of tractors) between Slovenia, Austria and Serbia

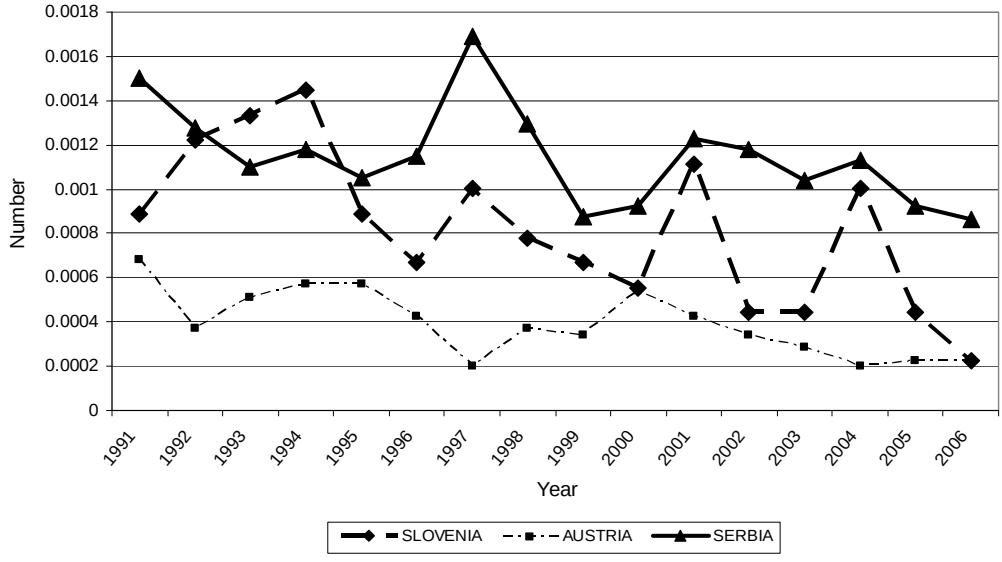

Figure 7: The comparison of reference data (deaths dividing by the area) between Slovenia, Austria and Serbia

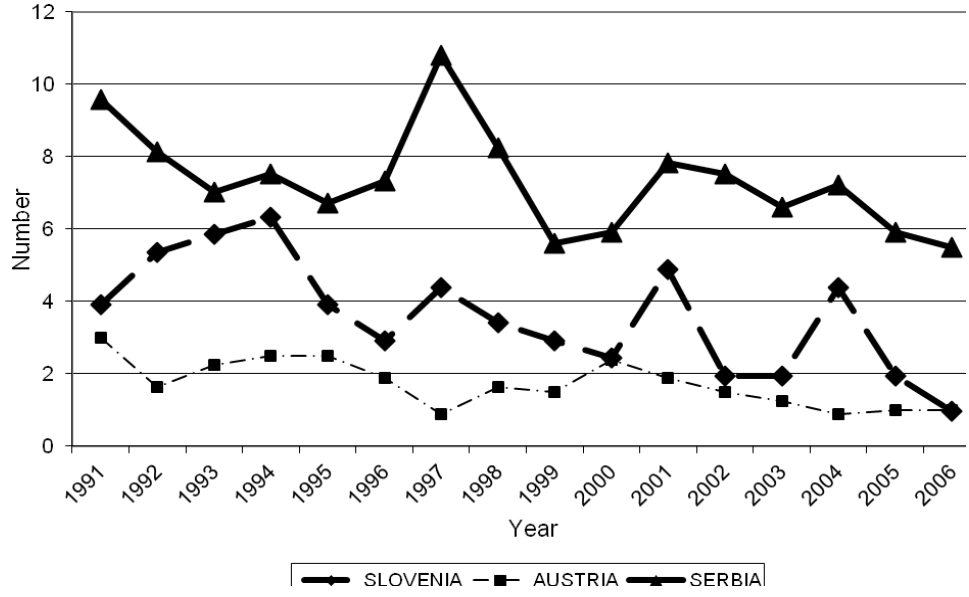

Figure 8: The comparison of reference data (deaths dividing by the number of residents) between Slovenia, Austria and Serbia

Although Slovenia and Austria have very similar landscape and therefore also very similar coefficient of the topography, it was indicated that this does not have a significant influence on the number of deaths in accidents with agricultural and forestry tractors. In Slovenia, the number of deaths in accidents with those vehicles is much higher than in Austria. But if we compare the regulation for agricultural and forestry tractors we could find out the following interesting result. Austria started to regulate motor vehicles with the prescriptions in terms of the first act on motor vehicles about 1923 (Wurst, 2004). This was almost 60 years earlier than Slovenia did. This reflects the fact that despite very similar geographic landscape the number of deaths with agriculture and forestry tractors in Austria is significantly less than in Slovenia.

Serbia started to regulate motor vehicles with the prescriptions at the same time as the whole of Yugoslavia and Slovenia. However, Slovenia took a big step in the years after 1993 when the legal system started systematically upgrading and implementing the international UN/ECE regulations into the national legislation. Serbia has remained on the same level as before. Furthermore, in their market as the major tractor manufacturer, IMT, does not follow the development of the technique, and therefore their tractors do not comply with the approved valid prescriptions.

6 CONCLUSIONS

This research has conducted a comprehensive analysis of the impact of various factors on the death rate related to tractors in agricultural and forestry industry and demonstrates quite a surprising finding. Neither the relief of the country or the landscape where the agricultural and forestry tractors are used, nor the economic development level of the country have a significant influence on the number of deaths in accidents related to the agricultural and forestry tractors. The most significant influence on the number of deaths is the tractor and the driver. Indirectly, this indicates that the influence of the legislation on motor vehicles is when some countries start to implement conformity assessment of tractors before they offer products to the market and the yearly technical inspections of tractors in use. In the EU Member States each type of tractor with all of its variants has to be type-approved before being offered for sale. That means that every type of tractor undergoes several tests and checks and then the EU Whole vehicle type approval document is issued. This area has gradually been regulated, therefore improving the safety of traffic, and reducing the number of deaths related to tractors.

Furthermore, the implementation of the prescriptions possibly and gradually halves the number of deaths if we compare Austria and Slovenia. With the same approach, it is possible to predict what the future outcome should be in Serbia with the full implementation of all of the relevant prescriptions to agricultural and forestry tractors. After approximately 15 years the number of deaths in accidents related to agricultural and forestry tractors will be reduced by 50%.

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