

Statistical Analysis of Road Accidents in Slovenia in Period 1996-2000

Elvir Mujkić¹ and Jože Rovan²

Abstract

Slovenia is facing similar traffic problems as many other countries in the world. A new traffic law, compliant with the European Union Guidelines, was adopted on May 1st, 1998. The main aim of the new law was to improve road safety by means of setting lower speed limits, by stressing compulsory use of safety equipment and by reducing the number of alcoholised drivers.

The goal of this article was to find out whether the new law had contributed to safer and more effective transportation system in Slovenia. We found out that the new law had some positive impacts. Aggravation of penalty policy, that concentrated in particular on new drivers with no experience, proved to be the right one. We found out that the new drivers did not step out as much as they did in the past, but there is still much to be done. We found out that today people are using safety belts and other safety equipment more regularly. The percentage of alcoholised accident provokers has also decreased. Nevertheless authorities would have to focus on this problem in future and introduce some specific measures (prevention measures, imprisonment of alcoholised drivers). Alcohol problem is a cultural problem so no major improvements can be expected in short term.

Data has shown that advanced technology in automobiles has had the highest impact on decreasing the number of fatalities on the roads. We can also give some credit to the new law, new highways and policemen actions.

The comparison of the situation in Slovenia with some other European countries has revealed that the road safety in Slovenia is far behind the level of European Union. Slovenia is in a very delicate situation. On one hand the number of automobiles is steadily growing while on the other hand we face large problems with traffic safety and law obedience. We will have to improve legal system, especially fasten penalty proceedings. Finally we will have to make our whole system work if we want to close the gap between Slovenia and European Union countries.

¹ Cesta zmage 26, 1410 Zagorje ob Savi, Slovenia.

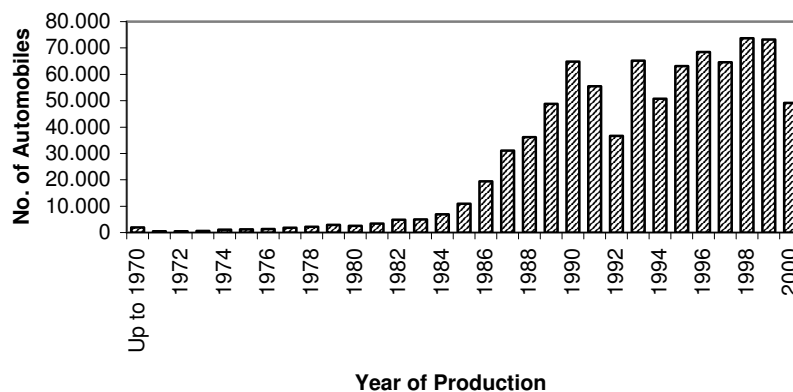
² Ekonomska fakulteta, Kardeljeva ploščad 17, 1000 Ljubljana, Slovenia.

1 Introduction

Since the invention of a wheel, people have striven for fast and comfortable travel. Automotive industry started with the invention of an internal-combustion engine. Serial manufacturing of Ford Model T made automobiles accessible to lower income classes. In this way, automobiles slowly became a necessity rather than luxury goods. Beside obvious advantages, there are many disadvantages of automobiles. The most important negatives are pollution and road accidents.

The first pedestrian died in 1896, while the first driver died in 1899. There were about 30 million deaths as a result of road accidents in the past century, with 1.17 million people dead in road accidents in 1998 alone. The annual costs of road accidents equal 1% of the World's GDP.

Slovenia is facing similar traffic problems as any other country in the world. A new traffic law, compliant with the European Union Guidelines, was adopted on May 1st, 1998. The main aim of the new law is to improve road safety by means of setting lower speed limits, by stressing compulsory use of safety equipment and by reducing the number of alcoholised drivers. In this article, we will try to evaluate the impact of the new traffic law on road safety.



Source: Database on registered vehicles in Slovenia in year 2000.

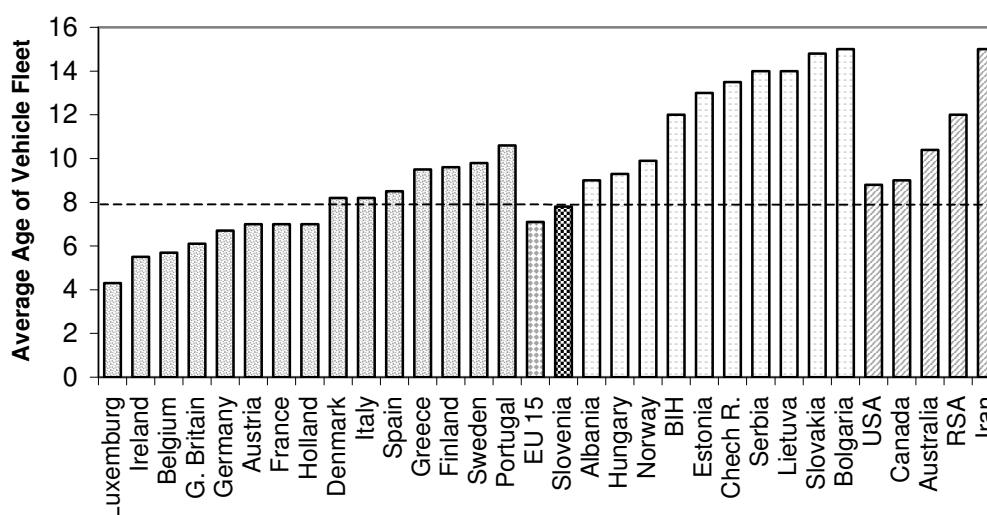
Figure 1: Distribution of passenger automobiles by age on Dec 31st 2000.

2 Slovenian motor vehicle fleet

On Dec 31st 2000 there were 1.035.937 motor vehicles registered in Slovenia. 81.9% of them were passenger automobiles, 6.2% tractors, 4.3% lorries, 2.8% trailers, 2% combined vehicles and 1.1% motorcycles. The most popular passenger

automobile trademark was Renault (17.1%). Many Zastava automobiles³⁾ (9.5%) are still present, but their proportion has dropped drastically from 46% in 1992 to only 9.5% in 2000. On the other hand, the market share of world-recognised trademarks, like Volkswagen, Fiat, Škoda and others, has been steadily growing during last ten years.

According to Figure 1, the majority of Slovenian automobiles were manufactured in the year 1990 and later. The sales of automobiles in the years 1991 and 1992 were relatively low because of unstable economic and political situation in Slovenia. Since then, the situation has improved and the sales of automobiles increased.



Source: Database on registered vehicles in Slovenia in 2000.

Sustainable Mobility 2030: A background report for WBCSD, Conference in Prague, May 2000.

European Environment Agency: Indicators and environmental integration in the EU TERM 2000.

Transportation energy data book: Edition 20, Nov 2000.

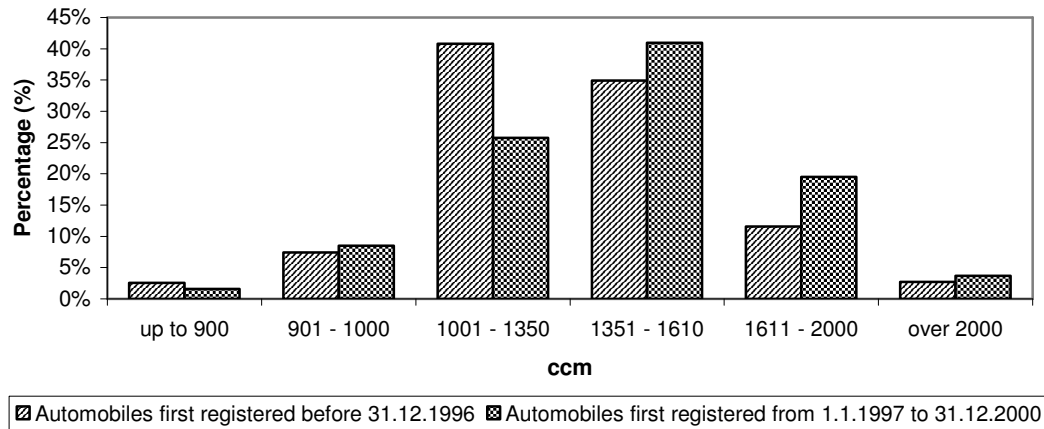
Economic Review, Volume 2, Aug 2001.

Figure 2: Comparison of the average age of fleets in Slovenia and some other countries in year 2000.

The average age of vehicle fleet in Slovenia is 7.8 years. As we can see from Figure 2, Slovenia is close to the average of the European Union, which is 7.1 years. Our fleet is even younger than the vehicle fleets of some EU members: Denmark, Italy, Spain, Greece, Finland, Sweden and Portugal. A young vehicle fleet assures that the majority of automobiles are technologically advantageous. This means less pollution and higher road safety (such automobiles have more safety equipment like ABS and airbags). Beside that, a tendency of buying

³⁾ Zastava has been the most important automobile manufacturer in the former Yugoslavia.

automobiles with larger and more powerful engines is also present (Figure 3). Nevertheless, the new vehicles are still of lower class than in the majority of EU countries.



Source: Database on registered vehicles in Slovenia in year 2000.

Figure 3: Automobiles by engine size (ccm).

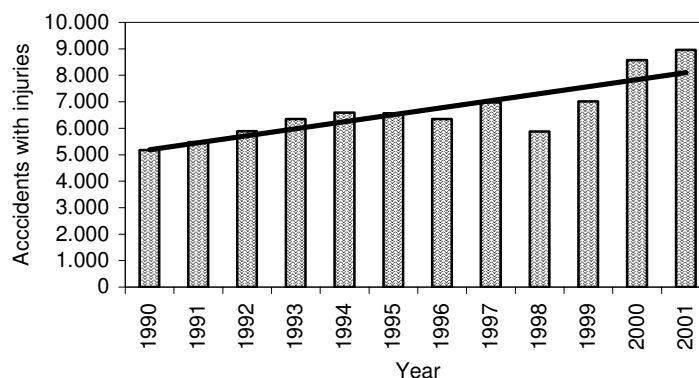
3 Road traffic accidents

In general, the number of road traffic accidents with injuries (including deaths) has steadily increased in past decade (Table 1 and Figure 4). On the other hand, the number of deaths has steadily decreased (Table 1 and Figure 5). Let us focus attention to substantive downward deviations from these two trends in 1998 when the new traffic law has been introduced. We can see that both the number of accidents with injuries and the number of accidents with deaths decreased in that year, which means that people were genuinely afraid of new law. Consequently, people drove carefully, within speed limits, which meant less road traffic accidents. Unfortunately, the demonstration effect of the new law did not last more than a few months and the number of accidents with injuries increased again in the next years. In spite of that, the number of deaths was about the same or even lower. According to the increase in the number of accidents with injuries we assume that the new law has not played a major role in decreasing the number of fatalities. This tendency is primarily the result of improved safety equipment of new automobiles and new highways. For the same reasons the year 2001 is characterised by the highest number of accidents with injuries on one hand and the lowest number of deaths on the other.

Table 1: Road traffic accidents in Slovenia in period 1990 – 2001.

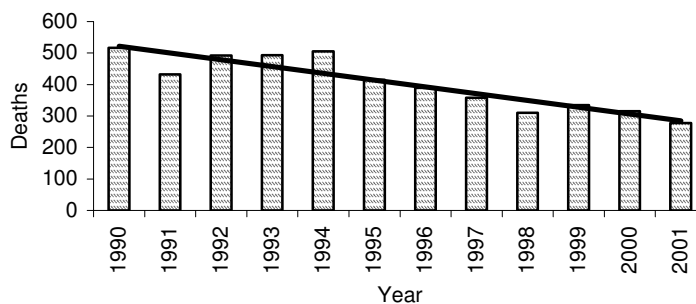
Year	<i>Accidents with injuries (including deaths)</i>	<i>Deaths</i>
1990	5.180	517
1991	5.479	432
1992	5.890	492
1993	6.349	493
1994	6.595	505
1995	6.567	415
1996	6.352	389
1997	6.973	358
1998	5.876	310
1999	7.009	335
2000	8.573	315
2001	8.956	278

Source: Database on road accidents in Slovenia in period 1995 – 2000. Police, Traffic safety, Statistics, 15.1.2002.



Source: Table 1.

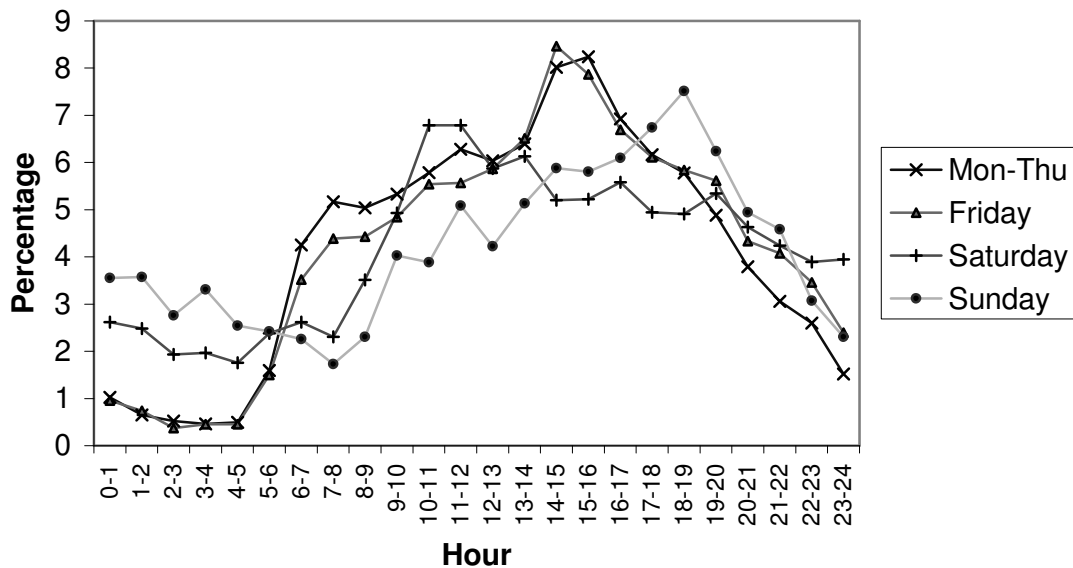
Figure 4: Number of injuries or deaths in road traffic accidents in Slovenia in period 1990-2001.



Source: Table 1.

Figure 5: Number of deaths in road traffic accidents in Slovenia in period 1990-2001.

If we turn our attention to the time when the accidents happen (Figure 6), we can conclude that there were no major changes in past few years⁴. Most road traffic accidents still happen from 13:00-17:00 on working days. On weekends accidents are distributed more evenly during the day. The highest numbers of accidents occur on Fridays, which have typical characteristics of working days but also some characteristics of weekends (departure towards weekend destination in the late afternoon, night life etc.)



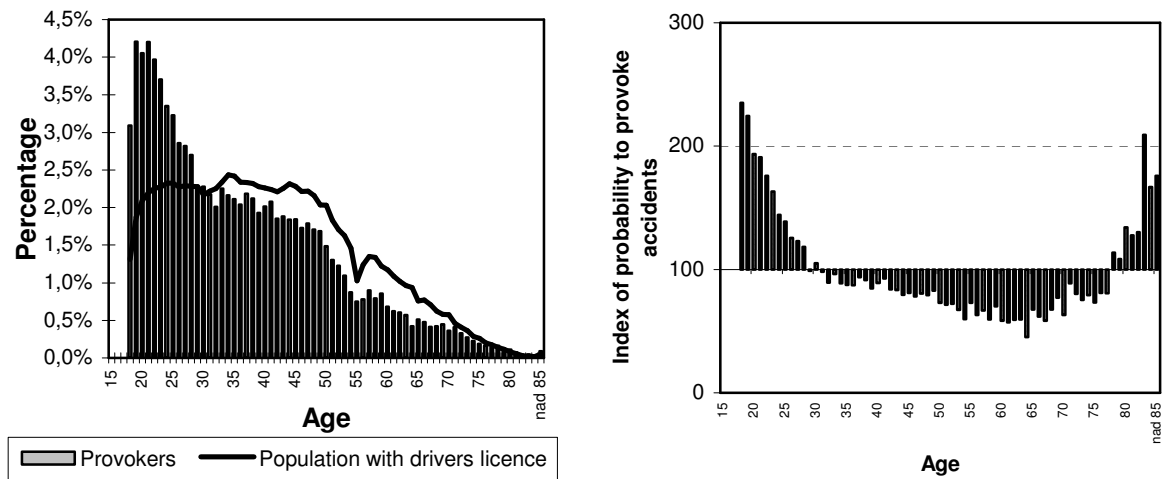
*100 % = 24 hours

Source: Database on participants in road accidents in Slovenia in year 2000.

Figure 6: The time of road traffic accidents in Slovenia in year 2000.

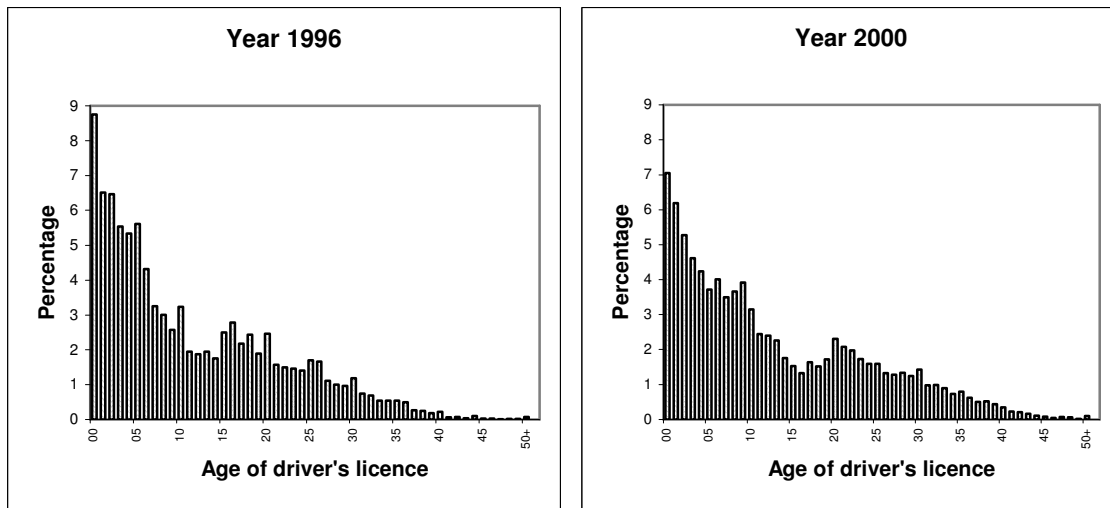
Road traffic accidents are also evenly distributed during the entire year. Surprisingly, accidents, which happen in winter, are less severe. It seems that police actions and winter equipment check-ups force the drivers to prepare for difficult conditions. On the other hand injuries that are caused by accidents in summer are much more serious. The results show that drivers often overestimate their capabilities (cause of accidents is exceeded speed limit or other primary causes that are connected with speed) when they drive away on holidays. Otherwise, we can say that the great majority of accidents occur at best driving conditions – sunny weather, best driving surface, ... Three quarters of drivers who are responsible for accidents are male.

⁴ More detailed analysis can be found in the diploma thesis of Marko Žnidaršič: Analiza prometnih nesreč, 1997.



Source: Database on participants in road accidents in Slovenia in year 2000.
 Database on population with drivers' licences on 31.12.2000
 Statistical yearbook of Slovenia in year 2000.

Figure 7: Age distribution of road traffic accidents provokers in Slovenia in the year 2000.



Source: Database on participants in road accidents in Slovenia in year 2000.

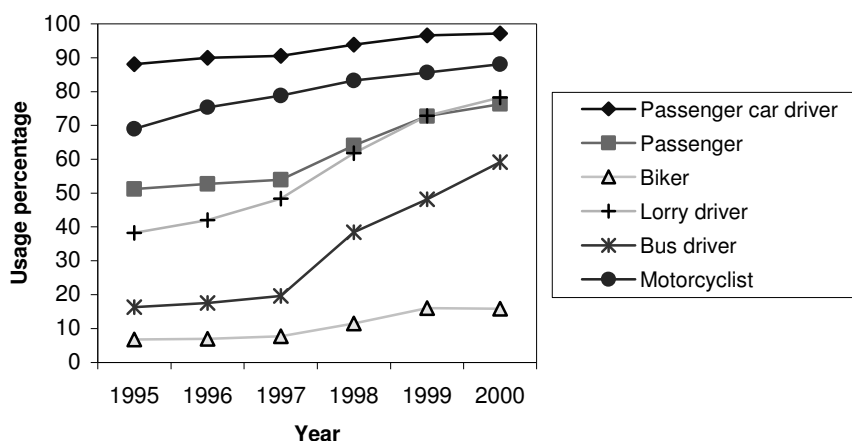
Figure 8: Distribution of road traffic accidents provokers according to the age of their driver's licences in Slovenia in years 1996 and 2000.

4 Provokers of accidents

In Figure 7 we have displayed the age distribution of road traffic accidents provokers in Slovenia in the year 2000. Additional continuous line shows the age distribution of the population with drivers' licences. On the right side we can see the index of probability of the age group to provoke accidents. We can clearly see that the people aged from 18 – 30 are above average provokers. Middle-aged people are less likely to provoke accidents. We can also see that the people older than 80 years become again more prone to provoke accidents because their physical condition deteriorates. The above mentioned index would be more reliable if we could also take into account the number of hours spent behind the wheel.

Driving is a complex thinking process, closely linked to automatic motion skills. According to Figure 8 drivers need at least 4-5 years to get enough experience. We can see that after the introduction of the new law the inexperienced drivers have provoked less traffic accidents than in the past. The percentage of drivers with less than one year of experience dropped from 8,8% in 1996 to 7,1% in 2000. The politics of discrimination of novice drivers (lower permitted limit of penalty points) proved to be the right one. The results might be even better if the novice driver's period would be extended to maybe 4 or 5 years instead of just 2.

The second major goal of the new law was a more consistent usage of safety belts. As we know, safety belts greatly increase the chance of survival in road accidents⁵. The usage of safety belts and other safety equipment (e.g., helmets on motorcycles and bikes) increased from 82.6% in 1996 to 92.4% in 2000.



Source: Database on participants in road accidents in Slovenia in period 1995-2000.

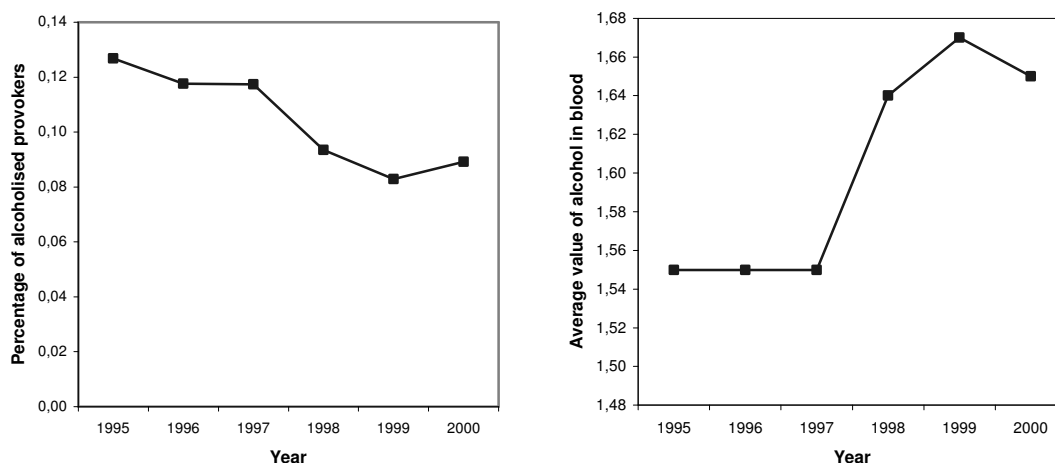
Figure 9: Usage of safety equipment in Slovenia in period 1995-2000.

⁵ More detailed analysis can be found in the diploma thesis of Elvir Mujkić: Analiza cestnoprometnih nesreč v Sloveniji v obdobju 1996-2000, 2002.

As we can see in Figure 9, the major shift in the usage of safety equipment occurred in 1998, when the new law has been introduced. At that time, people were influenced by the preventative campaign and by the information about strengthened penalty measures for nonusers of safety equipment. Thus they became more conscious about the importance of the use of safety equipment. The improved situation in this important field seems to be the major contribution of the new law.

Alcohol is one of the secondary causes of road accidents, but due to the high percentage of the alcoholised road traffic accidents provokers in Slovenia it deserves as much attention as any of the primary causes. The new law pays special attention to those drivers who drive under the influence of alcohol. It has introduced higher cash fines, accompanied by penalty points, which could lead to driver's licence withdrawal.

There were 40,801 provokers of road accidents in Slovenia in 2000. 3,640 provokers (9%) had exceeded the permitted level of alcohol in blood (0.5‰). Their average level of alcohol in blood was 1.65‰.



Source: Database on participants in road accidents in Slovenia in period 1995-2000.

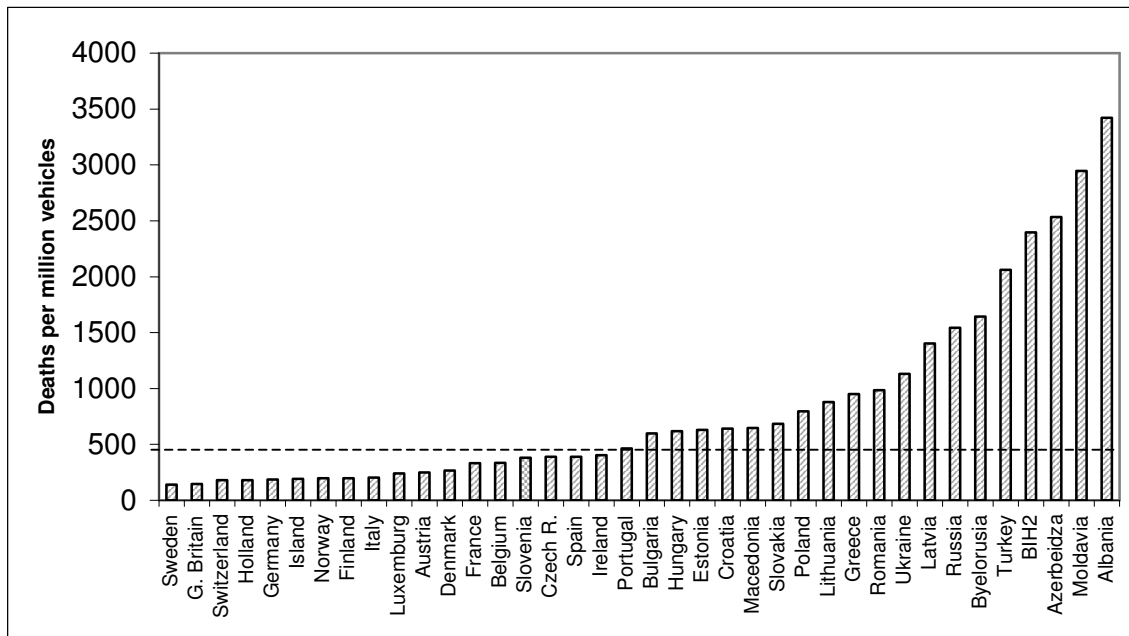
Figure 10: Percentage of alcoholised road traffic accidents provokers and their average level of alcohol in blood in Slovenia in the period 1995-2000.

According to Figure 10 the percentage of alcoholised accident provokers decreased from 12.8% in 1995 to 9% in 2000. In general, the situation has improved, but we have not reached a satisfactory level yet. The new traffic law has mainly affected the drinking habits of those drivers who did not significantly exceed the permitted alcohol limits in the past. On the other hand, the average level of alcohol in the blood of the accident provokers increased from 1.55‰ in 1995 to 1.65‰ in 2000. This means that the greater cash and point penalties have scared those drivers who did not significantly exceed the permitted alcohol limits

in the past and most of them do not reach over that limit anymore. On the other hand it seems that greater penalties have no impact on those drivers that have highly over passed the permitted limit of alcohol in the past. To solve the alcohol problem on our roads we need a national program, which would include road safety problems, alcohol politics, education foundations, health care (alcohol) and others. It would be rational to implement an obligatory in-jail sobering in case of proven excessive blood alcohol level. Besides, we should promote anti-alcohol addiction programs, which we have not been doing so far.

5 Slovenian position in Europe

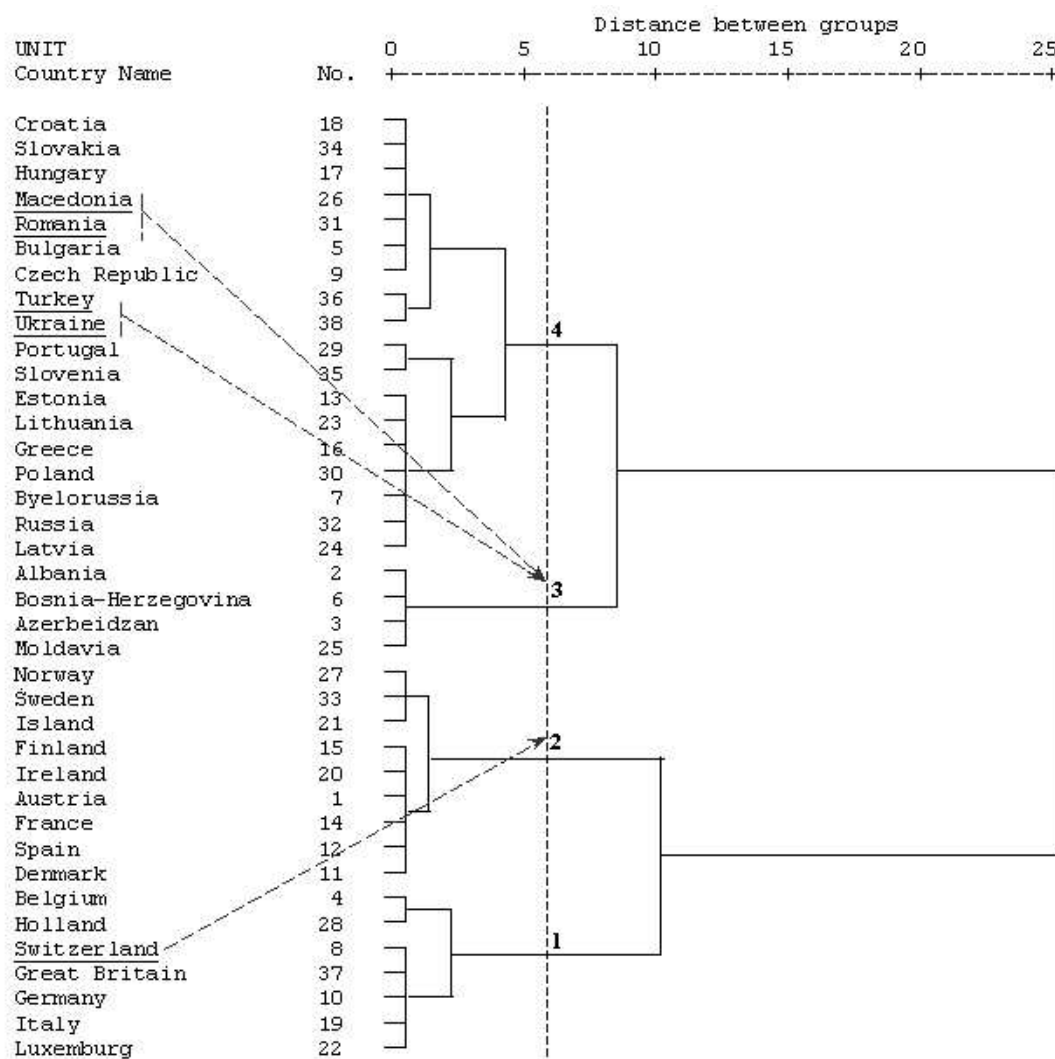
Until now we have analysed Slovenian situation independently of other European countries. Let us now try to make a comparison between countries to position Slovenia in Europe. On average, there are 335 vehicles per 1000 residents in Europe. Annually there are 2.1 million accidents with over 2.4 million injured participants and out of that over 100,000 dead participants. That means 135 deaths per million of residents and 404 deaths per million vehicles. We should be especially concerned about the high percentage of pedestrian deaths (28.8%) and try to find proper solutions.



Source: Statistical Report on Road Accidents 1997-1998.

Figure 11: Number of deaths per million vehicles in Europe.

According to the number of deaths per million vehicles (Figure 11) Slovenia is not far behind the most developed European countries. Slovenian position is similar to French, Belgian, Czech, Irish and Spanish. We are even much better than Portugal and Greece that are members of the European Union.



* Underlined countries have changed groups after K-means non-hierarchical cluster analysis.
 Source: Statistical Report on Road Accidents 1997-1998.

Figure 12: Dendrogram constructed by hierarchical cluster analysis (Squared Euclidean distance, Ward's method).

For a more detailed analysis of road safety and development of European countries we shall use cluster analysis. The objective of cluster analysis is to form such groups that each group is as homogenous as possible with respect to the characteristics of interest and that the groups are as different as possible. We have

used the following standardised variables (a very limited number of suitable variables is available for all the countries under consideration):

- GDP per capita (in USD),
- Population density (residents/km²),
- Percentage of urban population,
- Number of vehicles per thousand residents,
- Vehicle density (vehicles/km²),
- Deaths in road accidents per million residents,
- Deaths in road accidents per million vehicles.

We have analysed the data of 38 members of European Commission of Ministers of Transport (ECMT). In the first step Ward's hierarchical clustering method was used for grouping the countries (Figure 12). To improve the result K-means non-hierarchical method was used, with group centroids from hierarchical method as initial seed points. Let us mention that some countries have changed their group membership. Switzerland moved from group 1 to group 2 and Macedonia, Turkey, Romania and Ukraine moved from group 4 to group 3.

Table 3: Group averages and the number of countries in a group.

Index	Group 1	Group 2	Group 3	Group 4
GDP per capita	25 392	26 117	1 225	4 660
Population density	257.1	68.1	92.1	79.7
Urban population %	86.3	74.0	54.1	64.3
Vehicles per 1000 residents	537.1	483.5	82.2	313.4
Vehicle density	132.9	32.8	7.4	26.9
Deaths per million residents	101.9	103.8	102.6	181.5
Deaths per million vehicles	188.6	218.9	1 563.4	673.7
Number of countries in a group	6	10	8	14

Source: Statistical Report on Road Accidents 1997-1998.

The analysis has revealed that there are 4 major groups of countries in Europe, which differ among themselves by the level of economic development and road safety. The first two groups are quite similar. They consist of the most developed countries in Europe. Both groups have average GDP greater than 25.000 USD, the highest percentage of urban population and the highest number of vehicles per thousand residents. The main difference between these two groups of countries is in their geographical characteristics. Group 1 (Belgium, Italy, Luxemburg, Germany, Great Britain and Holland) consist of countries that have much higher population density. They have mostly plain relief. On the other hand, group 2 (Austria, Denmark, Finland, France, Ireland, Island, Norway, Spain, Sweden and Switzerland) is characterised by lower population density. Most of these countries are mountainous with severe winter climate. Due to different geographical characteristics the two groups of countries are faced with some specific road safety

problems. Anyhow, we can conclude that from the viewpoint of road safety both groups of countries are the safest in Europe.

The third group consists of Europe's least developed countries (Albania, Bosnia-Herzegovina, Azerbeidzan, Macedonia, Moldavia, Romania, Turkey and Ukraine). Their average GDP is only slightly more than 1.000 USD. Their percentage of urban population is the lowest, because many people are still farming for living. Their roads are in very bad condition. They do not have many vehicles. The average fleet age in these countries is quite high. Consequently, their road safety is the worst in Europe. They do not have many fatalities if we compare them with total population, but they are in catastrophic situation when we compare the fatalities with the number of vehicles that drive on their roads.

The fourth group (Slovakia, Czech Republic, Byelorussia, Bulgaria, Estonia, Greece, Croatia, Latvia, Lithuania, Hungary, Poland, Portugal, Russia and Slovenia) is the biggest group in this analysis. The GDP averages to about 4.700 USD per capita. They have quite a lot of vehicles per thousand residents (313). Unfortunately, these vehicles are mostly in bad shape. This means that passengers and drivers are poorly protected when an accident happens. Their roads are very unsafe. Road safety in these countries should be a major issue as their number of fatalities per million of residents is the highest. The majority of the dead participants are men aged 18 – 45, which means that they are losing the main labor force. In future, the countries from this group should focus on road safety issues and try to solve them as well as possible.

Slovenia is in a very delicate situation. On one hand most of the economic indicators reveal a promising situation, especially the number of vehicles. On the other hand we face large problems with traffic safety and law obedience. One of the most important things is to force the people to pay their fines more regularly. We will have to improve the legal system, in particular fasten penalty proceedings. Finally we will have to make our whole system work if we want to diminish the gap between Slovenia and European Union countries.

6 Conclusion

In this article we would like to evaluate the influence of the new law on the behaviour of Slovenian drivers. We wanted to test its contribution to safer and more effective transport system in Slovenia. As a result we found out that the new law had some positive impacts. The discriminatory politics towards new drivers with no experience proved to be the right one. We found out that new drivers are no longer stepping out as they did in the past, but there is still much to be done. When we considered the three major goals of the new law we found out that people are using safety belts and other safety equipment much more frequently. Regarding the alcohol we can see some progress with a lower percentage of alcoholised accident provokers. In our opinion the government would have to

focus on this problem in future and fight it with different instruments than other traffic problems. Alcohol problem is a cultural problem and therefore no major positive changes can be expected in short term.

In conclusion, we can say that the advance in safety equipment technology in automobile industry had the strongest impact on decreasing the number of fatalities. We can give some credit to the new law and police actions, which proved to be positive, since they forced the drivers to prepare for difficult conditions, which they might face when driving.

At the end of the article we compared the situation in Slovenia with other European countries. The above-mentioned substantial gap in road safety between Slovenia and EU countries is still present. If we want to improve our situation we will have to focus on the problems and find effective solutions.

Data sources

1. Database on registered vehicles in Slovenia in period 1992 - 2000.
2. Database on road accidents in Slovenia in period 1995 – 2000.
3. Police, Traffic safety, Statistics, [<http://www.policija.si/si/>], 15. 1. 2002.
4. Database on participants in road accidents in Slovenia in period 1995 - 2000.
5. Database on population with drivers' licences on 31. 12. 2000.
6. Statistical yearbook of Slovenia in year 2000, Ljubljana, 2000.
7. Average age of the vehicle fleet, European Environment Agency: Indicators and environmental Integration in the EU TERM 2001.
[http://themes.eea.eu.int/Sectors_and_activities/transport/indicators/technology/age/Average_age_of_the_vehicle_fleet_TERM_2001.pdf], 15. 11. 2001.
8. Davis Stacy: Transportation Energy Data Book. Edition 20, November 2000, 342. [http://www-cta.ornl.gov/data/tedb20/Full_Doc_tedb20.pdf], 15. 11. 2001.
9. Estimating Global Road Fatalities.
[http://www.factbook.net/EGRF_Economic_costs.htm], 11. 11. 2001.
10. Infonation, United Nations Cyberschoolbus. 15. 11. 2001.
[http://www.un.org/Pubs/CyberSchoolBus/infonation/e_infonation.htm].
11. Road Accidents: A Global Problem Requiring Urgent Action, World Bank Group. 25. 11. 2001.
[<http://www.worldbank.org/html/fpd/transport/topnotes/rh-2.htm>].
12. Road safety is a good business, Research for sustainable mobility.
[<http://www.mtc.government.bg/en/transport/prog/extra/m-4.htm>], 25. 11.2001.
13. Road Safety, World Bank Group.
[<http://www.worldbank.org/html/fpd/transport/roads/safety.htm>], 25. 11. 2001.
14. Statistical Report on Road Accidents in 1997-1998, bilingual, Feb. 2001, 92 p.
[<http://www1.oecd.org/cem/pub/contents/01Acc98e.pdf>], 15. 11. 2001.
15. Sustainable Mobility 2030: A background report for WBCSD, Conference in Prague, May 2000.

[http://www.wbcsmobility.org/dialogues/files/prague_stakeholder_bg_paper.pdf], 15. 11. 2001.

16. World Health Report 1999, World Health Organisation.

[<http://www.who.int/whr/1999/en/pdf/leading.pdf>], 25. 11. 2001.

References

- [1] Bercko, V. (1999): Smrt se (še) ne meni za predpise. Maribor: *Večer*, 24. 4. 1999. 40.
- [2] Bishop, Y. et al. (1989): *Discrete Multivariate Analysis: Theory and Practice*. Massachusetts and London: The MIT Press Cambridge, **X**, 557.
- [3] Blejec, M. (1973): *Statistične metode za ekonomiste*. Ljubljana: Ekonomska fakulteta. 2. razširjena in dopolnjena izdaja, 868.
- [4] Kocmur, H. (2001): Ostajajo tisti, ki globlje pogledajo v kozarec. Ljubljana: *Delo*, 17. 1. 2001. p. 3.
- [5] Mujkić, E. (2002): Analiza cestnoprometnih nesreč v Sloveniji v obdobju 1996-2000. Ljubljana: Ekonomska fakulteta, diploma thesis, 63+23.
- [6] Norušis, M. (1997): *SPSS® 7.5 Guide to Data Analysis*. NJ: Prentice-Hall, 553.
- [7] Sharma, S. (1996): *Applied Multivariate Techniques*. New York: John Wiley & Sons, 493.
- [8] Žišt, D. (1999) : Prometni zakon je učinkovit. Maribor: *Večer*, 24.4.1999.
- [9] Žišt, D. (2000) et al.: Policistov je premalo, vozniki pa spet po starem. Maribor: *Večer*, 6. 5. 2000.
- [10] Žnidaršič, M. (1997): Analiza prometnih nesreč. Ljubljana: Ekonomska fakulteta, diploma thesis, 53+14.