

The differentiated assessment of damage to economy of subjects of the Siberian Federal District from road and transport accident rate

Artur I Petrov^{1, a} and Vera A Svistunova¹ and Daria A Petrova²

¹ Tyumen Industrial University, 72 Melnikaita str., Tyumen, 625000, Russian Federation

² Ural Federal University named after the first President of Russia B. N. Yeltsin, 16a Chapaev str., Ekaterinburg, 620002, Russian Federation

E-mail: ^a ArtIgPetrov@yandex.ru

Abstract. The results of assessment of damage from the road accident rate in subjects of the Siberian Federal District (SFD) of the Russian Federation are presented in the article. The thesis about spatial differentiation of the Gross Regional Product (GRP) losses in different regions of the country because of people's death and injuries in the road accidents (RA) and due to formations of property and ecological damage was chosen as a working hypothesis. The calculations, carried out for 12 subjects of the SFD, confirmed this idea. The range of calculated values of economic damage from road accident rate (in % of GRP) was from 1.3 (Tomsk region) to 12.6 (Republic of Tyva) in 2015. In article the attempt to explain the received result by heterogeneous development of economics in various Russian regions is made. The consequence of it is a heterogeneous quality of people's life and quite various perception of life value by inhabitants of different regions that influences their life safety level.

1. Introduction.

According to the Federal State Statistics Service of the Russian Federation (hereinafter - Rosstat) [1] in the first half of the year 2017 from the external reasons in our country have left life of 69,3 thousand people, including 8,2 thousand people have died in road accident. The calculation shows that according to 2017 about 12 % of all premature deaths in our country is the proportion of people killed in an accident.

The struggle to reduce this indicator has long been among the priorities of the Government of Russia. This is evidenced by the implementation of the First (in the period 2006 ... 2011) and the Second (2012 ... 2020) Federal Target Programs for Road Safety.

The results of this work are unambiguously positive in the whole country, however, in different regions and cities the dynamics of the decrease in indicators of road and transport accident rate (absolute and relative) are not the same [2]. This is evidenced by the data of other authors [3, 4]. If countrywide the share of deaths from all types of transport accidents among those who died from external causes in 2014 was about 20 %, then in the Leningrad, Novgorod, Kaluga regions and the Republic of Karachaevo-Cherkessia this indicator reaches 32...35 %, and in the Republic of Tuva it is equal to 50 % [5].

Within the framework of this article, an attempt is made to assess the damage caused by road and transport accident rate to the economy of the Siberian Federal District (SFD) of Russia. At the same time, the priority task is to make it differentiated in relation to various subjects of the SFD.

2. The studied problem

Today Russia does not have an unambiguous understanding of the cost of human life and the damage caused by the death and injury of a person in a traffic accident (road accident). Those not numerous works [3, 4], which are performed in this direction, only state need of quantitative estimation of cost of life and offer only the general approaches to the solution of this task. In this case, you can use different



methodologies (the theory of human capital, the methodology of estimating the average life, methods of insurance companies in solving the problem [3, 4, 6, 7, 8]. It is also important that any of these methodologies uses the notion of “Loss of gross domestic product”, and the GDP index, in spite of an unambiguous quantitative estimate by Rosstat, in different accounting systems [7, 8] is also varies greatly.

Taking into account the considerable ambiguity of both the concept of the “Average cost of living” of a person (ACL) and the constant correction of GDP (due to inflation and reassessment of value added), it is proposed to solve the problem of estimating the damage from road and transport accident rate to the economy of the SFD from the perspective of differentiating this indicator in different regions of the District. A certain error in the calculations will be present, but this error will be systemic and practically identical for all regions.

3. Formulation of the problem.

It is necessary to estimate quantitatively damages to the economy of the subjects of the Siberian Federal District (SFD), formed upon the death and wounds of people in road accidents in the respective territories. The corresponding damage will be assessed on the basis of data of the Federal Target Program for traffic safety for the period 2012...2020 and Rosstat's data on the GDP of the Russian Federation [9, 10]. In [9] it is stated that the amount of social and economic damage from road accidents and their consequences for 2004...2011 is estimated at 8188.3 billion rubles. The actual total for 2004...2011 Russia's GDP in current prices is estimated at 281161.5 billion rubles [10]. Thus, the economic losses as a whole from road and transport accident rate in the country make up about 2.9 % of GDP. It is obvious, that in some years this indicator varies in a wide range. So, according to the Federal Target Program for traffic safety for the period 2006...2011 this indicator in Russia at the beginning of the 2000th was 2.2...2.6 % of GDP. In recent years, in 2015...2017 on the fact of a very significant decrease in indicators of the road and transport accident rate in recent years (in 2016, 20.308 thousand people died in an accident, compared to 27.025 thousand people in 2013), it can be considered that GDP losses due to road accidents decreased proportionally, approximately by 25 % and amount to today (2015...2017) about 2.0...2.1 % of GDP.

Problems solved in this article.

1. Calculation of the total damage to the economy of the SFD from the road accident.
2. Differentiated calculation of direct damage (formed by loss and decline in quality of the human capital) and external or indirect damage (formed by material losses in road accidents) to subjects of the SFD in absolute dimension.
3. Estimation of the relative magnitude of gross regional product (GRP) losses in the road accidents.
4. Explanation of the results.

4. Initial data

Let's take the magnitude of the economic damage from the road and transport accident rate is approximately 2 % of GDP in Russia in 2015, which one according to Rosstat [10] was 64997.04 billion rubles in 2011 prices. Conditionally, the damage from an accident in Russia in 2015 can be estimated at 1.3 trillion rubles. According to the worldwide approaches [3, 4, 6], the division of this damage into direct and indirect can be estimated on the basis of the ratio 57 : 43 (Fig. 1), i.e. about 57 % fall on direct damage (or 741 billion rubles) and 43 % fall on external damage (or 559 billion rubles). The immediate damage is the entire amount of loss associated with the death and wound of people in the road accident. Indirect (external) damage includes property and environmental damage.

In 2015, in Russia in the road accident killed 23.114 thousand people and 231.197 thousand people were wounded (with varying degrees of severity of health consequences).

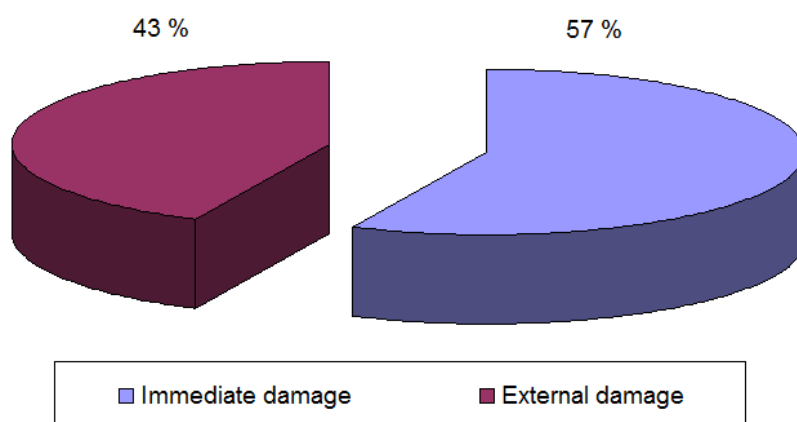


Figure 1. Differentiation of damages from the road accidents in the world practice [3, 4, 6]

5. Method of assessing damages from death and injuries in the accident

To solve the problem of a differentiated calculation of the immediate damage (generated by the loss and degradation of human capital) and external damage to the subjects of the Siberian Federal District it is necessary to quantify the “Average cost of living” (ACL) and “Average cost of injuries” (ACI) parties to the accident. The task of determining values for ACL and ACI will decide on the reverse (1).

$$\begin{aligned} & \text{The Number of Fatalities in Road Accidents} \cdot \text{ACL} + \\ & + \text{The Number of Injured in Road Accidents} \cdot \text{ACI} = \text{Immediate Economic Damage} \end{aligned} \quad (1)$$

$$23114 \cdot \text{ACL} + 231197 \cdot \text{ACI} = 741 \text{ billion rubles}$$

To solve this equation, it is necessary to determine the numerical relationship between the values of the ACL and ACI. In [11], the following data on the relationship between the severity of road accidents in various outcomes for victims (Table 1) are given.

Table 1. Ratio of severity of road accidents in different outcomes for victims [11]

Type of road accident outcome	Values of gravity ratios of outcomes of road accidents	
	F. Reingold	P. Fisher
Material damage	1	1
Injury in an accident	5	2
The fatal outcome of an accident	130	40
Ratio of the severity of road accidents		
Injury	$\frac{5}{130} = 0.038$	$\frac{2}{40} = 0.050$
Fatal outcome		

In the article [12] the data of 2013 are given, on the basis of which it is possible to determine this ratio as $0.235/11.25 = 0.02$.

In [7], the analogous ratio is defined as 0.045.

Let's assume that the ratio of the severity of the outcomes of the road accident $\frac{\text{Injury}}{\text{Fatal outcome}}$ is about 0.04, i.e. the economic damage from the ACI is about 25 times lower than the damage from the death of a person ACL.

Assuming that the $ACL = 25 \cdot ACI$, we write:

$$23114 \cdot (25 \cdot ACI) + 231197 \cdot ACI = 741 \text{ billion rubles}$$

$$577850 \cdot ACI + 231197 \cdot ACI = 741 \text{ billion rubles}$$

$$809047 \cdot ACI = 741 \text{ billion rubles}$$

$$ACI = 741 \text{ billion rubles} / 809047 = 0.915 \text{ million rubles}$$

$$ACL = (25 \cdot ACI) = 22.875 \text{ million rubles}$$

Let's check the correctness of the reasoning. Estimated damage from deaths and wounds of people in road accidents, taking into account the values of the ACL and ACI in the Russian Federation in 2015 amounted to:

$$23114 \cdot 22.875 \text{ mln. rubl} + 231197 \cdot 0.915 \text{ mln. rubl} = 740.8 \text{ billion rubles}$$

It should be noted that the assessment of the ACL is 22.875 million rub. and the ACI equal to 0.915 million rub., it is very conditional and averaged, because the quality of human capital is highly differentiated depending on age, social status, education, actual and potential contribution to the country's economic success. However, in view of the large-scale consideration of the problem, this reasoning fades into the background and can be withdrawn from consideration. Further calculations for each region of the SFD were carried out according to the following formulas (2) and (3).

$$\begin{aligned} & \text{Absolute Immediate Damage}_{\text{region}} (\text{Rubles}) = \\ & = (\text{The Number of Fatalities in RA} \cdot ACL)_{\text{region}} + (\text{The Number of Injured in RA} \cdot ACI)_{\text{region}} \end{aligned} \quad (2)$$

$$\begin{aligned} & \text{Relative Immediate Damage}_{\text{region}} (\% \text{ GRP}) = \\ & = 100 \% \cdot \frac{(\text{The Number of Fatalities in RA} \cdot ACL)_{\text{region}} + (\text{The Number of Injured in RA} \cdot ACI)_{\text{region}}}{GRP_{\text{region}}} \end{aligned} \quad (3)$$

6. Results and discussion

6.1. The differentiated for the SFD subjects calculation of direct (due to death and wounding of people) damage from the road accident

Further calculations are based on taking into account the statistics of deaths and wounds of people in road accidents in various regions of the Siberian Federal District in 2015.

Data on GRP in the regions of the SFD [13] and the calculated magnitude of direct damage are presented in Table 2.

The damage from death and wound to people in the road accident in the SFD in 2015 amounted to 103257.4 mln. rubl / 741000 mln. rubl. = 13.94 % of the Russian result.

The share of the GRP of the SFD in the total Russian GDP in 2015 was 6751.9 bln. rubl / 64997.04 bln. rubl. = 10.38 %

Comparison of the shares formed by the SFD in the Russian GDP (10.38 %) and damage from deaths and wounds in road accidents (13.94 %) allows us to conclude that the problem of the negative impact of road and transport accident rate in the SFD is somewhat more acute than in Russia as a whole.

Table 2. Results of calculation of direct damage (due to death and wounding to people)

from road accidents in the subjects of the SFD in 2015

Subject of the Siberian Federal District	Gross regional product (GRP) in 2015, mln. rubles [13]	Statistics of victims in road accidents (2015), people [15]		Damage (losses of GRP) due to death and wound of people (2015)	
		Fatalities in an RA	Injured in an RA	mln. rubles	% GRP
Altai Republic	41776.8	58	487	1772.35	4.24
The Republic of Buryatia	204156.2	163	1676	5262.16	2.58
Tyva Republic	47287.3	120	722	3405.63	7.20
The Republic of Khakassia	171663.9	116	1157	3712.15	2.16
Altai region	492138.9	313	4449	11230.71	2.28
Transbaikal region	248847.6	213	1834	6550.48	2.63
Krasnoyarsk region	1618166.0	567	5659	18148.11	1.12
Irkutsk region	1013542.3	479	4049	14661.96	1.45
Kemerovo Region	842618.9	435	4324	13907.08	1.65
Novosibirsk region	980850.5	360	3453	11394.49	1.16
Omsk Region	617184.4	259	4183	9752.07	1.58
Tomsk Region	473693.1	108	1040	3460.16	0.73
Total for the SFD	6751925.8	3191	33033	103257.3	1.53

6.2. *The differentiated for the SFD subjects calculation of external (indirect) damage from the road accident*

The external (property and environmental) damage from the road accident in the RF in 2015 amounted to 559 billion rubles. This value is calculated from the ratio of the shares between external and direct damages (43 : 57), generally accepted in the world practice [3, 4, 6]. Table 3 shows the results of calculating the external and total damage from the road accident in 2015, differentiated by the regions of the SFD.

Table 3. The results of calculating the external (property and environmental) and total damage from road accidents in the subjects of the SFD in 2015

Subject of the Siberian Federal District	External damage (losses of GRP)		Total damage (losses of GRP)	
	from the road accident in 2015		from the road accident in 2015	
	mln. rubles	% GRP	mln. rubles	% GRP
Altai Republic	1337.06	3.20	3109.42	7.44
The Republic of Buryatia	3969.78	1.94	9231.94	4.52
Tyva Republic	2569.21	5.43	5974.84	12.64
The Republic of Khakassia	2800.45	1.63	6512.60	3.79
Altai region	8472.45	1.72	19703.16	4.00
Transbaikal region	4941.68	1.99	11492.17	4.62
Krasnoyarsk region	13690.93	0.85	31839.04	1.97
Irkutsk region	11060.98	1.09	25722.94	2.54
Kemerovo Region	10491.50	1.25	24398.59	2.90
Novosibirsk region	8596.01	0.88	19990.5	2.04
Omsk Region	7356.96	1.19	17109.03	2.77
Tomsk Region	2610.35	0.55	6070.51	1.28
Total for the SFD	77897.37	1.15	181154.8	2.68

Graphically, the results of calculating the total damage from the road accident (in % of GRP region) are shown in Fig. 2.

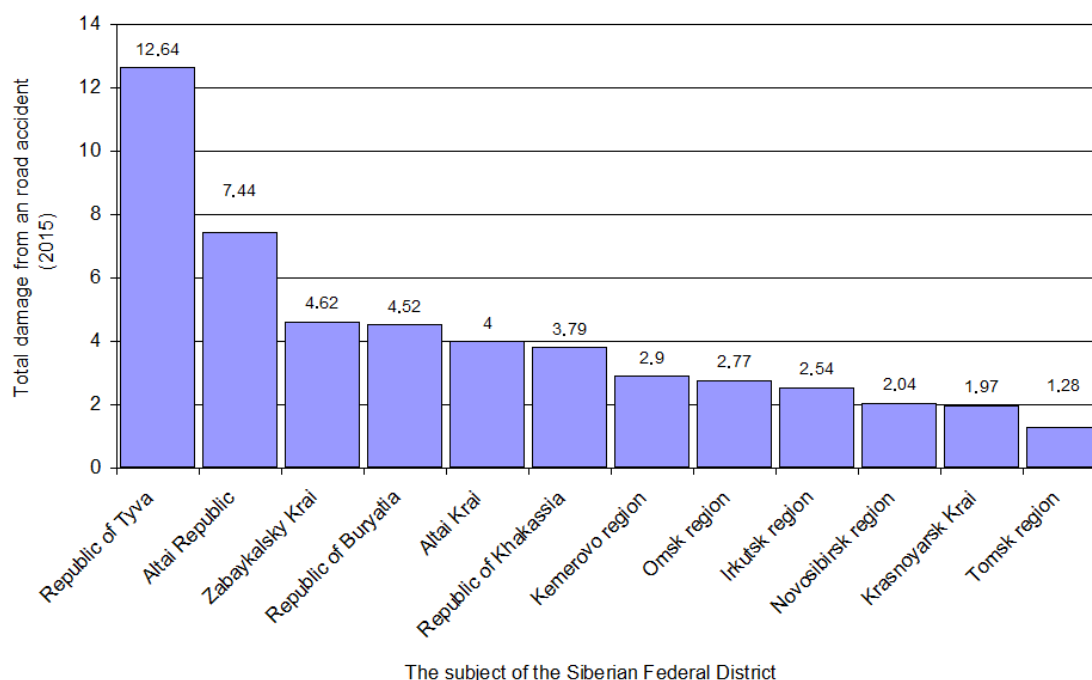


Figure 2. Total damage from road accident (in % of GRP region) in the subjects of the Siberian Federal District in 2015

6.3. Discussion of the results of damage assessment from road accident

Comparing the value of total damage from accidents in the SFD (2.68 % GRP) in comparison with the initial figure for calculations (2.00 % of GDP for the Russian Federation as a whole) allows to conclude that the situation in the Siberian Federal District in the field of road safety even on a national background.

It should be noted that in some regions of the SFD the situation in the field of road safety is simply catastrophic. Thus, the total damage from road accident in the Republic of Tyva reaches 12.5 % of GRP. This result correlates well with the data of [5]. The situation in the Altai Republic is not any better (7.44 % of GRP). Even in 7 regions, the damage exceeds the all-Russian level. And only in three regions (the Novosibirsk Region, the Krasnoyarsk Territory and the Tomsk Region), damages from road accidents are comparable with the national level or lower.

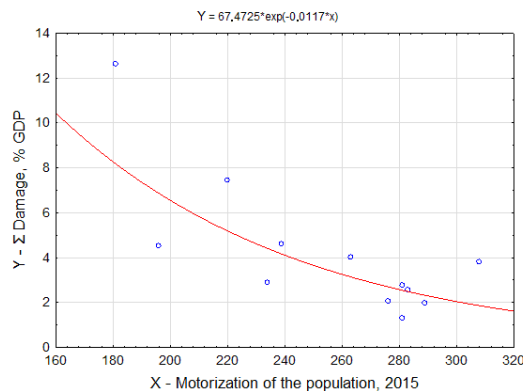
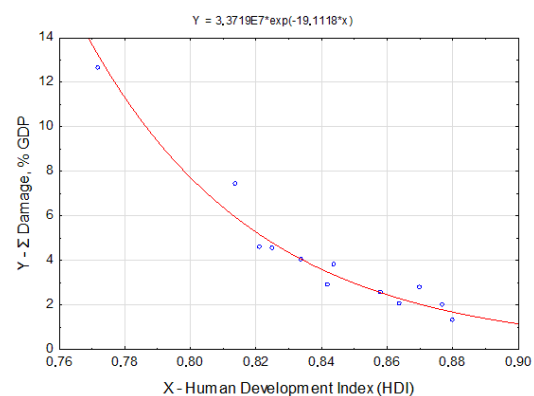
7. Explanation of the results

It is known [14], that the road and transport accident rate largely depends on the quality of life of the population. The cause and effect relationship between the quality of life of the population of the region and its deviant manifestations has been known for a long time. Incidents in transport are only part of the general situation in the region. In order to illustrate this relationship, this article presents regression models describing the statistical relationship between the regional automotive U_a and the human development index (HDI) as representative indicators of the socio-economic development of the regions and the estimated total damage from the road accident $\Sigma Damage$. The data necessary for constructing the regression models were obtained: for regional motorization in [15], and for the HDI in [16]. The data obtained in [15, 16] are presented in Table 4.

Table 4. Total damage from road accidents and representative characteristics socio-economic development in the regions of the SFD

Subject of the Siberian Federal District of the Russian Federation	Indicator values		
	Total (direct + external) damage from road accident, 2015, % GRP	Motorization of the population, 2015, passenger vehicles, units / 1000 people [15]	Human Development Index, 2014, HDI [16]
Altai Republic	7.44	220	0.814
The Republic of Buryatia	4.52	196	0.825
Tyva Republic	12.64	181	0.772
The Republic of Khakassia	3.79	308	0.844
Altai region	4.00	263	0.834
Transbaikal region	4.62	239	0.821
Krasnoyarsk region	1.97	289	0.877
Irkutsk region	2.54	283	0.858
Kemerovo Region	2.90	234	0.842
Novosibirsk region	2.04	276	0.864
Omsk Region	2.77	281	0.870
Tomsk Region	1.28	281	0.880

The processing data table 4 allowed to obtain the models $\sum \text{Damage} = f(Ua)$ and $\sum \text{Damage} = f(HDI)$. In a graphical form, these models are shown in Fig. 3 and Fig. 4.

**Figure 3.** Model $\sum \text{Damage} = f(Ua)$ **Figure 4.** Model $\sum \text{Damage} = f(HDI)$

Models $\sum \text{Damage} = f(Ua)$ and $\sum \text{Damage} = f(HDI)$ for the SFD

The coefficient of determination for the model $\sum \text{Damage} = f(Ua)$ is $R^2 = 0.58$; the determination coefficient for $\sum \text{Damage} = f(HDI)$ model is $R^2 = 0.87$. The Fisher criterion F for the model $\sum \text{Damage} = f(Ua)$ is $F = 13.77161$. The Fisher criterion F for the $\sum \text{Damage} = f(HDI)$ model is $F = 68.90596$, which allows to conclude that the models are highly

adequate. The standard error of approximation by the models of the experimental data is, respectively, 2.12 % and 1.16 %.

Thus, based on the presented models, it can be concluded in principle that a significant difference in the damage from the road and transport accident rate in different regions of the SFD is largely due to different quality of life of the population. This can also be judged by such an indicator as “% of the road accidents committed in a state of intoxication”. According to this indicator, the Republic of Tyva is a leader not only in the SFD, but also among all 85 Russian regions, with an 22 %. Thus, it is the significant marginalization of the population of the Republic of Tyva that explains the very high level of damage from road accidents (12.64 % GRP).

8. Conclusion

The most important conclusions on the presented material are presented below.

1. Today in Russia there is no unambiguous understanding of the cost of human life and damage caused by the death and wound of a person in the road accident.
2. GDP losses due to road accidents in Russia are in 2015 ... 2017 about 2.0 ... 2.2 % of GDP (64997.04 billion rubles in 2011 prices) or about 1.3 trillion rubles in the prices of 2011.
3. Damage from an accident in Russia in 2015, conditionally determined at 1.3 trillion (741 billion rubles) and external or indirect damage (559 billion rubles).
4. The calculated values of the indicators “Average cost of living” (ACL) and “Average cost of Injuries” (ACI) in 2015 in Russia were, respectively, 22.875 mln. rub. and 0.915 mln. rub.
5. Based on the statistics of the road and transport accident rate in the subjects of the SFD, the calculated values of the ACL and ACI, the calculated values of direct and external economic damage for the regions of the District were determined.
6. The values of the total damage to the economy of the subjects of the Siberian Federal District vary in a wide range (from 1.28 % for the Tomsk region to 12.64 % for the Republic of Tyva). In general, in the SFD, the damage from the road and transport accident rate is 2.68 % GRP, which is slightly higher than for Russia as a whole (about 2.0 %).
7. Economic damage from the road and transport accident rate is a derivative of the quality of life of the population. The magnitude of damage from road accidents is determined by the influence of such particular characteristics of people's quality of life as the Human Development Index (HDI) and the provision of material goods, in particular, by means of transport. This influence is described by exponential dependencies with an inverse positive coupling.

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