ANALOGY BETWEEN TRAFFIC ACCIDENTS AND REGIONAL SOCIOECONOMIC VARIABLES

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RESUMO

Este artigo objetiva estudar a relação entre acidentes de trânsito em rodovias e as variáveis socioeconômicas regionais, de forma a identificar fatores que contribuam para o aumento da sinistralidade. Primeiramente, são apresentados os trechos que compõem os 1028 km administrados pela Consórcio Univias, e sua alta relevância na economia do Estado do Rio Grande do Sul, atingindo diretamente 2 milhões de pessoas. Logo, é descrito como é formado o ambiente rodoviário, de forma a explicar os problemas urbanísticos resultantes e as deficiências de segurança viária. Fazendo-se uso de dados de 7 municípios componentes do sistema Univias, foi confirmado o comportamento indicado pela bibliografia nas maiores cidades, onde o crescimento dos acidentes rodoviários é inversamente proporcional ao crescimento da economia. Contudo, para as cidades médias e pequenas constatou-se o comportamento inverso. Portanto, nas cidades médias e pequenas é necessário uma maior atenção do Estado, de forma a garantir a segurança do tráfego e dos pedestres, ao mesmo tempo que fomenta-se o desenvolvimento socioeconômico local.

ABSTRACT

This article aims to study the relation between traffic accidents in highways and regional socioeconomic variables in order to identify the factors which contribute to the increase of accidents. First, the 1028 km managed by Univias and their high relevance in the economy of the State of the Rio Grande do Sul are presented once 2 millions people people are directly reached by these roads. After, it is described how the road environment is formed to explain its resultant urban problems and the fails of road safety. Using data of 7 cities of Univias system, the behavior indicated by the literature was confirmed in the biggest cities, where the increase of the accidents is inversely proportional to the economical. However, for medium and small cities the opposite behavior was evidenced. Therefore, the State must pay a special attention to medium and small cities for ensuring the security of the traffic, pedestrians and the local socioeconomic development.

1. INTRODUCTION

In Brazil, on average 34 thousand people die each year and other 400 thousand are injured or disable as a result of traffic accidents (DENATRAN and Ministério das Cidades, 2005). In 2004, the country recorded 127 thousand deaths due to external factors, of which about 27.5% were due to road accidents (Ministry of Health, 2006). According to Mantovani (2004), in the 1990s, Brazil had around 3.3% of the total number of fleet vehicles worldwide, accounting for 5.5% of all fatal accidents in the world.

The traffic in safe conditions is a right for all and a duty of the organs and organizations of the National Traffic System, which is responsible for adopting these measures to ensure this (Brazilian Traffic Code – CTB, 1997). Furthermore, it is up to the municipalities to assist appropriate land use through planning and controlling the use, the fragmentation and the occupation of urban land, promoting the protection of historic and cultural site, respecting the legislation and federal and state supervision action (Brazilian Constitution, 1988).

In this scenario, this paper aims to study the relation between the occurrence of traffic accidents on highways and socioeconomic regional variables in order to identify the urban factors that contribute to the increase of accidents. With a deeper knowledge about such factors it is possible to propose actions to reduce accidents and thereby improve the local life quality.

2. UNIVIAS SYSTEM

Univias System, located in Rio Grande do Sul state, is one of the largest road managers in the country, controlling 1028 km of highways in Brazil, distributed in 3 dealerships: Convias (Caxias do Sul pole); Sulvias (Lajeado pole), and; Metrovias (metropolitan area pole). The road system of Univias covers 63 municipalities, totaling 2 million people directly affected. Currently 79 thousand vehicles per day pass through the 14 tollplazas operated by Univias (see Figure 1).

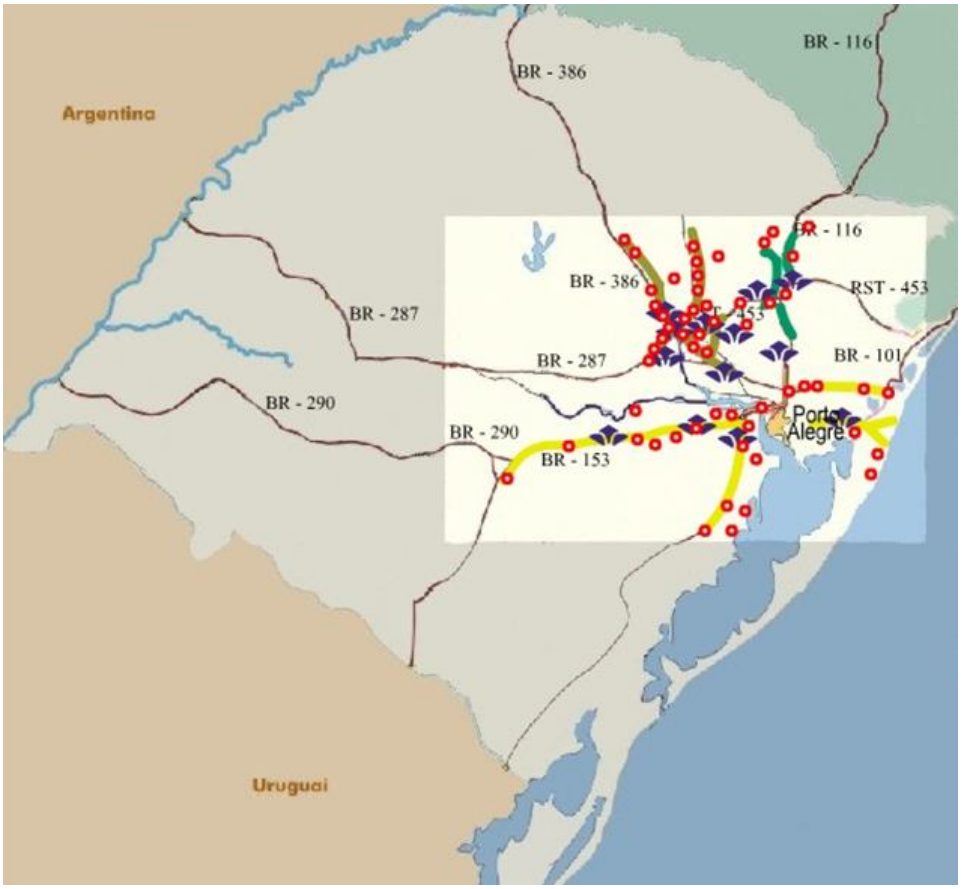

Figure 1: Road net controlled by Univias System

2.1. Convias Pole

Convias is basically formed by the roads BR/116, RSC/453 and RS/122, which concentrate the main companies of metal-mechanic industry of Rio Grande do Sul and the wine region; it also has a strong tourism appeal due to the natural beauty of South Sierra. Table 1 and Figure 2 summarize the roads and lengths of Convias pole, as well as the distribution of tollplazas.

Table 1: Roads, stretches and lengths Convias pole (Caxias do Sul)

Highway – Segment	Lenght
BR/116 – Caxias do Sul/Campestre da Serra	64 km
BR/116 – Caxias do Sul/Nova Petrópolis	30 km
RS/122 – Caxias do Sul/Antônio Prado	46 km
RSC/453 e RS/122 – Caxias do Sul/Nova Milano	34 km
Total Convias Pole	174 km

Figure 2: Net of Convias Pole (Caxias do Sul)

2.2. Sulvias Pole

Sulvias consists of segments of BR/386 – the road of production – and the roads RS/130, RS/129, RSC/453 and RS/128. Throughout BR/386, the agricultural production of the Missions and the North region goes foward the road-hydro-rail junction of Taquari River toward the port of Rio Grande. It is a highly industrialized region with great natural and cultural attractions due to the soil relief and the german and italian colonization. Table 2 details the scope of each segment of this pole; Figure 3 highlights the network map of Sulvias with the location of tollplazas.

Table 2: Roads, segments and lengths Sulvias pole (Lajeado).

Road – Segment	Length
RS/130 e RS/129 – Lajeado/Guaporé	84 km
RST/453 – Estrela/Garibaldi	57 km
BR/386 – Estrela/(RST/287)	40 km
BR/386 – Lajeado/Arroio Tatim	92 km
RST/453 – Lajeado/Venâncio Aires	29 km
RS/128 – Junction BR/386 / Junction RST/453 (Via Láctea)	16 km
Total Sulvias Pole	318 km

Figure 3: Net of Sulvias pole (Lajeado)

2.3. Metrovias Pole

Metrovias consists of two major federal highways – BR/290 and BR/116 – and three state highways. These segments are responsible for the flow of grain production from the border to the port of Rio Grande and industrial areas. Through these highways manufactured goods are also carried to the border. The BR/290 is the portal of entry and exit between the Rio Grande do Sul and Argentina. Among the state highways, it is worth highlighting the RS/040 that gives access to the southern beaches of the north coast. Table 3 and Figure 4 show the former parts of Metrovias pole as well as the location of tollplazas.

Table 3: Roads, segments and lengths Metrovias pole

Road – Segment	Lenght
BR/116 – Guaíba/Camaquã	98 km
BR/290 – Eldorado do Sul / Pantano Grande	112 km
RS/030 – Gravataí/Osório	74 km
RS/040 – Viamão/Pinhal	83 km
RS/784 – Junction RS/040 / Cidreira	15 km
BR/290 – Pantano Grande/ junction BR/153	93 km
BR/153 – Junction BR/290 / junction BR/392	26 km
RS/474 – Junction RS/030 / junction RS/239	35 km
Total Metrovias Pole	536 km

Figure 4: Metrovias pole net (Metropolitan)

3. ROAD ENVIRONMENT SETTING

To study the reason of urban problems and road safety in the proximities of the highways, it is necessary to understand how the road environment is formed. Once the highway is the link of the central areas and peripheral rural areas (means of access), it becomes highly attractive to the population since that accessibility is the use value most important for urban land (Villaça 1998 apud Lopes and Loch, 2004). Netto and Krafta (1999) say that the logicals of flow in the city relate to the possibilities of a shorter path between two points. In rural areas, in most cases, the highway is the shortest route.

The access varies according to the means of transport, and these are directly linked to social classes. The effect created by the deployment of a local road or of a regional transport terminal is the improvement of accessibility in the naerby lands and the consequent valorization. The land value generated by the construction of the road is usually greater than the value of the way itself. Therefore, the deployment of infrastructure for transport is due to intra-urban interests that represent the upper class and real estate agents (1998 apud Villaça Lopes and Loch, 2004). At the same time social exclusion takes place, leading to informal and cluttered occupation with poor quality housing in the urban fringe and areas of risk (Schvasberg, 2003) close to highways, increasing exposure to traffic accidents.

After the completion of a highway, the scarcity of jobs often hinders the social employment promotion of a good number of people who participated in the work (workers and family). They end up crowding in the areas bordering in an under-employment situation (Luzon, 1988), such as informal trade and prostitution. Often, the government promote further speculation disorderly instead of planning the occupation of the land.

The problems of irregular occupation were amplified after the federal government delegated the management of housing, sanitation, education, health and social assistance to states and municipalities, once these are responsibilities difficult to manage, given the asymmetry of capacities and resources of municipalities (Schvasberg, 2003).

Using a different perspective, Ball (2004) presents an interesting approach grounded in thermodynamics physics to explain the formation of new urban settings. In this case, to really make to happen the occurrence of changes in the road there was necessarily a preliminary stage of instability or several instances of sequential variability (crisis spots called bifurcations), these culminated in the setting of a new urban morphology. According to the author, otherwise, if the system is in equilibrium, it would return to pre-existing configuration. During this process of changing, the final shape becomes complex and impossible to predict.

4.ANALYSIS OF SOCIOECONOMIC VARIABLES

This stage aims to find relations between the number of road accidents and other local socioeconomic informations of seven municipalities that make up the network managed by the Consortium Univias. Knowing the urban aspects that contribute to accidents, it is possible to propose improvements, increasing traffic safety and at the same time the quality of local life.

These municipalities were chosen because they have strong urban concentration in the vicinity of the roads that intersect them, as well as the urban problems and road safety caused by this proximity. Of the seven selected cities, two of them are considered large (Viamão and Caxias do Sul), two are considered medium (Farroupilha and Lajeado) and three are considered small (Fazenda Vilanova, Marques de Souza and Santo Antonio da Patrulha).

First, we analyze the historical amount of road accidents in each of the selected cities, checking if there is any pattern of behavior in the locations. Then for each of the seven cities it is made the intersection between the amount of accidents and other local socioeconomic variables.

4.1. Accident analysis of the cities

The method of Pearson's correlation is used here for statistical analysis. The correlation coefficient (r) is the measure of the degree of linear association between two variables from a series of observations (Faculty of Medicine – USP, 2003) (see Equation 1). The value of r ranges from -1 to +1; a r value of 1 means that the variables are directly proportional, since a value of -1 depicts a behavior of the variables inversely proportional. Nul values represent independent variables one in relation to other or not related (Santos e Raia Junior, 2006).

$$r = \frac{\sum (x - \bar{x})(y - \bar{y})}{\sqrt{\sum (x - \bar{x})^2 \sum (y - \bar{y})^2}} \quad (1)$$

Where

r: correlation coefficient;
x = point values of the variable x;
x = mean of variable x;
y = point values of the variable y;
y = mean of variable

Table 4 shows the amount of accidents on roads managed by Univias in each of the seven cities studied, as well as the correlation coefficient between each pair of cities. It is observed that the number of accidents is higher in Caxias do Sul, where the number of circulating vehicles is higher than to the one of other cities. The volume of accidents in Viamão is large

due to high traffic, the existence of urban areas and the great length of existing highways. Lajeado presents an significant number of accidents, generated by strong urban character of the roads of the city. Finally, Santo Antonio da Patrulha presents a considerable number of accidents because it has great road length bound.

Regarding the relationship between the evolutionary behavior of the number of accidents in each city, it is observed in Table 4 that the towns cut off by the highway BR 386 (Marques de Souza, Lajeado and Fazenda Vilanova) have related accidents numbers. Yet, it is perceived that the neighboring municipalities of Farroupilha and Caxias do Sul show evolutionary accident patterns inversely proportional (r = -0.67). This finding is curious but it may show that accidents in the region move from one city to another depending on the time and patterns of displacement of the season. It is also possible to see that the municipalities of Santo Antonio da Patrulha and Viamão have matching behavior in relation to the accidents, both linking the metropolitan area to the North coast with similar seasonal and weather patterns.

Table 4: Accidents of the cities and their correlation coefficients

Accidents

City	2004	2005	2006	2007	2008
Viamão	122	130	122	138	150
Santo Antônio da Patrulha	111	120	105	124	118
Marques de Souza	70	68	77	80	84
Farroupilha	85	100	106	86	88
Caxias do Sul	386	340	327	334	380
Lajeado	96	111	109	118	122
Fazenda Vilanova	59	58	65	60	71

City	Viamão	Santo Antônio da Patrulha	Marques de Souza	Farroupilha	Caxias do Sul	Lajeado	Fazenda Vilanova
Viamão	1,00						
Santo Antônio da Patrulha	0,66	1,00					
Marques de Souza	0,73	0,17	1,00				
Farroupilha	-0,44	-0,49	-0,25	1,00			
Caxias do Sul	0,25	-0,03	0,03	-0,67	1,00		
Lajeado	0,86	0,58	0,76	-0,03	-0,25	1,00	
Fazenda Vilanova	0,61	-0,19	0,81	0,02	0,26	0,57	1,00

4.2. Analysis of Socioeconomic Variables of each City

After the evaluation of accident evolution in the seven studied cities, the intersection of local socioeconomic variables of each of these municipalities with the increase of accidents is presented. The goal is to identify variables that may influence the increase/ decrease of the local accident rate. Furthermore, we try to check the breeding behavior in the studied cities. Thus, it is possible to create general and specific strategies to increase road safety.

4.2.1 Viamão

The highway segment maneged by Univias in Viamão is composed primarily by RS 040 road. This highway crosses mostly in rural areas, interspersed areas of high urban concentration where the predominant portion of the accidents is present. Figure 5 shows the aerial image of the region and a photograph of an urbanized segment (Águas Claras District).

Figure 5: Aerial Image and Picture of RS 040 (Viamão)

In the analysis of correlation, it is possible to observe that the growth of traffic on the highway is inversely proportional to the growth of other socioeconomic aspects (see Table 5). This fact suggests that the socioeconomic growth near the downtown of Viamão restricts he highway traffic. In addition, the number of accidents on the highway RS 040 is directly proportional to the traffic that passes through it, since as higher the traffic is the greater the exposure to accidents. Still, it is observed that the correlation between accidents and other sócio-economic variables is weak.

Other socioeconomic aspects are all correlated, that is when the performance of industry and increases, the performance of the service sector, the urbanization rate, the number of consumers of electricity, the fleet, the population, the Product Gross Domestic Product – GDP and GDP per capita of the municipality increase too. These aspects are very concentrated near the Viamão downtown.

Table 5: Accidents and socioeconomic aspects of Viamão and their correlation degree

Viamão

Attributes	2000	2001	2002	2003	2004	2005	2006	2007	2008
Accidents					122	130	122	138	150
Industry	189.000	216.195	183.849	222.987	264.712	290.544	310.189		
Services	473.147	507.170	601.300	687.253	741.260	842.534	906.340		
Urbanization (%)	93	93	94	94	94	94	95		95
Electric Energy Consumers	57.702	58.155	60.080	60.789	61.119	61.862	64.522	65.346	
Fleet				41.708	45.214	49.981	53.350	57.778	
Population	227.429	230.961	234.540	238.183	241.873	245.617	249.421	253.264	255.617
Traffic	1.587.256	2.749.596	2.750.222	2.657.633	2.785.615	2.765.569	2.650.215	2.810.764	3.164.104
GDP (R$ thousands)	895.666	906.815	933.855	1.096.794	1.218.743	1.329.721	1.425.387		
GDP per capita (R$)	3.887	3.849	3.877	4.456	4.848	5.180	5.441		

	Accidents	Industry	Services	Urbanization (%)	Electric Energy Consumers	Fleet	Population	Traffic	GDP (R$ thousands)	GDP per capita (R$)
Accidents	1,00									
Industry	0,08	1,00								
Services	0,13	1,00	1,00							
Urbanization (%)	0,11	1,00	1,00	1,00						
Electric Energy Consumers	-0,31	0,92	0,90	0,91	1,00					
Fleet	0,10	1,00	1,00	1,00	0,92	1,00				
Population	0,00	1,00	0,99	0,99	0,95	0,99	1,00			
Traffic	0,38	-0,89	-0,87	-0,88	-1,00	-0,88	-0,93	1,00		
GDP (R$ thousands)	0,04	1,00	1,00	1,00	0,94	1,00	1,00	-0,91	1,00	
GDP per capita (R$)	0,07	1,00	1,00	1,00	0,93	1,00	1,00	-0,90	1,00	1,00

4.2.2 Caxias do Sul

The highway segments controlled by Univias in the city of Caxias do Sul (RS/122, RSC/453, BR/116) are mostly located in urban areas, as shown in Figure 6. The gray area in the aerial image shows the large urbanized area, while the picture exposes the residential area in the fringe of the RSC 453 highway.

Figure 6: Aerial imagem and Picture of Caxias do Sul

In the correlation analysis, the behavior of the number of accidents in road segments of Caxias do Sul is inversely proportional to other socioeconomic variables. In other words, the more the city grows smaller is the number of road accidents. Other socioeconomic aspects are all highly correlated, that is, when the local industry sector is increasing or decreasing, the other aspects (services, urbanization rate, eletricity consumed, fleet, population, GDP and GDP per capita) present the same behavior.

Table 6: Accidents and socioeconomic aspects of Caxias do Sul and their correlation degree

Caxias do Sul

Attributes	2000	2001	2002	2003	2004	2005	2006
Accidents					386	340	327
Industry	2.326.568	2.504.988	1.794.715	2.179.147	2.931.798	3.040.701	3.096.853
Services	1.656.973	1.763.228	2.759.966	3.039.833	3.312.998	3.883.005	4.123.393
Urbanization (%)	93	93	93	93	94	94	94
Electric Energy Consumers	122.979	128.623	133.155	137.531	140.321	143.955	148.994
Fleet				146.293	154.756	165.456	176.037
Population	360.419	365.557	370.790	376.135	381.597	387.213	393.021
GDP (R$ thousands)	4.613.949	5.047.241	5.466.216	6.328.377	7.481.649	8.294.152	8.621.444
GDP per capita (R$)	12.643	13.543	14.366	16.295	18.881	20.521	20.923

	Accidents	Industry	Services	Urbanization (%)	Electric Energy Consumers	Fleet	Population	GDP (R$ thousands)	GDP per capita (R$)
Accidents	1,00								
Industry	-0,99	1,00							
Services	-1,00	1,00	1,00						
Urbanization (%)	-0,95	0,98	0,97	1,00					
Electric Energy Consumers	-0,92	0,96	0,95	1,00	1,00				
Fleet	-0,95	0,98	0,97	1,00	1,00	1,00			
Population	-0,95	0,98	0,97	1,00	1,00	1,00	1,00		
GDP (R$ thousands)	-1,00	1,00	1,00	0,97	0,94	0,97	0,97	1,00	
GDP per capita (R$)	-1,00	0,99	0,99	0,94	0,91	0,94	0,94	1,00	1,00

4.2.3 Farroupilha

The city of Farroupilha is cut by the RS 122 road, according to Figure 7. The highway is used as a means of connection to urban movements and gateways displacements from Farroupilha to Caxias do Sul and other municipalities of Rio Grande do Sul and Santa Catarina (Flores da Cunha, São Marcos, Vacaria and Lages-SC). In this city, there are several conflict accident locations due to the crossing flow of vehicles and local pedestrians with local passing traffic.

Figure 7: Aerial imagem and Picture of Farroupilha

The Analyzis of the number of accidents with other socioeconomic variables of Farroupilha shows that the evolution of the traffic accident is directly proportional to the development of the city (see Table 7). It happens because when the economic activities progress, the conflict of local traffic increases. The other local socioeconomic elements are all strongly correlated and have the same pattern of growth and decline.

Table 7: Accidents and socioeconomic aspects of Farroupilha and their correlation degree

Farroupilha

Attributes	2000	2001	2002	2003	2004	2005	2006	2007	2008
Accidents					85	100	106	86	88
Industry	335.840	320.812	234.662	282.435	354.840	349.266	358.770		
Services	262.070	271.309		394.427	418.905	474.295	509.479		
Urbanization (%)	77	78	78	78	79	79	80		82
Electric Energy Consumers	18.253	18.922	19.576	20.239	20.570	21.172	21.755	22.560	
Fleet				22.327	23.463	24.817	26.206	27.560	
Population	55.308	56.078	56.790	57.481	58.131	58.742	59.319	59.871	60.816
Traffic	2.638.017	2.331.061	447.085	5.036.268	4.968.804	4.523.565	4.224.430	4.315.783	4.841.329
GDP (R$ thousands)	758.253	771.659	812.569	926.685	1.043.020	1.090.784	1.145.553		
GDP per capita (R$)	13.546	13.508	13.942	15.587	17.205	17.651	18.193		

	Accidents	Industry	Services	Urbanization (%)	Electric Energy Consumers	Fleet	Population	Traffic	GDP (R$ thousands)	GDP per capita (R$)
Accidents	1,00									
Industry	0,18	1,00								
Services	0,99	0,29	1,00							
Urbanization (%)	0,97	0,41	0,99	1,00						
Electric Energy Consumers	0,97	0,40	0,99	1,00	1,00					
Fleet	0,97	0,42	0,99	1,00	1,00	1,00				
Population	0,97	0,40	0,99	1,00	1,00	1,00	1,00			
Traffic	-0,99	-0,31	-1,00	-0,99	-0,99	-0,99	-1,00	1,00		
GDP (R$ thousands)	0,96	0,45	0,99	1,00	1,00	1,00	1,00	-0,99	1,00	
GDP per capita (R$)	0,96	0,46	0,98	1,00	1,00	1,00	1,00	-0,99	1,00	1,00

4.2.4 Lajeado

The municipality of Lajeado is heavily dependent on BR/386, RSC/453 and RS/130 roads, through which its population and economy pass. Moreover, in these roads there is a strong passage flow to municipalities in the North and Northeast area of the State. The central region is very urbanized according to Figure 8, and the highway has a high traffic and pedestrian flows (see Figure 8).

Figure 8: Aerial imagem and Picture of Lajeado.

Comparing the evolution of the number of accidents with other socioeconomic aspects, it is observed that the behavior of the accident is directly proportional to the socioeconomic activities, except for the behavoir of industry which is inversely proportional (see Table 8). The correlation between industry and other socioeconomic aspects is low and its behavior is similar to the urbanization rate of the city (r = 0.6). Other socioeconomic attributes are all highly correlated (services, urbanization rate, electricity consumption, fleet, population, GDP and GDP per capita).

Table 8: Accidents and socioeconomic aspects of Lajeado and their correlation degree

Lajeado

Attributes	2000	2001	2002	2003	2004	2005	2006	2007	2008
Accidents					96	111	109	118	122
Industry	325.263	321.161	222.809	288.267	389.952	374.632	392.314		
Services	262.235	269.891	429.649	499.736	558.642	633.969	718.820		
Urbanization (%)	94	99	99	99	100	100	100		100
Electric Energy Consumers	15.526	15.930	16.321	16.766	17.280	17.834	18.226	18.658	19.168
Frota				28.281	30.335	32.628	34.829	37.185	
População	64.133	60.876	61.951	63.038	64.130	65.239	66.341	67.476	68.386
GDP (R$ thousands)	662.875	676.259	773.774	934.199	1.109.222	1.183.686	1.299.260		
GDP per capita (R$)	10.220	10.968	12.316	14.595	17.015	17.833	19.232		

	Accidents	Industry	Services	Urbanization (%)	Electric Energy Consumers	Fleet	Population	GDP (R$ thousands)	GDP per capita (R$)
Accidents	1,00								
Industry	-0,50	1,00							
Services	0,78	0,16	1,00						
Urbanization (%)	0,39	0,60	0,88	1,00					
Electric Energy Consumers	0,85	0,02	0,99	0,81	1,00				
Fleet	0,81	0,11	1,00	0,86	1,00	1,00			
Population	0,80	0,12	1,00	0,87	1,00	1,00	1,00		
GDP (R$ thousands)	0,72	0,25	1,00	0,92	0,98	0,99	0,99	1,00	
GDP per capita (R$)	0,70	0,27	0,99	0,93	0,97	0,99	0,99	1,00	1,00

4.2.5 Fazenda Vilanova

The city of Fazenda Vilanova is highly subordinate of BR/386 highway, a road which crosses toward the east-west, according to the aerial image of Figure 9. There is great conflict between traffic and local pedestrian flows with high passing traffic, which creates a representative number of accidents (see photo in Figure 9). The trade and schools are located in the fringe area of the highway.

Figure 9: Aerial imagem and Picture of Fazenda Vilanova.

The analysis of the correlation between the amount of accidents and the socioeconomic variables of FazendaVilanova shows that the results are directly proportional, that is, when the city develops the number of accidents increases. Only the industry and traffic of the tollplazas have an opposite behavior of the accidents. Therefore, the higher industrial activity and traffic in the tollplaza, the lower the amount of accidents. This can be explained by the industries and the tollplaza located far away from the downtown, where most of the claims concentrate (see Table 9).

Table 9: Accidents and socioeconomic aspects of Fazenda Vilanova

Fazenda Vilanova

Attributes	2000	2001	2002	2003	2004	2005	2006	2007	2008
Accidents					59	58	65	60	71
Industry	4.157	4.728	5.114	14.308	27.784	29.940	26.376		
Services	6.371	7.026	12.985	10.733	12.920	16.262	20.830		
Urbanization (%)	43	43	44	44	45	45	46		50
Electric Energy Consumers	750	816	869	905	938	984	1.030	1.103	
Fleet				957	1.052	1.194	1.312	1.428	
Population	2.833	2.877	2.914	2.953	2.984	3.011	3.046	3.088	3.134
Traffic	1.705.375	3.181.516	3.193.262	3.157.105	3.221.351	3.110.991	3.110.270	3.297.292	3.440.191
GDP (R$ thousands)	21.816	23.078	71.921	41.792	58.531	65.449	67.075		
GDP per capita (R$)	7.612	7.895	24.126	13.752	18.893	20.738	20.870		

	Accidents	Industry	Services	Urbanization (%)	Electric Energy Consumers	Fleet	Population	Traffic	GDP (R$ thousands)	GDP per capita (R$)
Accidents	1,00									
Industry	-0,87	1,00								
Services	0,84	-0,47	1,00							
Urbanization (%)	0,82	-0,44	1,00	1,00						
Electric Energy Consumers	0,79	-0,39	1,00	1,00	1,00					
Fleet	0,76	-0,34	0,99	0,99	1,00	1,00				
Population	0,84	-0,46	1,00	1,00	1,00	0,99	1,00			
Traffic	-0,39	-0,11	-0,82	-0,84	-0,87	-0,89	-0,83	1,00		
GDP (R$ thousands)	0,54	-0,06	0,91	0,92	0,94	0,96	0,91	-0,98	1,00	
GDP per capita (R$)	0,44	0,06	0,85	0,87	0,89	0,92	0,86	-1,00	0,99	1,00

4.2.6 Marques de Souza

The municipality of Marques de Souza has a great rural characteristic, and its most urbanized area developed near the highway BR/386, according to the aerial image in Figure 10. Much of the accidents caused by cross traffic of vehicles and local pedestrians with flow passage happen in this urban area (see photo of Figure 10).

Figure 10: Aerial imagem and Picture of Marques de Souza

The correlation between the amount of accidents with the socioeconomic variables of the city shows that the accidents increases with the development of the city (see Table 10). There are two variables that are inversely proportional to the amount of accidents, namely population and traffic in the tollplaza. The other economic variables are all correlated (industry, services, urbanization rate, fleet, GDP and GDP per capita).

Table 10: Accidents and socioeconomic aspects of Marques de Souza and their correlation degree

Marques de Souza

Attributes	2000	2001	2002	2003	2004	2005	2006	2007	2008
Accidents					70	68	77	80	84
Indústria	3.204	3.747	3.167	3.292	4.054	3.941	4.319		
Services	4.442	4.666	4.530	5.521	6.099	6.849	7.766		
Urbanization (%)	35	35	35	36	36	36	37		41
Fleet				1.236	1.343	1.449	1.538	1.618	
Population	4.241	4.217	4.195	4.162	4.138	4.107	4.072	4.043	4.106
Traffic	1.713.382	1.747.847	1.749.013	1.759.992	1.773.849	1.645.017	1.599.432	1.734.314	1.913.310
GDP (R$ thousands)	26.494	29.479	23.345	28.123	31.244	30.459	35.775		
GDP per capita (R$)	6.215	6.852	5.379	6.422	7.070	6.832	7.955		

	Accidents	Industry	Services	Urbanization (%)	Fleet	Population	Traffic	GDP (R$ thousands)	GDP per capita (R$)
Accidents	1,00								
Industry	1,00	1,00							
Services	0,78	0,72	1,00						
Urbanization (%)	0,79	0,74	1,00	1,00					
Fleet	0,71	0,65	0,99	0,99	1,00				
Population	-0,76	-0,71	-1,00	-1,00	-1,00	1,00			
Traffic	-0,54	-0,46	-0,95	-0,94	-0,98	0,95	1,00		
GDP (R$ thousands)	1,00	0,99	0,82	0,84	0,76	-0,81	-0,60	1,00	
GDP per capita (R$)	1,00	1,00	0,78	0,80	0,71	-0,77	-0,54	1,00	1,00

4.2.7 Santo Antônio da Patrulha

The municipality of Santo Antônio da Patrulha is crossed by two highways managed Univias Consortium System (RS/030 and RS/474). The RS 474 road is a very rural new road, while the RS 030 highway, originally built in the 30s, has a very undeveloped segment near the center of the city (aerian picture in Figure 11). In this urban segment, the degree of traffic conflict between internal circulation and passage flow volume (photo in Figure 11).

Figure 11: Aerial imagem and Picture of Santo Antônio da Patrulha

The behavoir checking between the evolution of the number of accidents and other socioeconomic variables of Santo Antônio da Patrulha shows that they are inversely proportional (see Table 11). The higher the socioeconomic growth is, the lower the amount of traffic accidents. Only the variable industry has no correlation with the ratio (r = 0.02). The other socioeconomic variables are all correlated.

Table 11: Accidents and socioeconomic aspects of Santo Antônio da Patrulha and their correlation degree

Santo Antônio da Patrulha

Attributes	2000	2001	2002	2003	2004	2005	2006	2007	2008
Accidents					111	120	105	124	118
Industry	71.228	83.038	63.274	64.465	71.315	78.258	79.041		
Services	91.137	95.554	114.466	133.551	141.034	157.473	172.842		
Urbanization (%)	63	64	65	66	67	68	69		73
Electric Energy Consumers	11.703	12.277	12.665	13.017	13.379	13.736	14.116		
Fleet				10.667	11.253	11.929	12.438	13.378	
Population	37.035	37.192	37.336	37.457	37.579	37.696	37.806	37.910	38.391
GDP (R$ thousands)	197.465	225.454	223.591	265.347	286.524	299.255	319.678		
GDP per capita (R$)	5.309	6.019	5.926	6.983	7.487	7.764	8.235		

	Accidents	Industry	Services	Urbanization (%)	Electric Energy Consumers	Fleet	Population	GDP (R$ thousands)	GDP per capita (R$)
Accidents	1,00								
Industry	0,02	1,00							
Services	-0,38	0,92	1,00						
Urbanization (%)	-0,37	0,92	1,00	1,00					
Electric Energy Consumers	-0,41	0,90	1,00	1,00	1,00				
Fleet	-0,32	0,94	1,00	1,00	1,00	1,00			
Population	-0,38	0,92	1,00	1,00	1,00	1,00	1,00		
GDP (R$ thousands)	-0,52	0,84	0,99	0,99	0,99	0,98	0,99	1,00	
GDP per capita (R$)	-0,53	0,84	0,99	0,98	0,99	0,97	0,99	1,00	1,00

5. FINAL CONSIDERATIONS

Once the roads are the shortest path between origin and destination cities in most cases, they become highly attractive to the population by improving accessibility and enhancing the value of land bordering. However, this occupation has some negative consequences, such as informal and disorderly housing occupation; deficit in the population's life quality, and increase of exposure to accidents. This becomes more serious because of the asymmetry of capabilities and resources of municipalities, creating distinct patterns of accidents.

This asymmetry in the patterns of accidents between the municipalities was observed in this study, considering the lack of general correlations of the behavior of the accidents in the different areas studied. However, each city presented certain reproduction of its own internal standards. For instance, the socioeconomic aspects of the cities usually are all related, that are, increase as well. Furthermore, there were correlations between the increase of the amount of accidents and local socioeconomic variables.

In larger cities, such as Caxias do Sul, the increase of accidents is inversely proportional to the growth of the economy, that is, the high levels of development of the city represented less traffic accidents. This fact is confirmed by other studies of the literature, such as that of Sauer and Wagner (2003) performed with information from the Federal Capitals and the Federal District. This study showed a strong correlation between death traffic index and infant mortality rate, reaching the hypothesis that there is a direct relationship between socioeconomic status of a population and traffic mortality (the poorer the municipality, most accidents occur). According to the authors, the causes of mortality in traffic are: a multifactorial action of environmental, social, political, economic and cultural aspects (Bastos et al., 1999, Mao et al., 1997, Marín & Queiroz, 2000; Soderlund & Zwi, 1995; Williams, 1999 cited in Sauer and Wagner, 2003).

However, in medium and small municipalities as Farroupilha, Lajeado, Fazenda Vilanova and Marques de Souza, there was an inverse behavior in relation to the one suggested by literature. The more the socioeconomic impacts of cities grow, the larger is the number of accidents. This fact is strongly connected with the high socioeconomic dependency of the municipalities in relation to crossing roads. Therefore, in these small and medium-sized cities bordering business expansion (traffic generator poles) require strong mitigation traffic measures to avoid impacts on accidents. As the Federal Constitution, it is the duty of the State (country, states and municipalities within their offerings) to promote appropriate land use through urbanistic and engineering improvements, or even demanding highway concessionaires for ideal conditions of security.

Besides, it is important to consider the prevention of mortality in traffic through the principles of the concept of population human development. It means a greater equality in the construction and distribution of benefits and political, social, cultural, economic and environmental sustainability (Sauer and Wagner, 2003).

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