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Determinant of Road Traffic Crash Fatalities in Iran: A Longitudinal Econometric Analysis

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ABSTRACT

Background: Injuries and deaths from road traffic crashes are one of the main public health problems throughout the world. This study aimed to identify determinants of fatality traffic accident in Iran for the twenty-span year from 1991 to 2011.

Methods: A time series analysis (1991-2011) was used to examine the effects of some of the key explanatory factors (GDP per capita, number of doctors per 10,000 populations, degree of urbanization, unemployment rate and motorization rate) on deaths from road traffic in Iran. In order to examine long- and short-run effects of variables, we employed autoregressive distributed lag (ARDL) approach and error correction method (ECM). The data for the study was obtained from the Central Bank of Iran (CBI), Iranian Statistical Center (ISC) and Legal medical organizations (LMO).

Results: GDP per capita, doctor per 10,000 populations, degree of urbanization and motorization rate had a significant impact on fatality from road traffic in Iran. We did not observe any short- and long-term effects of the unemployment rate on fatality from road traffic.

Conclusions: GDP per capita, doctor per 10,000 populations, degree of urbanization and motorization rate were identified as main determinant of fatality from road traffic accidents in Iran. We hope the results of the current study enable health policy-makers to understand better the factors affecting deaths from road traffic accidents in the country.

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Introduction

Fatalities from road traffic crashes (RTCs) are one of the major public health issues throughout the world, especially for developing countries. Based on recently report, published by WHO, road traffic crashes annually are responsible for 1.2 million deaths and over 25 million injuries over the world which about 90% of these occur in low and middle-income countries (LMICs)^{1,2}. It is estimated that RTC will be the third leading cause of death and disability worldwide by the year 2020 after ischemic heart disease and unipolar major depression³. The economic costs of RTC are substantial in developed as well as developing countries. Total cost of RTC is estimated 1% of gross national production (GNP) in low-income countries, 1.5% in middle-income countries and 2% in high-income countries. In addition, direct economic cost of RTC in LMICs is estimated 65 billion US Dollars, which is more than the financial aid received for development from developed countries⁴.

Many studies have examined the relationship between macro-determinant and fatalities from RTC over the world⁵⁻⁹. These studies highlighted the effect of different variables on

RTC fatalities such as socio-demographic (employment rate, urbanization degree and per capita GDP), road behavior (alcohol use), road vehicles (number of vehicles) and medical care (number of bed, physician and MRI or CT-scan)⁵⁻⁷. Torre et al.⁷ investigated main determinants of within-country variation in traffic accident mortality in Italy using multiple linear regression models. They concluded that employment rate and prevalence of alcohol drinking are the main determinant of mortality due to road traffic. Law et al.⁸ demonstrated that improvement in medical care and technology had a significant relationship with reduction of fatalities from road accident.

Iran has one of a highest RTC fatality rate in the world. Iran also accounts for 1 and 2.5 per cent of world's population and road traffic accidents¹⁰. Each year, around 28000 people are killed and as many as 800,000 are injured or disable due to RTC in Iran¹¹⁻¹². RTCs are the second cause of death in Iran after cardiovascular diseases¹³. In addition, they have a significant burden on economic of Iran. Rezaei et al.¹⁴ have investigated that the economic burden of RTC in

Iran for the year 2009. They found that the economic burden of RTC in Iran was 7.2 billion US Dollars in 2009, which amounts to 2.19% of Iran’s gross domestic production (GDP). To the best of our knowledge at the time of this study, there was not any study focusing on the macro-determinant of RTC fatality in Iran.

The purpose of the current study was to examine the association between macro-determinant and fatalities from RTCs in Iran using a time series using a time-series analysis approach. The results of this study could enable health policy-makers to understand better the factors affecting fatalities from road traffic crashes in the country and thereby take necessary steps in managing and controlling the upward trends in overall RTC fatalities.

Methods

Based on available information, we constructed a data set comprising information on fatality rate from RTC, GDP per capita (current US\$), degree of urbanization, unemployment rate, motorization rate (number of vehicle per 10,000 populations) and number of doctors per 10,000 populations over the period between 1991 and 2011. The data were obtained from the Central Bank of Iran, Iranian Statistical Center and Legal Medical Organization. The data analysis was performed by STATA V.12 and Microfit 4.1.

Test for unit root and stationery

The first step in a longitudinal study is to determine whether the variables are stationary. Based on econometrics text, most of time series data are not stationery and when variables are not stationery, the estimation of parameters is not consistence and spurious regression will occur¹⁵. The Augmented Dickey – Fuller (ADF) unit root test was used to test for examine the stationary of the variables in the model. The ADF test can be defined as follows:

$$\Delta LFAT_t = \alpha_0 + \alpha t + \varphi LFAT_{t-1} + \sum \varphi_i LFAT_{t-i} + u_t$$

(Equation 1)

$$\Delta LFAT_t = LFAT_t - LFAT_{t-1}$$

Where:

LFAT denotes the dependent variable; α_0 constant, t trend variable; u_t shows the stochastic disturbance term. In this test, the null hypothesis is that the variable has a unit root and is not stationery.

$$H_0: \varphi = 0 \text{ (Variable is non-stationary)}$$

$$H_1: \varphi \neq 0 \text{ (Variable is stationary)}$$

Tests for Cointegration

The second step, whether or not the variables are cointegrated. If the variables are cointegrated, there are a long-run relationship between RTC fatality and its determinants. The Banerjee, Dolado, and Mestre (BDM) test¹⁶ was used to assess cointegration amongst variables.

Therefore, it is necessary to test the following hypothesis:

$$H_0 = \sum_{i=1}^p \varphi_i - 1 \geq 0 \text{ (Variables are not cointegrated)}$$

$$H_0 = \sum_{i=1}^p \varphi_i - 1 < 0 \text{ (Variables are cointegrated)}$$

The following t-statistic can be used to test for the above-mentioned hypothesis:

$$t = ((\sum \alpha^{\wedge} - 1)/(\sum s^{\wedge})) \text{ (Equation 2)}$$

S is the standard error of dependent variable with lag and α^{\wedge} is the sum of the coefficient dependent variable. If the amount of the t statistic (Equation 2) is greater than the critical value suggested by BDM test¹⁶, the null hypothesis will be rejected and the model will tend towards long-term equilibrium.

Stability of coefficients

The cumulative sum of recursive residuals (CUSUM) and cumulative sum of square of recursive residuals (CUSUMSQ) tests was used to examine the stability of coefficients proposed by Brown et al.¹⁷. In two tests if the plots of CUSUM and CUSUMSQ inside in two critical lines, the coefficients of model are structurally stable.

Econometric Model

This approach was introduced firstly Pesaran and shin in 1999 and extended by Pesaran et al. in 2001¹⁸⁻¹⁹. This approach does not require all variables are integrated at first difference I (1) and is suitable for either I (1) or I (0) or mixed integration. In addition, this model provides short- and long-run dynamic relationship between independent variable and explanatory variables without losing long-run information.

The ARDL equation used in our study as follows:

$$\begin{aligned} \text{Ln FAT}_t = & \alpha_0 + \sum_{i=1}^p \alpha_{1i} \Delta \text{Ln FAT}_{t-i} + \sum_{i=0}^{q_1} \alpha_{2i} \Delta \text{Ln GDP}_{t-i} \\ & + \sum_{i=0}^{q_2} \alpha_{3i} \Delta \text{Ln DOC}_{t-i} + \sum_{i=0}^{q_3} \alpha_{4i} \Delta \text{Ln URB}_{t-i} \\ & + \sum_{i=0}^{q_4} \alpha_{5i} \Delta \text{Ln UNEMP}_{t-i} \\ & + \sum_{i=0}^{q_5} \alpha_{6i} \Delta \text{Ln MOT}_{t-i} + \beta_1 \text{Ln GDP}_{t-i} \\ & + \beta_2 \text{Ln DOC}_{t-i} + \beta_3 \text{Ln URB}_{t-i} \\ & + \beta_4 \text{Ln UNEMP}_{t-i} + \beta_5 \text{Ln MOT}_{t-i} + \varepsilon_t \end{aligned}$$

(Equation 3)

Where:

Ln FAT: logarithm of Fatality rate per 10,000 populations; Ln GDP: logarithm of GDP per capita ((current US\$)); Ln DOC: logarithm of number of doctors per 10,000 populations; Ln URB: logarithm of percentage of people who lived in the urban relative to the total populations; Ln UNEMP: logarithm of unemployment rate; Ln MOT: logarithm of Motorization rate (number of vehicle per 10,000 populations); Δ is the first difference; ε_t is assumed to be a white noise error process. The variables are transformed by their logarithm to make for easy interpretation of regression coefficients.

While the expressions with summation sign indicate the short-run dynamics of the model, the expressions with β_1 to β_6 represent the long-run relationship. If there are a long run relationship between variables, the final step is the estimation the short-run dynamic coefficients via the following error correction model²⁰.

$$\Delta LFAT_t = \alpha_0 + \sum_{i=1}^p \alpha_{1i} \Delta LFAT_{t-i} + \sum_{i=0}^{q_1} \beta_{1i} \Delta LGDP_{t-i} + \sum_{i=0}^{q_2} \beta_{2i} \Delta LDOC_{t-i} + \sum_{i=0}^{q_3} \beta_{3i} \Delta LURB_{t-i} + \sum_{i=0}^{q_4} \beta_{4i} \Delta LUNEMP_i + \sum_{i=0}^{q_5} \beta_{5i} \Delta LMOT_i + \lambda ECM_{t-1} + \varepsilon_t$$

(Equation 4)

All of variables have been defined before except Δ and λ . Δ shows the first difference of variables and λ represents the speed of adjustment to the long-term equilibrium and ranges from zero to minus one. A negative value of the λ indicates a short-term adjustment in the percentage changes of HCE towards its long-term equilibrium.

Results

From 1991 to 2011, approximately 424855 people died in traffic accidents in Iran. The trend number of deaths per 100,000 populations from RTC between 1991 and 2011 year in Iran is shown in Figure 1. Accordingly, the number of death from RTC increased from 20 per 100,000 populations in 1991 to 40 per 100,000 in 2005, but it was decreased to 27 in 2011. Moreover, GDP per capita (as measured in current US\$) increased from 2056 in 1991 to 7006 in 2011.

Table 1: ADF unit-root test of levels and first difference of variables used in our study

Variables	Level (P value)		First difference (P value)		Order of integration
	Constant	Constant and trend	Constant	Constant and trend	
Stationery at the first difference					
Ln FAT	-1.39 (0.581)	0.54 (0.987)	-3.94 (0.011)	-3.94(0.011)	I (1)
Ln MOT	-0.23 (0.993)	-2.78 (0.218)	-3.04 (0.029)	-3.07(0.001)	I (1)
Ln GDP	1.20 (0.996)	-2.2 (0.481)	-3.59 (0.024)	-3.11(0.025)	I (1)
Ln UNEM	-2.63 (0.082)	-2.55 (0.299)	-5.33 (0.001)	-5.18(0.001)	I (1)
Stationery at level					
Ln URB	-3.43 (0.009)	-3.01 (0.043)	-	-	I (0)
Ln DOC	-7.51 (0.000)	-5.77 (0.001)	-	-	I (0)

ARDL estimates (1, 0, 0, 0, 0 and 0) selected based on Schwarz Bayesian Criterion is shown in Table 2. The value of R² is 0.986, which indicates there is a high correlation between fatality from RTC and explanatory variables in the model. In addition, the calculated F-statistic (P= 0.001) confirms all estimated variables are significant.

Table 2: ARDL estimates (1, 0, 0, 0, 0 and 0) selected based on Schwarz Bayesian Criterion

Variables	Coefficient	T Ratio	P value
Ln FAT(-1)	0.66	3.72	0.003
Ln GDP	-1.59	-5.68	0.000
Ln MOT	0.13	2.04	0.032
Ln UNEM	0.05	0.39	0.689
Ln URB	6.68	5.06	0.000
Ln DOC	-0.39	-0.71	0.048
C	-11.36	-4.56	0.001
- R-Squared		0.98	
- F-statistic		0.00	
- DW-statistic		2.49	
Diagnostic Tests			
- Serial Correlation		0.31	
- Functional Form		0.98	
- Heteroscedasticity		0.32	
- Normality		0.47	

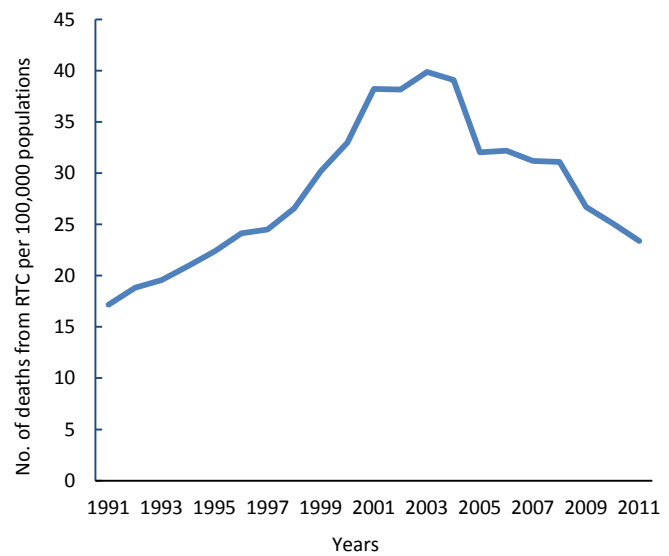


Figure 1: Trends of death rate per 100,000 populations in Iran (1991-2011)

The results about unit root of variables based on ADF test are shown in Table 1. The fatality rate, motorization rate, per capita GDP and unemployment rate are stationary at the first difference and the rest of variable are stationary at the level. Based on results of the Table 1, the estimation of parameters in the model is consistence and the spurious regression will not occur.

The value of Durbin Watson (DW) statistic is 2.49 for the model. This implies that there are absences of auto-correction problem in residuals of the model. The result of BDM test was -4.9 and significant at the 0.1 (-4.43) and 0.05 (-4.85). Therefore, it indicated that there was a long-run relationship between independent and its determinants. The results long-run relationship between RTC fatality and its determinants presented in Table 3.

Our findings showed that increase in per capita GDP and physician per 10000 populations reduces the fatality rate and increase in motorization rate and degree of urbanization increase the fatality rate. There was not a significant association between unemployment rates with fatality rate. The results of short-run coefficients are shown in Table 4. According to results of short-run, the relationship between fatality rate and urbanization degree was positive and significant. In addition, the per capita GDP had a negative impact and significant on RTC fatality during the studied period. This indicated that 1% increase in per capita GDP will leads to 1.59 % decrease in fatality from RTC. Besides, the coefficient ECM (-1) is -0.33 and this implies an about 33% of the disequilibrium in the total fatality rate in the previous year is corrected in the current year.

Table 3: Estimated Long Run Coefficients for selected ARDL Model

Variables	Coefficient	T Ratio	P value
Ln GDP	-4.78	-2.15	0.049
Ln MOT	0.38	3.69	0.003
Ln UNEM	0.16	0.42	0.682
Ln URB	20.09	2.26	0.042
Ln DOC	-1.18	-0.83	0.041
C	-34.99	- 1.88	0.083

Finally, we had to test the stability of coefficients and investigate whether the estimated long run relationship were stable during the studied period. Figure 2 shows that both

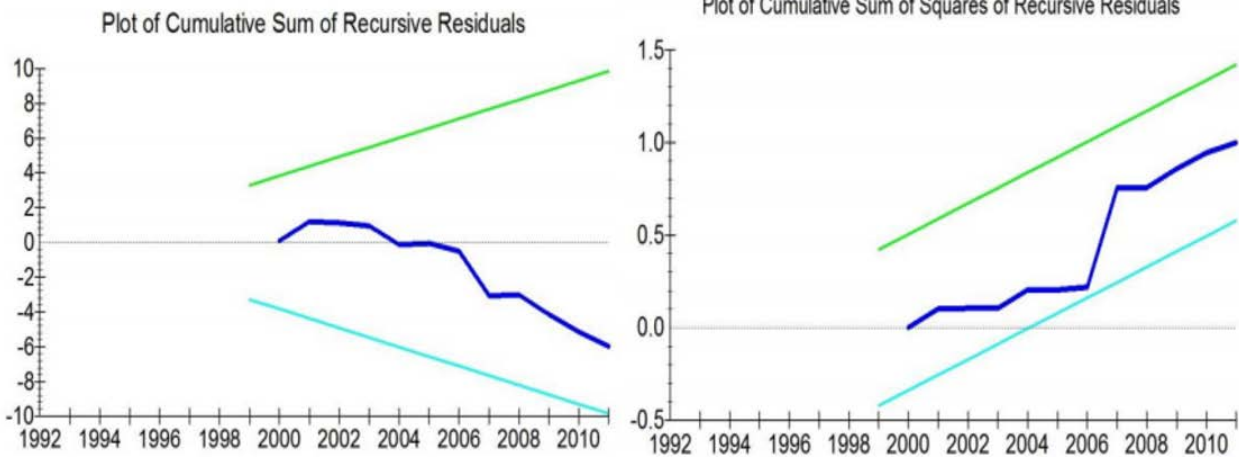


Figure 2: Cumulative Sum of Residuals and Cumulative Sum of Squares of Recursive Residuals

Discussion

Road traffic crashes are one of the main public health problems over the world. They are also one of the main leading cause of deaths and disability in a given country and the second of death after cardiovascular diseases in Iran^{7, 13}; Researchers in Italy⁷, in industrialized countries²¹, in Ohio²² and in Sweden²³ have examined the effect macro-determinant such as GDP per capita, unemployment rate, and urbanization degree of road traffic crashes. To the best of our knowledge at the time of this study, studies about macro-determinant of RTC fatality in Iran were not published. The present study aimed to examine the main factors affecting on fatality from road traffic crashes using a time-series analysis approach.

GDP per capita generally have been considered as one of the main determinant of RTC fatality. There is an inverted U-shaped patters between fatality rate of traffic and economic growth^{8, 24, 25}. Our empirical analysis showed that the per capita GDP had a negative and statistically significant effect on RTC fatalities in both short- and long-term estimation. The long-run coefficient of this variable was -4.7 which implies a 1 per cent increase in per capita GDP causes 4.7 per cent decrease in fatalities due to RTC. This result is consistent with finding of previous studies^{22, 24}. Van Beeck et al.⁹ found the income per capita had a statistically significant inverse impact on traffic fatalities. They concluded that a lower mortality from RTC is associated with higher income per capita. The income per capita had a negative effect on regional mortality levels, although this relationship was not significant⁷. Nagata et al.²⁶ in Japan reported an inverse association between income per capita and traffic mortality.

We used the number of doctors per 10000 populations as proxy of access to health care. The results show that there was an inverse association between number of doctors and

CUSUM and CUSUMSQ are placed in two lines, so this implies that the coefficients in the short and long run model are structurally stable.

Table 4: Estimated Short-Run Coefficients based on Error Correction Model

Variables	Coefficient	T Ratio	P value
dLn GDP	-1.59	-5.70	0.001
dLn MOT	0.13	2.04	0.032
dLn UNEM	0.05	0.40	0.689
dLn URB	6.68	5.06	0.001
dLn DOC	-0.39	-0.71	0.049
dc	-11.99	- 4.56	0.001
ecm(-1)	-0.33	-1.84	0.088

traffic fatality rate, both in short- and long-term. Our study showed for every 1% increase in number of physician causes decrease traffic fatalities by 3.9 %, which is in consistence with other studies^{9, 21, 26}. Noland has examined the effect medical treatment on traffic fatality in industrialized countries which physician per 10000 populations, the average number of days in the hospital for acute care patients was used as proxies for improvements in medical care and technology. There was a significant indirect association between the physicians per capita, total traffic fatalities, and its coefficient varied between -0.254 and -0.465²¹. Some studies have used alternative measures of access to health care such as availability of CT-Scan and MR- Scan^{7, 9}. Torre et al.⁷ found a higher availability of MR- Scan is associated with lower mortality levels.

Another factor, which was considered in our study, was the number of vehicle per 100,000 populations (motorization rate). Our study showed that motorization rate was positive and significantly associated with traffic fatality rate, both in short- and long-term. This result is consistent with finding of other studies^{6, 7, 9}. Torre et al.⁷found that the coefficient of number of vehicle in Italy was 0.028 and this indicates a 10% increase in the number of vehicles causes increase in fatality rate of traffic by 0.28%. The results also indicated that the coefficient of unemployment rate and degree of urbanization was positive. This implies that higher levels of unemployment and urbanization degree are associated with higher traffic fatalities level in Iran.

Conclusions

Using time series national data, we explored the association between macro-determinant and traffic fatality rate for the years 1991 to 2011 in Iran. The motorization rate,

degree of urbanization, GDP per capita and number of doctors per 10,000 populations were the main factors affecting fatality from RTC. We hope the results of this study enable health policy-makers to understand better the factors affecting RTC fatality in the country.

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The authors declare that there is no conflict of interests.

Conflict of interest statement

None declared.

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