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The relationship between traffic accidents and economic growth in China

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Abstract

Using province-level panel data in China, we examine the relationship between traffic accidents and economic growth. A semiparametric partial linear model is used to account for potential nonlinearity in the relationship. The estimation results indicate that the relationship exhibits an inverted U-shaped pattern; traffic fatality and injury increase as provincial GDP per capita rise up to about $1500 and $4000 respectively, and decline thereafter. Unlike cross-country studies in the literature, we show that traffic fatalities in the entire China are already in a decreasing phase.

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1. Introduction

Under the well-known environmental Kuznets curve (EKC) hypothesis (Grossman and Krueger 1991), the relationship between environmental externalities and economic growth exhibits an inverted U-shape. That is, environmental externalities increase as the economy grows in countries with low income; once the economy exceeds a certain threshold, the externalities start declining with further development.

The hypothesis has been tested in numerous environmental studies. Besides the field, the curve has been found in other fields that deal with externalities. For example, Kellenberg and Mobarak (2008) show that there is an inverted U-shaped relationship between damages from specific types of natural disasters and economic levels. Also, Andrés (2006) shows the presence of a concave relationship between piracy and per capita income. These studies exhibit the potential of applying the concept of the EKC hypothesis not only to the environmental field but also to other fields.

We may be able to observe the curve also in traffic accident externalities. In countries with low income, economic growth increases number of vehicles and traffic accidents because people's marginal utilities for possessing and using vehicles are larger than those for protecting traffic accidents. However, the magnitude relation between the marginal utilities turns over at a certain economic level, and then traffic accidents start declining.

Van Beeck et al. (2000) use data from 21 industrialized countries from 1962 to 1990 and show that the traffic fatality rate rises until per capita Gross Domestic Product (GDP) grows to around \$3000; after this, it begins to decrease. Kopits and Cropper (2005) use panel data from 1966 to 1999 for 88 countries (including developing countries) and show that the threshold for the fatality rate is \$8600. Bishai et al. (2006) conclude that the threshold of the traffic fatality rate is around \$1500 to \$8000, but that there is no inverted U-shaped relationship between traffic injury rate and prosperity. Anbarci et al. (2009) indicate that the threshold is \$11454 and provide an economic theoretical framework of the traffic fatality rate.

Previous literature has used panel cross-country data and has assumed homogeneous economic growth effects on the fatality/injury rate across countries. That is, all countries are assumed to have the same threshold and to follow the same path. This assumption may generate a misunderstanding. For example, even though a country is already in a decreasing phase for traffic fatality rate, if its income level is lower than the thresholds estimated in previous studies, it is expected that the rate in the country increases.

Unlike previous studies, we focus only on China in order to avoid country-specific heterogeneity on the slope of per capita GDP. This note attempts to examine the relationship between the traffic fatality/injury rate and economic growth in China.[1]

2. Empirical Framework

Since the beginning of the twenty-first century, China has attained a double-digit annual average GDP growth rate. Despite this rapid growth, the Chinese have been experiencing severe traffic accidents. In 1996, the number of traffic fatalities per 10000 persons (hereafter referred to as the traffic fatality rate) was only 0.61; this rate increased to 0.86 in 2002 and declined thereafter. The number of traffic injuries per 10000 persons (traffic injury rate) demonstrates a similar trend.

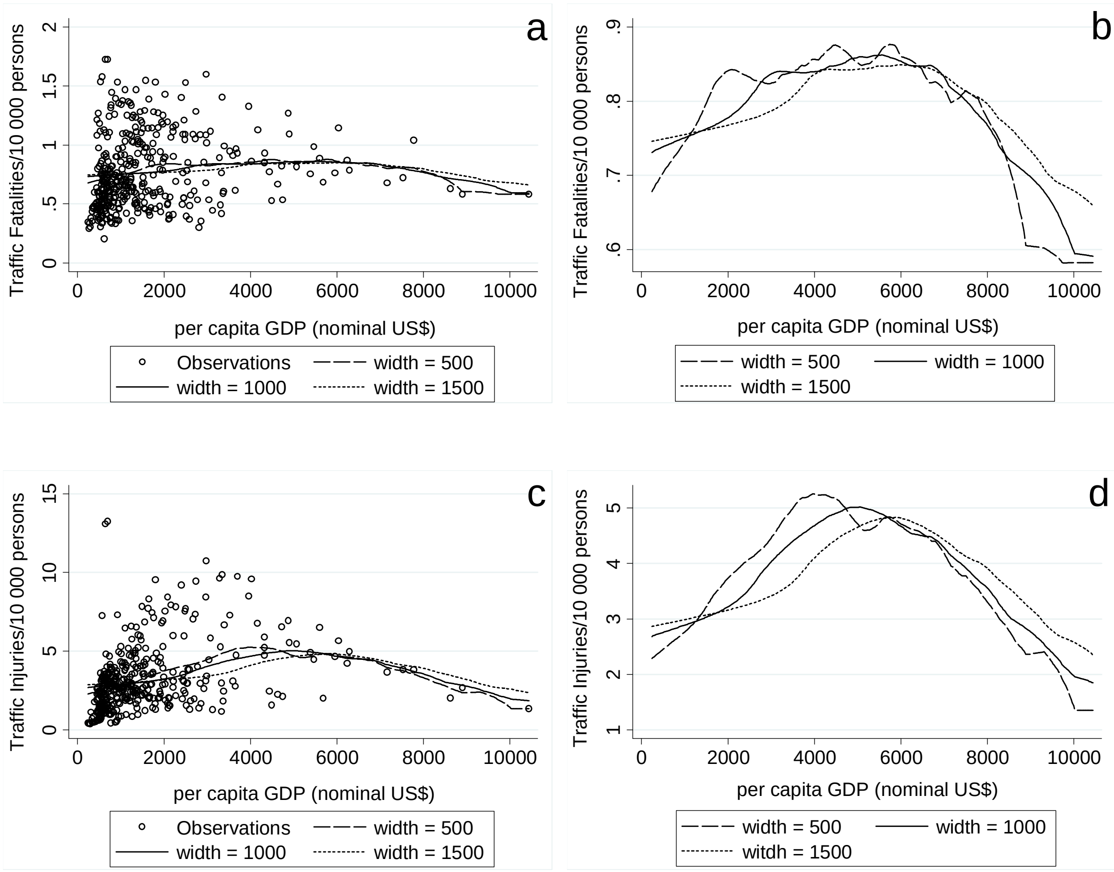
To capture the approximate trend of the relationship between traffic fatalities/injuries and per capita GDP, we have plotted the numbers in Figure 1 with Chinese provincial data for 1996 to 2008. The vertical axes in Figure 1(a) and (c) represent traffic fatality and injury rates, respectively. The smooth lines obtained from a Kernel-weighted local polynomial regression have also been added in each figure. In the nonparametric analysis, as width assumed for estimation is large, the shape of line is smooth. In both figures, three lines under different width assumptions for robustness are shown. The number of observations is 389 (= 13 years times 30 provinces minus 1 missing value). [2]

[1] Using Chinese provincial data for 1992 to 2003, Kaneko et al. (2009) reveals there is an inverted U-shape between income and environmental quality in China.

[2] The 30 provinces in this paper consist of 22 provinces, four autonomous regions and four government-ruled cities. Note that we exclude Tibet from the analysis owing to a missing value.

To clearly see the shapes of the lines, we have inserted Figure 1(b) and (d) on the right without the observations in the figures on the left. The concave features are observed in each line. The peaks for both rates seem to be at around \$5000.

Figure 1. Nonparametric estimation result on per capita GDP (Left: with observations. Right: without observations)



However, the estimator in the nonparametric analysis does not isolate the provincial unobserved fixed effects from the error term. In addition, the provincial characteristics other than GDP are not controlled. To tackle this issue, we consider the semiparametric model as follows:

$$T_{it} = f(GDP_{it}) + \delta LH_{it} + \mu_i + \varepsilon_{it},$$

where T_{it} is the traffic fatality/injury rate in province i in year t. *GDP* and *LH* denote per capita GDP and length of highway per 10000 persons, respectively. The function of per capita GDP, f, is not linear but is an unspecified smooth. The coefficient δ is linear parametric. μ and ε are provincial fixed effects and an independent identically distributed error term with mean zero, respectively.

Governments expand road infrastructure as a countermeasure to traffic issues like car crashes and congestion (Forkenbrock and Foster 1990). To control the influence of roads on the fatality/injury rate, we have incorporated *LH*. Though some may claim that the correlation between per capita length of road and GDP is large, it is only 0.03 in our data.

3. Estimation Results

All data in this note are collected from the *Chinese Statistical Yearbook*, which is published by the National Bureau of Statistics of China. [3] The estimated smooth lines of per capita GDP by partial linear regression are shown in Figure 2. Figure 2(a) to (d) correspond to the similarly labeled figures in Figure 1. Other coefficients are shown in Table 1.

We can easily recognize the inverted U-shaped patterns in Figure 2. The thresholds for the fatality and injury rates are around \$1500 and \$4000, respectively, which are smaller than the values of the nonparametric analysis. Hence, upward biases on the thresholds are generated unless we control the provincial fixed effects and length of highway. Patterns between the fatality rate and economic growth may be different among countries because our peaks are smaller than those of the previous studies and the difference of the peaks may be generated from country heterogeneous relationship between the accident and growth.

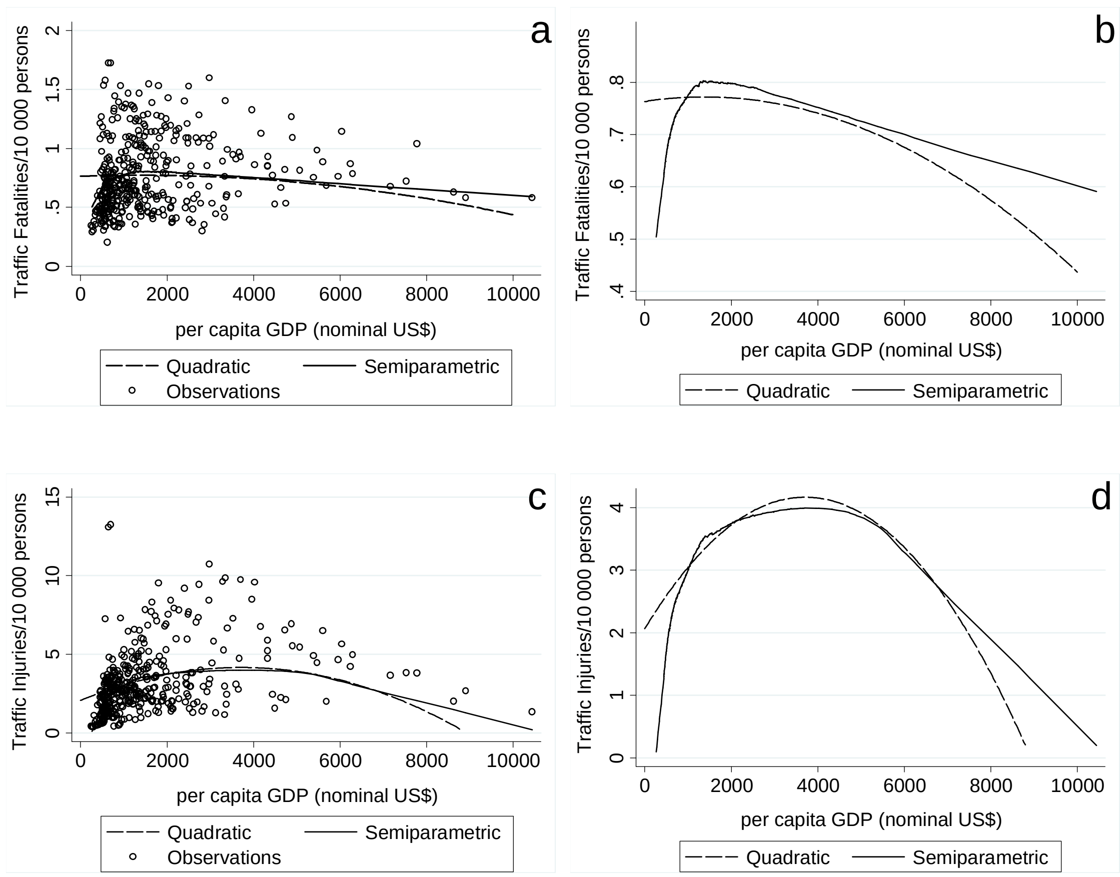
The null hypothesis that *GDP* does not have effect on *T* is rejected at the 1% significant level. The coefficients of road infrastructure on fatality and injury rates are significantly negative. This shows governments can mitigate traffic casualty by increasing the length of highways.

[3] The statistics are available at http://www.stats.gov.cn/english/statisticaldata/.

Additionally, we restrict the unspecified function *f* to the quadratic linear. The result under the constraint is also presented in Figure 2 and Table 1. Even with the restriction, inverted-U shape is observed. The thresholds are \$1383 and \$3710 for fatality and injury rates, respectively.

An incorrect conclusion, however, may be obtained if we introduce the quadratic form assumption. Using mean squared errors, the specification tests on the semiparametric and quadratic estimators significantly indicate that the former is appropriate. It is also remarkable that the former can capture surge of fatality rate until the peak, unlike the later. This comes from the asymmetric form of per capita GDP on the rate.

Figure 2. Estimation results on per capita GDP (Left: with observations. Right: without observations)



Notes: The quadratic line is derived under the constraint that other explanatory variables are fixed at sample means.

Table 1. Estimation results of semiparametric and quadratic regressions

Dependent Variables	Traffic Fatality Rate				Traffic Injury Rate			
	Semiparametric		Quadratic		Semiparametric		Quadratic	
Explanatory Variables	Coefficient		Coefficient		Coefficient		Coefficient	
per capita GDP			0.000013				0.001135	***
			(0.000023)				(0.000207)	
squared per capita GDP			-4.52E-09	*			-1.53E-07	***
			(2.49-E09)				(2.23-E08)	
Length of Highway	-0.003845	**	-0.001064		-0.046844	***	-0.021118	*
	(0.001576)		(0.001246)		(0.014575)		(0.011147)	
Adj. R-square	0.804		0.770		0.583		0.608	
F-value	53.97	***	41.58	***	19.09	***	19.83	***
mean squared error	0.191		0.222		1.633		1.785	
significance of GDP	3.97	***			4.85	***		
specification test	3.20	***			1.84	**		
threshold	about $1500		$1383		about $4000		$3710	

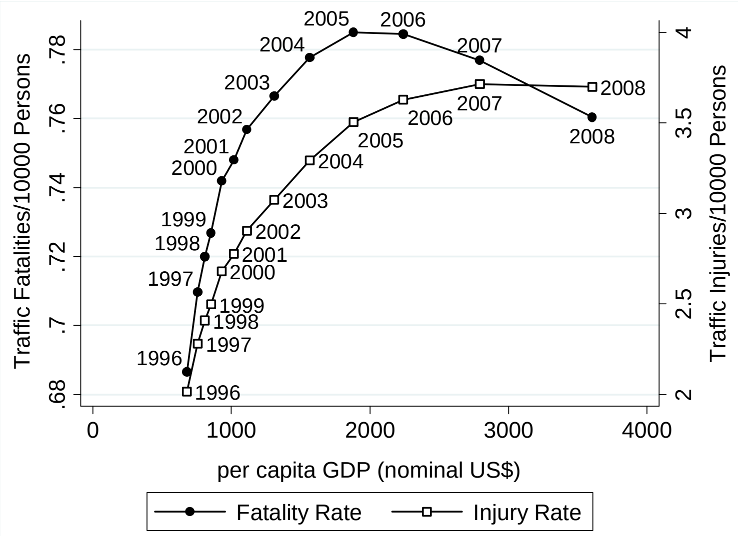
Notes: All estimations include provincial fixed effects. The values in parenthesis represent standard deviations. ***, ** and * indicate significant level at 1%, 5% and 10%, respectively.

Furthermore, we aggregate the provincial predicted fatality and injury rates from the partial linear regression into country levels. The aggregated rates and entire per capita GDP from 1996 to 2008 are depicted in Figure 3. The left and right vertical axes indicate traffic fatality and injury rate, respectively.

It is concluded that traffic fatality in China is already in a decreasing phase because the Chinese fatality rate increased until 2005, and declined thereafter. [4] In contrast, China is about to face downward phase for traffic injury as the peak for injury rate is 2007, whereas the 2007 and 2008 rates are not far from each other.

Figure 3. Relationship between per capita GDP and traffic fatality/injury rate in entire China

[4] Per capita GDP in 2005 is about $1883.



Notes: The data of Guizhou province in 1996 is dropped in the calculation because we employ partial linear regression and Guinzhou's values for the rates are smallest in our data.

Our results show two implications. First, when we examine the relationship between traffic fatality/injury rate and economic growth, it is preferable to allow flexible functional form because function of the relationship may be asymmetric. This suggestion is similar to that of Kopits and Cropper (2005), which use spline function. Second, it is important to consider country specific heterogeneous effect of income on the traffic accidents. If the Chinese government makes policies against traffic accidents with the facts from previous studies, they may fail to choose proper policies.

4. Conclusion

Using Chinese provincial data for 1996 to 2008, this note examines whether the fatality-/injury-income relationship is inverted-U shaped, similar to the EKC. We employ the semiparametric partial linear model in order to observe the flexible relationship. The estimation results show that the peaks for traffic fatality and injury in China are \$1500 and \$4000, respectively. Unlike previous cross-country studies, it is concluded that China is already and about in decreasing phases for traffic fatality and injury, respectively.

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