The motorcycle Kuznets curve

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A R T I C L E   I N F O

A B S T R A C T

The evolution of motorcycle ownership is a crucial issue for road safety, as motorcyclists are highly vulnerable road users. Analyzing a panel of 153 countries for the period 1963–2010, we document a motorcycle Kuznets curve which sees motorcycle dependence increase and then decrease as economies develop. Upswings in motorcycle ownership are particularly pronounced in densely populated countries. We also present macro-level evidence on the additional road fatalities associated with motorcycles. Our results indicate that many low-income countries face the prospect of an increasing number of motorcycle-related deaths over coming years unless adequate safety initiatives are implemented.

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1. Introduction

How does dependence on motorcycles evolve during the process of economic development? Using data for a large panel of countries for the period 1963–2010 we find that motorcycle ownership exhibits a Kuznets-style inverse-U pattern as average incomes increase, with the per capita motorcycle fleet on average increasing until mid-range income levels and then subsequently declining.[1] In contrast, the fleets of cars and trucks tend to expand monotonically. A country's population density has a large effect on the motorcycle Kuznets curve pattern: more crowded countries tend to see much larger upswings in motorcycle dependence through the middle stages of economic development. We also present evidence on the extent to which dependence on motorcycles is associated with higher national road death rates.

Detailed knowledge on how motor vehicle fleets evolve as economies grow is useful for planning infrastructure, policies, and programs for the transport sector. The evolution of motorcycle ownership is a particularly crucial issue for road safety, which is a leading public health issue. Road crashes were the cause of 1.3 million deaths in 2011, making them the ninth-leading cause of death globally and the number one cause of death for people between 15 and 29 years of age (World Health Organization (WHO), 2013a). Up to 50 million people worldwide also suffer non-fatal injuries each year, which carries large human and financial costs.

The global road death toll is expected to increase to around 2.4 million per year by 2030 in a business-as-usual scenario, becoming the fifth-leading cause of death (WHO, 2013b).

Motorcyclists are highly vulnerable road users: in the United States, road fatality risks per vehicle mile travelled are estimated to be 30 times higher for travel by motorcycle than for travel by passenger car (National Highway Traffic Safety Administration (NHTSA), 2012). Similar ratios have been reported by, for example, Australia (Department of Infrastructure, Transport, Regional Development and Local Government, 2008) and the United Kingdom (Department for Transport, 2012). Globally, motorcyclists account for around 23% of all road deaths (WHO, 2013b), although this share exceeds 50% in some developing countries (Lin and Kraus, 2009). The vulnerability of motorcyclists emanates from their lack of direct protection, their young average age, the often minimal training and testing requirements for motorcycle use, and relaxed motorcycle inspection procedures (Asian Development Bank, 2003). The "Global Plan for the Decade of Action for Road Safety 2011–2020", adopted by the United Nations General Assembly in March 2010, highlights the importance of protecting vulnerable road users such as motorcyclists (WHO, 2010).

This is the first study on the motorcycle Kuznets curve. Prior studies (e.g. Nagai et al., 2003; Pongthanaisawan and Sorapipatana, 2010) have presented cross-sectional evidence that motorcycle ownership increases in the initial stages of development, but have not fully documented the motorcycle Kuznets curve. Kopits and Cropper (2005) used data for 88 countries to find that the total number of motor vehicles increases with per capita income, but did not explicitly consider motorcycles. Others (e.g. Dargay et al., 2007) have focused solely on vehicles with four or more wheels. This paper also adds to the literature examining the effects of

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[1] Kuznets (1955) posited that inequality proceeds along an inverse-U as per capita incomes increase. His name has been used in describing similar inverse-U patterns for outcomes such as pollution.

Table 1
International road motor vehicle fleets, 2007.

	per '000 population				%
	Motorcycles	Cars	Buses	Trucks	Motorcycle share of road motor vehicles
World	54	138	3	52	22
Country groups					
Low-income	4	7	1	3	30
Middle-income	63	52	3	19	46
High-income	53	445	3	167	8
Population density					
Below-median	20	189	3	108	6
Above-median	69	116	3	27	32
Selected countries					
Ethiopia	0	1	0	2	3
Bangladesh	5	2	0	0	65
China	67	23	2	8	67
Thailand	238	54	7	76	63
Germany	43	499	1	52	7
US	24	450	3	366	3
Coefficient of variation for countries in group					
World	2.0	1.1	1.1	1.1	1.3
Low-income	1.3	1.9	0.9	1.0	1.0
Middle-income	1.9	1.0	0.9	0.6	1.3
High-income	1.6	0.3	1.1	0.7	1.3

Notes: Data are for 2007 rather than 2010 so as to maximize country coverage. Income classifications are from the World Bank as of July 2012. Country groupings use data for a total of 127 countries. The coefficient of variation is the standard deviation divided by the mean. Source: IRF (2012). See the Appendix for definitions.

motorcycle use on road fatalities. Most existing evidence relates to developed countries, although Grimm and Treibich (2013) study India. Consideration of middle-income countries is crucial given that it is in these countries that both motorcycle dependence and road death rates are highest.

Motorcycles, defined here as two- or three-wheeled road motor vehicles including mopeds and motorized scooters, are a primary form of transport in many developing countries.[2] Motorcycles make up more than three-quarters of the total road motor vehicle fleet in countries such as Burkina Faso, the Central African Republic, India, Indonesia, Laos, the Maldives, Myanmar, and Vietnam (International Road Federation (IRF), 2012). Historically, motorcycles have also played an important role in the motor vehicle fleets of some now-developed countries. In 1963, motorcycles accounted for 70% of all road motor vehicles in Sweden and Poland, 64% in Portugal, 60% in Japan, 58% in the Netherlands, 55% in Italy, 44% in Austria, and 41% in France. These rates had all fallen to below 14% by 2010.

Table 1 presents international data on the fleets of motorcycles, cars, buses, and trucks (a category which includes lorries, vans, and pick-ups) for various country groups and example countries. Motorcycle ownership is higher in middle-income countries (63 motorcycles per thousand population in 2007) than either low-income (4) or high-income countries (53). This is an initial indication of the existence of a motorcycle Kuznets curve. In contrast, the fleets of cars and trucks are largest in high-income countries. The coefficient of variation (standard deviation divided by mean) is larger for motorcycles than other vehicles in middle- and high-income countries, suggesting that countries take different paths in terms of motorcycle adoption. Our results will show that population density is a key underlying reason for why heterogeneous motorcycle adoption paths have been observed as countries develop.

The empirical results that we present in this paper indicate that low-income countries are set to see large rises in motorcyclist deaths as per capita incomes increase. Our estimates show that the motorcycle share of the vehicle fleet typically peaks at a per capita gross domestic product (GDP) of $3000–$4000 and that motorcycles per thousand population on average increase until a mid-range per capita GDP of $7000–$9000. To explore the implications of vehicle mix for road fatalities, we use our large international sample to estimate the marginal effects of motorcycles and other motor vehicles on national road death tolls. Our findings add to the evidence that motorcycle travel is particularly risky.

The initial increase and subsequent decrease in motorcycle ownership as per capita incomes increase is likely a function of three considerations. First, affordability: motorcycles are cheaper than cars, and for people exiting poverty are often the only option when it comes to private motor vehicles. As incomes reach higher levels, four-wheeled vehicles become more affordable, and motorcycles are likely to lose market share (Jou et al., 2012). The second and third considerations are safety and comfort: motorcyclists are exposed to higher safety risks than drivers of other motor vehicles, and travel in automobiles is in many instances more comfortable. If safety and comfort are normal goods we should expect to see a reorientation of vehicle demand away from motorcycles as incomes increase.[3]

This paper is structured as follows. Section 2 describes our method and data. Section 3 presents results on how vehicle fleets evolve as economies develop. Section 4 explores how vehicle fleet sizes affect road death rates. The final section concludes.

2. Approach

To quantify the evolution of the number of motorcycles per thousand population (M) as per capita income increases, we estimate the following specification:

$$\ln M_{c,t} = \alpha_1 \ln Y_{c,t} + \alpha_2 (\ln Y_{c,t})^2 + \alpha_3 \ln P_{c,t} + \delta_c + \omega_t + \varepsilon_{c,t} \quad (1)$$

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[2] An alternative term is "powered two-wheelers" (Haworth, 2012), although we avoid this because our data cover three-wheeled vehicles also. The data used in this paper exclude off-road vehicles, but do not allow a disaggregation of the type of motorcycles being used in each country or on factors such as whether they are used for transport or recreation, or whether they provide private or public (e.g. taxi) transport. We note that some countries have taxi networks that are reliant on auto rickshaws, which fall under our definition of "motorcycles". Future research may wish to use country case studies to explore how the composition of the motorcycle fleet changes as economies develop.

[3] Working against this might be an increase in demand for recreational motorcycling as incomes increase.