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Car ownership and urban development in Chinese cities: A panel data analysis

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ABSTRACT

Growth in car ownership has significant impacts on the use of urban space and management of urban environments, which makes it a topic of increasing interest especially for developing countries such as China. The dynamics of and factors influencing ownership in Chinese cities need careful investigation. Using fixed effects models applied to annual panel data (1994–2012; 293 cities) this study aimed to achieve the following: 1) assess the relationships between car ownership and average annual income *per capita*, population, built-up area, road area *per capita*, urban population density, number of taxis and bus passenger volume; 2) examine the variation of these relationships across geographical regions (East, middle, and West China) and city sizes (cities with small, medium, large, and super-large populations). The results showed that car ownership was positively associated with average annual income *per capita*, built-up area, road area *per capita*, urban population density, and number of taxis at the national level. All associations, except with the number of taxis, varied significantly across geographical regions. Built-up area, road area *per capita*, and number of taxis had different associations with car ownership depending on city sizes. The findings improve the understanding of relationships between car ownership and urban environments vis-a-vis variations in income and infrastructure *per capita*, population density, and transportation alternatives. These results have important policy implications for managing cars and health problems related to cars in China.

1. Introduction

Growth in the number of cars has become a prominent feature of contemporary cities, as the accumulation of personal wealth and the demand for transport greatly encourage the ownership and use of cars. On one hand, cars provide convenience, but on the other hand, they place unprecedented pressure on energy conservation objectives, transport infrastructure, air quality, and human health (Pucher et al. 2007). Cities have been severely affected by health- and transport-related problems, many of which accompany growth in the number of cars, such as air pollution, traffic congestion, and shortage of parking space (Carty 1999; Clayton et al. 2014). Before taking measures to address these issues, it is necessary to understand the factors influencing car ownership. There have been a number of studies on the influential factors of the growth of car ownership in North America (Ogilvie et al. 2008; Potoglou and Kanaroglou 2008) and the European Union (Kain 2001; Mogridge and Eldridge 1970; Prieto and Caemmerer 2013); researchers have also begun showing interest in countries with emerging economies, which are experiencing fast growth in car numbers along with dramatic economic growth and urban expansion (Verma 2015; Wu et al. 2014).

Current understanding of car ownership growth is primarily a function of two lines of research. One line of research involves forecasting the growth of car ownership, based on aggregated time-series or cross-sectional data, to test its relationship with gross domestic product (GDP) and other income measures (Ingram and Liu 1999; Wu et al. 2014). The other line involves a growing body of research using disaggregated data to reveal other importance of indicators, particularly related to urban characteristics such as built-up area and urban population density, that may influence car ownership and use. However, these emerging studies are limited to cross-sectional data analysis or short-term time-series analysis for specific spatial areas (Guerra 2014; Schwanen and Wang 2014; Zhao 2011). A large-scale and longitudinal association between car ownership and urban development indicators, has not been established yet, except in terms of road metrics (Ingram and Liu 1999). Furthermore, this association may vary across geographical and/or urban features, such as different city sizes. This has not

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previously been examined elsewhere but could be pertinent in the context of China, given that it is a geographically large and heterogonous country, where the growth in car numbers could be similarly heterogonous in different cities and geographical locations with different development trajectories.

Using annual panel data for 1994–2012 from 293 prefecture-level cities in China, this study aims to achieve the following: (1) assess the relationship between car ownership and urban development measured in terms of increasing affluence, changes in population and the urban environment, and provision of transportation alternatives and (2) examine the variability in these relationships in different settings based on geographical locations (Eastern, middle, and Western China) and city size groups (cities with small, medium, large, and super-large populations). Accordingly, we developed three hypotheses as follows:

H1. Car ownership is co-influenced by variables related to wealth (annual income *per capita*), changes in population (total population and urbanization rate), urban environment (built-up areas, road area *per capita*, and urban population density), and transportation alternatives (buses and taxis);

H2. The influences of wealth, population, urban environment, and transportation alternatives on car ownership vary across regions;

H3. The influences of wealth, population, urban environment, and transportation alternatives on car ownership vary across city size groups.

The findings provide information on the dynamics of and factors influencing the growth in car numbers in China, and provide evidence for national policy-making and the development of local strategies to manage growth in cars. Next, we summarize the existing literature on the relationship between the growth of car ownership and urban development (Section 2) before describing the data and inferential methods employed in this study (Section 3). This is followed by the analytical results (Section 4) which are discussed according to the current stage of development of Chinese cites (Section 5). Finally, we conclude the study, discussing its limitations whilst offering recommendations for future research (Section 6).

2. Car ownership growth with urban development

Existing literature reveals that car ownership growth is closely related to socioeconomic development and urban development metrics, such as the urbanization rate. Wealth is a key connector between car ownership growth and societal development. After an international investigation of motorization and road provision using cross-sectional data, Ingram and Liu (1999) determined that gross national product (GNP) *per capita* is positively correlated with car ownership with a higher elasticity at the national level than at urban levels. Chamon et al. (2008) documented a non-linear relationship between gross domestic product (GDP) *per capita* and car ownership, stating that car ownership remained low up to a *per capita* annual income of approximately 5000 US dollars (USD) and then grew rapidly. Dargay and Gately (1999) predicted that vehicle purchases increased sharply for incomes in the range of 2000 USD to 5000 USD and, further, that car ownership is affected by urban development. Additionally, cross-country analyses revealed that urbanization rate was positively associated with the growth of car ownership, because larger urban populations were synonymous with higher incomes and stronger willingness to travel (Ingram and Liu 1997).

Moving from these general trends regarding the relationship between car ownership and socioeconomic and urban development, a growing body of research has started to explore and reveal the variation in car ownership levels seen across different territories at various stages of development. Metz (2013) found indications that the effect of income on car ownership lost significance when the spatial region of interest was highly developed in economic terms. Moreover, peak car theory suggests, usually in terms of motor vehicle distance travel *per capita*, that car use has saturated in the developed world, whilst continuing to grow in the developing world (David 2013). Pucher et al. (2007) stated that rapid growth of the urban population and urban sprawl were key to understanding the burgeoning increase in ownership of motor vehicles in India and China.

In addition to urbanization rates, researchers have examined high-resolution urban environment indicators, which can offer explanatory value in this context: certain disaggregated data analyses have shown that urban population density effects on car ownership and travel demand are context dependent. Further, Beesley and Kain (1964) stated that the number of car owners was negatively correlated with population density in American cities in 1960. Another study illustrated a causal relationship between car density and human travel behavior (Badoe and Miller 2000). Other disaggregate studies have involved detailed survey data pertaining to household attributes, neighborhood features, urban form, and transportation accessibility. For example, Chen and McKnight (2007) analyzed the effects of the built environment on the travel behavior of homemakers in New York; Boarnet and Crane (2001) investigated the impact of urban form on non-work trips in Orange County, Los Angles; Cervero and Kockelman (1997) examined the influences of transport intensity and accessibility on household travel in San Francisco; and Hong et al. (2014) investigated the influence of the built environment on transport behavior in Seattle. Going beyond developed country contexts, Zegras (2010) analyzed the relationship between the urban built environment and car ownership in Santiago de Chile, and Guerra (2014) argued that the relationship between urban built environment and car use in Mexico City was stronger than the relationship observed in American cities.

These findings encourage examination of the relationship between car ownership and urban development, which is a major driver of the growth in car numbers encapsulating a wide range of metrics such as road infrastructure and metrics quantifying built-up areas. Exploration of this relationship contributes to urban spatial management. Modern transport planning often employs land use patterns and road infrastructure as important mediums to modify travel demands and behaviors (Guerra 2014; Schwanen and Wang 2014; Zhao 2011). Additionally, large cities tend to impose high import duties, vehicle registration fees, parking fees, road taxes, and vehicle quotas to restrain car ownership, as is the case in Singapore and Hong Kong (Lam and Tam 2002). Alternative transport choices are encouraged, including public transportation, walking, and bicycling; however, the effectiveness of such alternatives in controlling the growth in car numbers is equivocal and requires continued investigation. Recently, some Chinese cities, including Beijing, Shanghai, and Guangzhou, started to control the number of cars by various means, such as the implementation of quota systems to limit private car ownership (Wang et al. 2014). There has been evidence to suggest that public transport services could serve to temper car ownership in Portland (Jun 2008), Yorkshire (Button et al. 1980), and Hong Kong (Cullinane 2002), although the magnitude of this effect differs across cities.

Surprisingly, most of our understanding of the heterogeneity of car ownership is implicitly dependent on disaggregated analyses of individual, selected cities (Chen and McKnight 2007; Zegras 2010; Zhang et al. 2014), which have been subject to changes in explanatory forces over time. By contrast, aggregated analyses are often limited to considering wealth related factors (Dargay and Gately 1999; Ingram and Liu 1999), which needs to be improved upon by incorporating alternative potential explanatory variables as identified by disaggregated analyses. Evidence from aggregate analyses covering a long time period could illuminate an overall picture of the influences of multifaceted urban characteristics on car ownership. There is also a need to examine car ownership explicitly based on the demographic and locational characteristics of cities.