Journal of Transport Geography 66 (2018) 1–9

Contents lists available at ScienceDirect

Journal of Transport Geography

journal homepage: www.elsevier.com/locate/jtrangeo

Effects of additional capacity on vehicle kilometers of travel in the U.S.: Evidence from National Household Travel Surveys

Edmund J. Zolnik

Schar School of Policy and Government, George Mason University, 3351 Fairfax Drive, MS 3B1, Arlington, VA, 22201, USA

ARTICLE INFO

Keywords:
Induced demand
Vehicle kilometers of travel
Capacity
Multilevel models

ABSTRACT

Adding capacity is one policy mechanism to alleviate congestion. However, the empirical evidence strongly suggests that additional capacity only makes congestion worse. This study analyzes the differential effects of additional freeway capacity versus additional arterial capacity on vehicle kilometers of travel (VKT) in metropolitan areas across the U.S. The analysis uses vehicle data and household data from the 2001 and the 2009 National Household Travel Surveys (NHTS) and includes stock and flow measures of road capacity, road congestion, commuter demand, and economic growth for metropolitan areas. Taking into account differences between metropolitan areas on each measure, the study adopts a novel multilevel model approach to estimate how additional capacity affects VKT. Results indicate that adding more arterial capacity slightly decreases VKT over a lag period from six years (1995 to 2001) to eight years (2001 to 2009), probably because adding arterials shortens routes between origins and destinations more so than adding freeways. Consistent with expectations, VKT is lower in more congested metropolitan areas, and in metropolitan areas that got more congested. Results also indicate that rebound effects (higher fuel-economy vehicles are driven much more than lower fuel-economy vehicles) will at least partially offset the demand management benefits of (gasoline) price sensitivity (higher gasoline prices decrease VKT).

1. Introduction

Congestion is a major transportation problem in metropolitan areas across the U.S. There are many different strategies to mitigate congestion, including adding more capacity (freeways and arterials). Whichever strategy is adopted, it is important to account for all of the potential impacts. For example, in the case of adding more capacity, it is important to account for indirect and long-term impacts of induced demand for private-vehicle travel. In order to account fully for such impacts, this study explores the differential effects of additional freeway capacity versus additional arterial capacity on private-vehicle travel demand in metropolitan areas across the U.S. in 2001 and in 2009.

Freeways and arterials are complementary functional types of capacity in the road network, but the differential effects of additional capacity are important to explore for many reasons. First, the economic returns on different functional types of capacity are not the same. Returns for interstate highways are greater than returns for non-interstate major roads (arterials and collectors). Likewise, returns for the latter are greater than returns for local roads (Jiwattanakulpaisarn et al., 2012). Second, the effects of different functional types of capacity on vehicle miles of travel (VMT), the most common measure of private-vehicle travel demand in the U.S. (Rentziou et al., 2012), are not the same. For example, the travel-time benefits of new collectors are greater than the travel-time benefits of new interstates or new arterials (Noland, 2001). Third, the effect of additional capacity is not the same in different metropolitan areas. That is, the effect tends to be greater in metropolitan areas where the percentage increase in capacity (freeway and arterial) is larger (Noland and Cowart, 2000).

The organization of the paper is as follows. The next section briefly reviews the induced demand literature. The data section lists the data sources for the vehicle level, the household level, and the metropolitan area level, respectively. The methodology section introduces the multilevel model in the study and also hypothesizes the effects of the vehicle-level, the household-level, and the metropolitan area-level independent variables. The results section presents the outcomes of the multilevel model. The discussion section focuses on the policy implications of the results. Finally, the conclusions section highlights the contributions of the results to the induced demand literature, as well as the most fruitful direction for future research.

2. Background

Economic theory on induced demand—additional capacity attracts more traffic (AASHO, 1957)—suggests that additional capacity

E-mail address: ezolnik@gmu.edu.

https://doi.org/10.1016/j.jtrangeo.2017.10.020
Received 15 January 2015; Received in revised form 6 October 2017; Accepted 26 October 2017

Table 1
Key literature on induced demand.

Author(s), year	Area(s)	Unit(s)	Year(s)	Methodology	Results
Downs, 1962	US			Theoretical	Law of peak-hour traffic congestion—traffic and congestion are in equilibrium.
Hills, 1996	UK			Theoretical	Additional capacity induces demand by changing network accessibility.
Goodwin, 1996	UK		1938–1994	Review	Demand induced by 10% in the short term and by 20% in the long term.
Noland and Lem, 2002	UK/US		1994–1998 1993–2001	Review	Lane-mile elasticities range from +0.3 to +0.6 regardless of the data or the methodology.
Hansen and Huang, 1997	CA	C/CEA/(C) MSA	1973–1990	FE	Marginal effect of lane-miles of state highway on VMT is greatest in largest CMSAs/MSAs.
Noland and Cowart, 2000	US	MSA	1982–1996	2SLS	Lane-mile additions account for 15% of annual VMT growth with great variation between MSAs.
Noland, 2001	US	State	1984–1996	FE/SURE	Induced demand effects of lower functional types of new capacity (collectors) is greater than the induced demand effects of higher functional types of new capacity (interstates and arterials).
Cervero and Hansen, 2002	CA	C/CEA	1976–1997	SE	Induced demand effect of +0.6 and induced investment effect of +0.3.
Hymel et al., 2010	US	State	1966–2004	3SLS	Total road length induces demand by 3.7% in the short run and by 18.6% in the long run.
Duranton and Turner, 2011	US	MSA	1983/1993/2003	3SLS	VKT increases proportional to additional interstate capacity.
Su, 2011	US	State	2001–2008	DPD	Short-run and long-run rebound effects of 3% and 11%, respectively. Short-run and long-run road capacity per capita effects of 7% and 26%, respectively.
Rentziou et al., 2012	US	State	1998–2008	SURE/RE	VMT elasticity with respect to lane-miles higher on urban versus rural roads.

Area abbreviations: CA = California; UK = United Kingdom; and US = United States. Unit abbreviations are: C/CEA = County/County Equivalent Area; (C)MSA = (Consolidated) Metropolitan Statistical Area. Methodology abbreviations are: 2SLS = Two-Stage Least Squares; 3SLS = Three-Stage Least Squares; DPD = Dynamic Panel Data; FE = Fixed Effects; RE = Random Effects; SE = Simultaneous Equations; and SURE = Seemingly Unrelated Regression Equations.

increases traffic because travel times decrease. The effect on travel times is due to the following (short-term and/or long-term) behavioral changes in response to less congestion:

- taking different routes for the same trip;
- making the same trips at different times of the day;
- using different modes for the same trip;
- substituting destinations for the same (shopping or recreational) trip; and
- making more trips (TRB, 1995).

Table 1 summarizes the key literature on induced demand, and the citations here are by no means exhaustive. Rather, the citations highlight the trajectory of the literature from the theoretical to the empirical, with the trend toward methodological sophistication in the latter.

The law of peak-hour traffic congestion (Downs, 1962, 393) states that "congestion rises to meet maximum capacity." The law assumes the following with regard to commuter decision making:

- commuters seek to minimize travel times cognizant of income, monetary cost, place of residence, and personal comfort constraints;
- the law of inertia rules—unless events in the environment compel change mode choices and route choices are habitual;
- events in the environment which compel mode choice and route choice changes are those that decrease travel times; and
- commuters are of two types—those who are passive and those who are active in seeking out different routes to save themselves time. Hills (1996) spelled out exactly what is meant by induced demand in order to distinguish generated traffic from induced traffic and to relate the latter phenomenon to the range of travel behavior responses to additional capacity. The cumulative route choices of all private-vehicle drivers generate traffic on a network whereas the addition of capacity to a network, by design, changes accessibility and induces traffic.

A review of the extant empirical literature on induced demand by Goodwin (1996) showed that additional capacity induces demand by 10% in the short term and by 20% in the long term. However, induced demand is dependent on the context, size, and location of the new capacity. For example, increases in traffic on the new routes are not offset by decreases in traffic on the old routes that provide alternatives either on a short-term or a long-term basis. The latter empirical result contradicts Downs' (1962) theory that older commuter routes will experience less congestion. A review of the empirical literature on induced demand from the U.K. and from the U.S. by Noland and Lem (2002) showed that lane-mile elasticities range from +0.3 to +0.6, regardless of the data or the methodology.

The most methodologically sophisticated citations in the induced demand literature also account for the rebound effect (Jevons, 1865; Khazzoom, 1980; Alcott, 2005; Sorrell, 2007). The rebound effect is "the interaction of energy use with the efficiency of energy use: lower the energy required to do something, and you will do a bit more of that thing" (Schipper, 2000, 351). The most conservative estimates of the short-term (one-year) rebound effect for private vehicles from the literature are about 10% (Greening et al., 2000; Sorrell et al., 2009; Chakravarty et al., 2013). However, the least conservative estimates of the long-term rebound effect for private vehicles are about 30%. Such a range of estimates on the magnitude of the rebound effect is a source of controversy in academic and in policy circles (Tierney, 2011; Turner, 2013). Some argue that the rebound effect is in decline (Small and Van Dender, 2007) or that it is just a distraction to divert attention from efforts to enact stricter energy-efficiency regulations (Gillingham et al., 2013). Others argue that energy efficiency standards like Corporate Average Fuel Economy (CAFE) standards in the U.S. are not cost effective because of the rebound effect (Frondel and Vance, 2013) and, perhaps, greater energy efficiency leads to backfire—more usage offsets any energy savings due to efficiency improvements (Jenkins et al., 2011; Tierney, 2011). Regardless of the academic and the policy debates on the magnitude of the rebound effect, two examples from the induced demand literature (Hymel et al., 2010; Su, 2011) confirm that the rebound effect affects private-vehicle travel demand.

In order to heed Hills' (1996) call to specify a realistically complex mathematical model of induced demand, the study pools disaggregate cross-sectional data from the National Household Travel Survey (NHTS) for two time points (2001 and 2009) to account for short-term and for long-term travel behavior changes in response to additional capacity. Barr (2000) also uses disaggregate cross-sectional data from an older version of the NHTS, known as the Nationwide Personal Transportation Survey, to model induced demand, but only for one time point (1995).