Journal of Public Economics 124 (2015) 44–62

Contents lists available at ScienceDirect

Journal of Public Economics

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

What is the optimal speed limit on freeways?☆

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ARTICLE INFO

Article history:
Received 17 September 2013
Received in revised form 2 February 2015
Accepted 10 February 2015
Available online 18 February 2015

JEL classification:
H23
Q51
Q58
R41

Keywords:
Speed limit
Travel time
Accidents
Pollution
Infant health
Value of a statistical life
Value of time
Externalities

ABSTRACT

When choosing his speed, a driver faces a trade-off between private benefits (time savings) and private costs (fuel cost and own damage and injury). Driving faster also has external costs (pollution, adverse health impacts and injury to other drivers). This paper uses large-scale speed limit increases in the western United States in 1987 and 1996 to address three related questions. First, do the social benefits of raising speed limits exceed the social costs? Second, do the private benefits of driving faster exceed the private costs? Third, what is the optimal speed limit? I find that a 10 mph speed limit increase on highways leads to a 3–4 mph increase in travel speed, 9–15% more accidents, 34–60% more fatal accidents, and elevated pollutant concentrations of 14–24% (carbon monoxide), 8–15% (nitrogen oxides), 1–11% (ozone) and 9% higher fetal death rates around the affected freeways. Using these estimates, I find that the social costs of speed limit increases are two to seven times larger than the social benefits. In contrast, many individual drivers would enjoy a net private benefit from driving faster. Privately, a value of a statistical life (VSL) of $6.0 million or less justifies driving faster, but the social planner's VSL could be at most $0.9–$2.0 million to justify higher speed limits. I conclude that the optimal speed limit was lower, but not much lower, than 55 mph.

1. Introduction

Two interesting and actively debated policy questions that economists are well-positioned to consider are: should we increase speed limits on freeways, and what is the optimal speed limit? When choosing his speed, a driver faces a trade-off between private benefits (time savings) and private costs (increased fuel use, risk of personal injury, death or damage). It is thus an empirical question if driving faster than the current speed limit is rational. Besides private costs, there are external costs to driving faster that motivate the use of speed limits: increased pollution, adverse health impacts and damage or injury to other drivers. Speed limits have recently been under active debate. Early in 2011, Spain temporarily reduced the freeway speed limit from 120 to 110 kilometers per hour (kph) to achieve gasoline reductions, while the Netherlands raised it from 120 to 130 kph to reduce travel time.[1] In the United States, travel time reduction inspired Illinois (2014), Kentucky (2007), Utah (2009), Ohio (2011) and Texas (2012) to increase their posted maximum speed. Germany's "no speed limits" rule for rural *autobahns* is facing increased criticism from politicians and environmentalists.

This paper aims to answer three related questions. First, should we raise speed limits? A social planner would do so only if the social benefits of speed limit increases exceed the social (private plus external) costs. Second, do speed limits constrain drivers' speed choices? That is, would individuals enjoy private net benefits from driving faster if speed limits were raised? Third, what is the optimal speed limit? To answer these questions, I estimate the effect of speed limit increases on a wide range of outcome variables: travel time, accidents, air pollution and health. I use these estimates to calculate the private and external benefits and costs summarized in Fig. 1.

☆ I thank Ran Abramitzky, Larry Goulder, Matt Harding, Caroline Hoxby, Mark Jacobsen and Olivia Mitchell for their guidance and encouragement. I am also grateful to seminar participants at Berkeley Haas, Chicago Harris, Columbia SIPA, Cornell, LSE, Maryland ARE, Michigan, Pompeu Fabra, Sciences Po, Stanford, Toulouse, UC Davis ARE, Wharton and Yale FES as well as three anonymous referees for the many helpful comments and suggestions. Many individuals at various state agencies have been very generous with their time. I gratefully acknowledge the Stanford Institute for Economic Policy Research and Wharton's Institute for Global Environmental Leadership for the financial support.

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[1] Spain's deputy prime minister Alfredo Pérez Rubalcaba expressed it as follows: "We are going to go a bit slower and in exchange for that we are going to consume less gasoline and therefore pay less money." (http://www.guardian.co.uk/environment/2011/feb/25/spain-speed-limit-oil-prices). Dutch transport minister Melanie Schultz van Haegen defended her decision by claiming that "a higher speed limit leads to a travel time reduction of up to eight percent." (http://www.rijksoverheid.nl/ministeries/ienm/nieuws/2011/02/28/130-km-u-van-start-op-afsluitdijk.html). Other governments proposed to decrease speed limits to reduce traffic accidents (United Kingdom, 2009) or pollution and associated adverse health effects (Texas, 1992; green parties in Europe).

http://dx.doi.org/10.1016/j.jpubeco.2015.02.001
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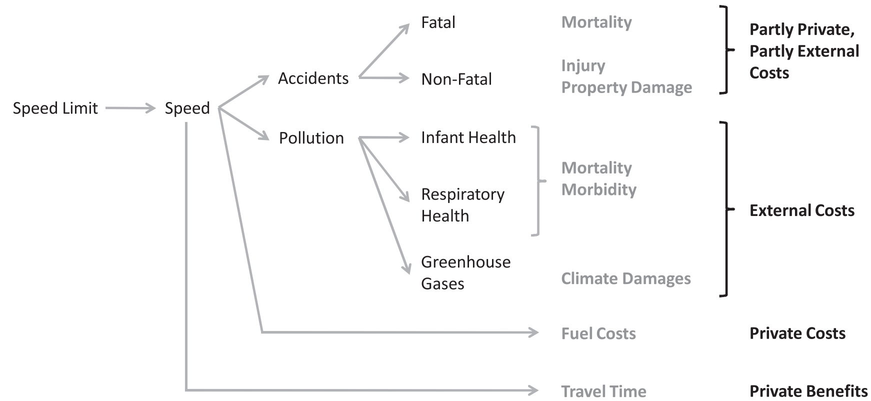

Fig. 1. An overview of the costs and benefits of speed limit changes. Higher speed limits may lead to a higher average travel speed. This higher speed has a direct benefit (reducing travel time), but also three direct costs: higher accident rates, increased pollution and increased fuel expenditures. The pollution channel has indirect negative effects on infant and respiratory health, and climate change. Time savings benefits are private, while some of the costs are externalities.

I use a unique setting and rich data to address these questions. The 1987 amendment and 1995 repeal of the National Maximum Speed Law in the United States provide quasi-experimental variation in speed limits. Between 1974 and 1987, this law prescribed a maximum speed limit of 55 mph across the entire United States. In 1987, states were allowed to raise the speed limits to 65 mph on rural interstates, but not on other similar urban or rural highways. In 1996, speed limit authority was returned to the states, which decided to raise speed limits on a variety of highways. This provides a rare opportunity to use difference-in-differences and ratio-in-ratios (count data) methods to identify the effect of speed limit changes on travel speed, accidents, pollution and health. I construct control highways or areas that are unaffected by the speed limit changes, but otherwise very similar to the affected highways or areas. Also, I exploit geographically precise micro data to make within-state difference-in-differences comparisons while holding constant weather, daylight, hour-of-day, traffic density, road construction, and much else.

My paper uses a detailed data set to evaluate the effects of speed limit changes. First, I use location descriptions of speed limit changes in California, Oregon and Washington. These states are selected because of superior data quality and availability. Second, I collect hourly measurements of actual traffic speed. Third, I use a data set of all highway accidents. Fourth, I use daily air pollution measurements at various monitoring stations. Fifth, I requested all birth records in California to estimate the effect on infant health. Finally, I use geographical mapping techniques to augment these data sets with meteorological and geographic information wherever applicable.

In terms of the specific outcome variables, I find that a 10 mph speed limit increase leads to a 3–4 mph increase in travel speed, 9–15% more accidents, 34–60% more fatal accidents, a shift towards more severe accidents, and elevated pollution concentrations of 14–24% (carbon monoxide), 8–15% (nitrogen oxides) and 1–11% (ozone) around the affected freeways. The increased pollution leads to a 0.07 percentage point (9%) increase in the probability of a third trimester fetal death, and a positive but small and statistically insignificant increase in the probability of infant death. I use these estimates to calculate the time saving benefits and the private and external costs from accidents and deteriorated infant health. Moreover, I combine the travel speed estimates with engineering data to compute the increase in fuel consumption at higher speed. Similarly, I combine the air pollution estimates with epidemiology research to compute adverse health effects for adults.

Using these estimates and a wide array of plausible values of a statistical life (VSL) and values of time routinely adopted by governments, I find that the social costs of raising the speed limit from 55 to 65 mph are two to seven times larger than the social benefits. My social cost estimates are two to four times larger than in previous studies, in large part due to the greater comprehensiveness of my approach: I not only consider travel time and fatal accidents, but also non-fatal accidents, climate damages, fuel costs and health. While net social benefits are negative, I find that many individual drivers would enjoy a net private benefit from driving faster as a result of the higher speed limit. Privately, a VSL of \$6.0 million or less justifies driving faster, but the social planner's VSL could be at most \$0.9 million to justify higher speed limits (\$2.0 million if adult health impacts are conservatively left out due to their uncertain nature). While \$6.0 million is within the conventional range of VSL estimates, \$0.9–\$2.0 million falls well below it. Although these results suggest a surprisingly large difference between the social and private optimal speed choices, the optimal speed limit was likely not much below 55 mph since driving slower does not yield substantial pollution reduction benefits and gasoline savings in that speed range.

A seminal paper in this literature is Ashenfelter and Greenstone (AG; 2004), who use the 1987 speed limit changes to estimate the value of a statistical life based only on the trade-off between travel time and fatal accident risk. This is the only well-known study that has produced modern empirical evidence on how speed limits affect speed and fatal accidents.[2] AG use annual data by state and road type in a difference-in-differences framework to estimate the impact of the 1987 speed limit changes on speed and fatal accidents. They can employ cross-state variation in the adoption of the 65 mph speed limit: seven states in the Northeast retained the 55 mph limit, whereas the other eligible states adopted the 65 mph limit. They find that the average speed increased by 2.5 mph and fatality rates by 35%. The paper calculates an upper bound on the value of a statistical life: \$1.54 million (1997 USD) for the full sample, but higher estimates for California (\$4.75 million) and Oregon (\$5.41 million). Section 8 discusses how my results are different.

My paper's main contributions are threefold. First, I explicitly distinguish between private and external costs and benefits and show a stark contrast between them. Second, because I employ an unusually rich data set, I can estimate the effect of speed limit changes on additional important outcome variables such as severe but non-fatal injuries, property damage from accidents, air pollution and the health of infants and others who live near freeways. These estimates allow me to perform a more complete cost–benefit analysis. They are also interesting in their own right. Third, by exploiting within-state variation in speed limits and a wide range of control variables, my approach mitigates potential

[2] This is surprising, since other driving-related policies have attracted considerable attention from economists. Examples include the impact on accidents of seat belt laws (Cohen and Einav, 2003), highway police enforcement (DeAngelo and Hansen, 2014) and vehicle weight (Anderson and Auffhammer, 2014; Jacobsen, 2013).