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Efficiency of speed limits in cities: A spatial computable general equilibrium assessment

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ABSTRACT

Road traffic speed limits are suggested to be associated with, e.g., changes in travel times, vehicle operating costs, accidents, noise and emissions. In this paper we analyze the impacts of speed limit policies, i.e. restricting the maximum permissible road traffic speed, on an urban economy. While most existing studies do only focus on the effects of speed limits on frequency and severity of accidents, we provide a more general assessment of speed limit policies by employing a spatial computable general equilibrium model calibrated to an 'average' German metropolitan area. It is shown that besides transport related effects additional economic effects may influence the overall performance of speed limit policies significantly. Driven by spatial economic effects, tightening speed limits on all roads, i.e. setting a general urban speed limit of, e.g. 30 km/h, lowers aggregate social welfare, although aggregate environmental and accident costs decline. However, setting speed limits around the city center only and not in suburban areas with access to beltways curtails negative effects on the urban economy and, in the end, may result in overall welfare gains. Therefore, our results suggest that implementing a general speed limit uniformly in the entire urban area, thus paying no attention to the spatial shape of the city and its road network, is likely to be an inadequate measure to enhance social welfare. However, restricting speed limits locally, thus focusing on the design of a 'slow zone', is essential and, in the end, is a more promising speed regulation policy having more likely the chance to enhance social welfare.

1. Introduction

A major issue surrounding the effects of tightening road traffic speed limits in urban areas concerns the impacts on mobility and the environment. Speed limit policies – either already implemented or at least controversially discussed in cities or countries around the world – are suggested to be associated with, e.g., changes in travel times, congestion levels, vehicle operating costs, the frequency and severity of accidents, noise and emissions of air pollutants and carbon dioxide. Furthermore, because car drivers seem to overestimate time benefits from speeding at the expense of higher accident risks (see e.g. Elvik, 2010; Matsuki et al., 2002), only consider private costs (ignore externalities) by their choice of driving speed, and are just inadequately informed on traffic conditions and their consequences, regulating drivers speed choice may be a useful and essential traffic managing instrument (see e.g. Archer et al., 2008).

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The suggested positive impacts of speed limits have triggered European citizens to form an initiative called "30 km/h – making the streets liveable!".[1] The 'vision' of the initiative is that a car speed of 30 km/h should no longer be limited to single zones, but shall become the standard speed limit for villages, towns and cities with local authorities being able to decide on exemptions. To meet the subsidiarity principle, the local authorities should have the final decision to set other speed limits on their roads and implement equivalent alternatives to meet, e.g., environment related goals.

There are extensive research efforts towards the impacts of lowered automobile travel speed on accidents, CO_2 emissions, noise and air pollution. In particular the relationship between driving speed and the risk and severity of road crashes has been analyzed and reviewed to a large extent (see e.g. Aarts and van Schagen, 2006; Aljanahi et al., 1999; Archer et al., 2008; Baruya and Finch, 1994; BMJ, 2009; Elvik, 2009; Elvik and Amundsen, 2000; Elvik et al., 2004; Garber and Graham, 1990; Joksch, 1975; Kloeden et al., 1997, 2001, 2002; Lai et al., 2012; Nilsson, 1982, 2004; OECD/ECMT, 2006; Taylor et al., 2000; Wong et al., 2005). Some studies figured out an evidence for an exponential function or a power function between speed and accidents/crash rates. But almost all studies conclude that the probability of being involved in a crash as well as the severity of an accident increases with travel speed and that lowering speeds improves the interaction between different road users.[2] Furthermore, there is evidence that increasing speed differences between vehicles (speed dispersion) increase the crash rate, too.[3]

The impact of speed management policies on CO_2 and air pollution emissions are analyzed in detail as well (see e.g. Baldasano et al., 2010; Dijkema et al., 2008; Gan et al., 2012; Madireddy et al., 2011; Int Panis et al., 2011, 2006; OECD/ECMT, 2006; Owen, 2005). These studies show that reducing speed on urban ring highways/beltways significantly reduces emissions. For local urban roads, however, this picture is less clear.[4]

Studies examining the impact of reduced speeds on noise emissions (see e.g. Amundsen and Klæboe, 2005; den Boer and Schroton, 2007; Dora et al., 2011; Freitas et al., 2012; Gan et al., 2012; Nijland and Van Wee, 2012; OECD/ECMT, 2006) mainly conclude that lowering speeds reduces noise emissions,[5] but the potential of noise reduction is mainly influenced by the speed level.

Further studies analyze the impacts on speed choice behavior (see e.g. Åberg et al., 1997; Delhomme et al., 2010; Elvik, 2010;Elvik, 2009; Fuller et al., 2009; Haglund and Åberg, 2000; Matsuki et al., 2002; Nilsson, 1991; Schmid Mast et al., 2008; Tarko, 2009). Their main results can be summarized as follows: first, most drivers choose speed above the limit because they overestimate time profits as well as they underestimate rising accident risks from speeding[6]; second, because drivers experience social pressure from other road users they choose their speed according to the speed of others even though the speed is above the limit (Åberg et al., 1997); and third, although drivers are aware of the negative impact of speed on noise and emissions, this knowledge affects the choice of speed only to a little degree.[7]

[1] According to the European Citizen's Initiative (ECI) – in operation since 2012 and one of the main features of the Lisbon Treaty – EU citizens are able to influence European legislation by launching their own proposals in any area of EU law. Once an initiative has registered and the registration has been formally checked by the European Commission, the process of collecting one million signatures within 12 months from at least seven member states starts. If the organizers succeed to have more than one million verified signatures the commission must consider the ECI within 3 months. Although the Commission is not bound to act upon a proposal, it is required that they give it serious consideration. See http://en.30kmh.eu/ for further information on the initiative.

[2] Aarts and van Schagen (2006) carried out a considerable review of the extensive literature about the relationship between individual vehicle speed/traffic speed and the risk of road crashes. OECD/ECMT (2006) summarize that the probability of pedestrians to survive in a car accident increases from 20% when they are hit by a car at 50 km/h to 90% if the car only drives at speeds of 30 km/h. The more recent study of Lai et al. (2012) analyzes the impact of Intelligent Speed Adaptation (ISA informs drivers about speed limits and warns when exceeding the limit; it could also be linked to the vehicle's engine management system to slow down the vehicle if necessary) on speed choices and hence on safety and the environment. They conclude that, first, an intervening ISA system is more effective than a just informing system, second, in the long term such a ISA system could save 30% of fatal accidents and 25% of serious accidents, and, third, ISA could improve the environment even though these environmental benefits become insignificant if compared with safety benefits.

[3] Garber and Ehrhart (2000), Garber and Gadiraju (1989) and Taylor et al. (2000) show that a more uniform speed and therewith a smoother traffic flow is associated with better traffic safety.

[4] Int Panis et al. (2011) and Madireddy et al. (2011) examined the impacts of speed management policies on exhaust emissions not only for freeways but also for local roads within urban areas. For three different vehicles (powered by diesel or petrol) and six urban driving cycles, Int Panis et al. (2011) measure the relative changes of exhaust emissions which are caused by reducing speeds from 50 km/h to 30 km/h. Madireddy et al. (2011) combine a microscopic traffic model with an air pollution model to analyze potential environmental impacts of traffic management measures in Antwerp. While Madireddy et al. (2011) find that reducing speed limits from 50 to 30 km/h within residential areas reduces NO_x and CO_2 emissions of the order of 25%, Int Panis et al. (2011) as well as Owen (2005) conclude that it is unlikely that NO_x and CO_2 emissions are significantly influenced by strict urban speed limits.

[5] Although Freitas et al. (2012) studied the impact of speed on noise at the micro level and Gan et al. (2012) at the macro level, both found that road traffic noise emissions increase with speed as well as with traffic density. Freitas et al. (2012) analyzed the noise annoyance of different pavements (cobblestones, dense asphalt, and open asphalt rubber) which are typically used in European cities with regard to car speeds and traffic densities. Gan et al. (2012) analyzed, among others, the impact of speed and traffic density on noise within a large metropolitan area using input data for traffic volume, road type, speed limits, traffic lights, road surface, buildings and topography.

[6] Matsuki et al. (2002) used a driving simulator to investigate the profit of fast driving. Therefor they compared speedy driving and safe driving with regard to traveling time and accident risk. They collected data about driver's time of arrival, headway, and collision prone index (CPI-Ratio between stopping distance and distance headway; the higher the index, the higher the possibility of collision). The results suggest that the difference between the guessed times and the actual traveling times increases with speed. This could be one factor for speeding because drivers believe that driving faster shortens travel time more than it really happens. But, from analyzing and comparing the actual travel times and CPI's, Matsuki et al. (2002) figured out that the relative savings in travel time do not offset the relative increase of the CPI. Hence, speedy driving is not worth the crash risk. Fuller et al. (2009) found that drivers overestimate travel time profits from speeding, particular at higher speed levels.

[7] Elvik (2009) reviewed some literature about the influence of environment polluting factors of speeding on the drivers' choice of speed and concludes that drivers have the negative impacts of speeding on noise and air pollution even in mind, but do not really consider these circumstances for their choice of speed.