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Temporary speed limit changes: An econometric estimation of the effects of the Spanish Energy Efficiency and Saving Plan

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ABSTRACT

Nowadays, speeding is one of the most relevant problems for traffic safety and most resistant to change in motorized countries. The key instruments in Speed Management Policy are speed limits. This road safety strategy is often established or changed, in order to save fuel during periods of rising prices. However, the relationship between speed limits and traffic accidents, is a topic widely discussed by researchers, and there seems to be some consensus about "speed kills." By applying advanced time series models of unobserved components, our study investigates the impact of a temporary reduction of maximum speed limits, implemented in Spain in 2011, in terms of fuel consumption and fatalities. Our analysis shows that this measure caused a positive effect, although with a limited statistical significance, on fuel consumption and a discrete reduction in road mortality.

1. Introduction

The speed of road transport has contributed to countries' economic development and has increased wellbeing and the quality of life because of travel time savings, which, according to Metz (2008), helps generate productivity gains and reduce opportunity costs in terms of user time. Nevertheless, speed also has very adverse impacts in the form of energy consumption, air pollution, noise emissions, and, above all, road traffic accidents as pointed out by Kremers et al. (2002). Nowadays, excessive and inappropriate speed[1] is one of the biggest road safety problems (Wegman and Aarts, 2006), for both rich and highly motorized (Elvik, 2010) and developing countries (Afukaar, 2003). Despite speeding being a widespread issue and everybody being convinced that "speed kills" (GRSP, 2008), it is widely tolerated and, in the words of Elvik (2010:1092): "one of the road safety problems most resistant to change".

For all these reasons, most governments regard speeding as a priority within the road safety strategies, such as Vision Zero in Sweden, Sustainable Safety in the Netherlands and Safe System in Australia, and a range of tools are applied for developing an effective Speed Management Policy (GRSP, 2008), from road engineering treatment to the setting of maximum speed limits (see e.g., Bolderdijk et al., 2011; Elvik and Vaa, 2004; Feng Ng and Small, 2012).

Although an appropriate combination of measures is required (Elvik, 2012), the key tool for speed management, and the most widely addressed, is speed limit (Ritchey and Nicholson-Crotty, 2011). There are some roads in motorized countries where no speed limits are in force (i.e., German Autobahns), but the need for legal speed limits on all types of roads is very widely recognized and commonly legitimated by the fact that drivers' choices of speed may not always be perfectly rational from a social perspective (Elvik, 2012; Jørgensen and Polak, 1993) and may be strongly influenced by how fast others are driving (Haglund and Åberg, 2000).

In this paper, we analyze a recent change to maximum speed limits allowed on free-public and toll-private dual carriageways and motorways in Spain during a few months in 2011, which was put in place with the primary objective of obtaining savings in fuel consumption.

Speed limit laws have existed in Spain since the mid-nineteen-seventies and the speeding problem has been reflected in Spanish active traffic safety policies developed during recent years (December 2007 and June 2010 Penal Code Reforms; penalty points system-based driving license in 2006; the 2005–2008 and 2011–2020 Strategic Road Safety Plans). However, the most unforeseen strategy may have been the reduction in the maximum speed limits allowed on dual carriageways and motorways, which was reduced from 120 km/h to 110 km/h from the 7th of March 2011 to the 30th of June 2011 for automobiles and motorcycles. This measure was taken at a time of political instability in oil producing countries during the first quarter of 2011, known as the "Arab Spring", and which entailed a steep hike in the price of oil (around USD 125 per barrel). Therefore, in the local context of a serious economic crisis in Spain and with the aim of reducing fuel consumption, the

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[1] According to ECMT (2006), excessive speed is a speed over the legal speed limit and inappropriate speed is a speed much too high for the road, and the weather and congestion conditions, but within the legal speed limit. Excess speed covers both terms.

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government adopted a package of measures included in the so-called Energy Efficiency and Saving Intensification Plan (2008–2011), as part of which this reduction in speed limits was implemented.

Our goal is to analyze the impact of this temporary change in the Spanish speed limits, measured by road fatalities and fuel consumption, for the whole national road network. Although the speed limit reduction was valid only for dual carriageways and motorways, our aim is to determine its full impact, taking into account the consequent traffic transfer between different types of alternative roads (secondary). Changes in speed limits may have effects that extend beyond the roads that are affected, such as speeds being generalized (Richter et al., 2004) and traffic transferring to and police enforcement on other roads (Lave and Elias, 1994) which, in the opinion of these authors, might lead to an increase in top-end limits having a neutral or even positive effect on the number of road fatalities in the road network.

In order to isolate the impact of the provisional reduction in speed limits, we use a method based on advanced time series treatment, the Unobserved Component Model, of the discrete linear time transfer function type, with multiple explanatory variables. In the line of other preceding studies, such as Balkin and Ord (2001) in the U.S. and Johansson (1996) in Sweden, this methodology answers the need stated by authors such as Dee and Sela (2003) and Shafi and Gentilello (2007) of pursuing findings that control potential confounding factors and eliminate the biases that may be due to unobserved or specific aspects of traffic safety, such as other simultaneous policies implemented. For the purpose of comparison and as a benchmark, ARIMA models with exogenous variables are also included (Box et al., 1994).

The paper is structured in the following way: after this introduction, Section 2 lays out a brief review of literature on speed limit effects; Section 3 explains the empirical framework; the findings are stated and discussed in Section 4 and the conclusions and resulting policy implications are analyzed in Section 5. Finally, we include a methodological annex in Section 6, and the references.

2. Literature review

Since they became widespread at the beginning of the nineteen-seventies (Elvik and Vaa, 2004) speed limit strategies appear to have been linked not only to the goals of traffic safety, such as controlling speeding and reducing road accidents, but have also very frequently formed part of broader policies with environmental, health or economic purposes, such as reductions in fuel consumption for less foreign energy dependence during times of increased gasoline prices or reducing Greenhouse Gas (GHG) emissions, and road safety issues seem to have been afforded secondary importance. However, the relationship between speed limits and traffic safety has been widely addressed by researchers worldwide, especially in the U.S. (Albalate and Bel, 2012; Dee and Sela, 2003; Friedman et al., 2009; Lave, 1985; Retting and Teoh, 2008). Since the initial estimates obtained by Solomon (1964), there has been a degree of consensus on speed having a significant effect (with certain causality) on road safety, in the sense that both accident incidence and accident severity are expected to increase with higher speed limits (Ashenfelter and Greenstone, 2004).

How changes in speed limits affect actual driven speeds and the consequent estimation of their effects on road accidents is a controversial topic addressed from a wide range of focuses and approaches. Many of the studies examined the influence of absolute speed on accident rates (Kloeden et al., 2001), either at individual vehicle level or at average road section level (the Power Model by Nilsson, 1982, 2004 and its evaluations made by Elvik, 2009; Elvik et al., 2004; Hauer and Boneson, 2008 are well-known). Both types were founded on an exponential function and a power function between speed and accidents (prevalent in the literature) and recent validations have shown that the effect on rural roads is relatively greater than on urban roads (SWOV, 2012).

Other studies emphasized the influence of speed dispersion on the risk of a crash (with the first studies conducted by Cirillo (1968) and Solomon (1964), and modern reformulations by Kloeden et al. (2001) and Lave (1985)) finding that large speed differences between vehicles (speed variance) increase the likelihood of an accident. In addition, drivers driving much faster than the average driver have a higher accident risk ("variance kills", Dee and Sela, 2003); although it is not yet evident that this is also the case for the slower driver, and neither has any clear relationship been established to date to quantify the effect of speed differences and the crash involvement rate.

In general terms, the evidence seems to confirm the negative/positive impact of raising/decreasing the speed limits on average speed and consequently on road accidents. Research, such as Elvik et al.'s (2004) points to the average speed varying in the same direction as the change in the speed limit on roads affected by the change, although approximately 25% less in magnitude.

In conclusion, the exact relationship between speed and crash rate seems to depend on a large number of different factors and, as pointed out by authors like Ritchey and Nicholson-Crotty (2011, 331): "…despite years of research, there is still no clear consensus in the literature on the impact that speed limit laws have on traffic fatalities".

Neither does there seem to be any agreement on mechanisms for gasoline prices affecting speed limit compliance. The findings of Blomquist (1984), Goodwin et al. (2004) and Peltzman (1975) show that vehicle speeds decrease with higher gasoline prices. However, Burger and Kaffine (2009) have recently found the opposite relationship and rejected the hypothesis that drivers reduce speeds when gasoline prices are high. There are only a limited number of empirical studies on how speed limits specifically affect health, although some results obtained indirectly suggest that higher speed limits might have adverse health effects (Currie & Walker, 2011).

From a methodological point of view (see the meta-analyses and reviews by Aarts and Van Schagen (2006); Elvik et al. (2004); Finch et al. (1994); McCarthy (2001); and Wilmot and Khanal (1999)), existing research on speed limits generally employ before–after analysis, a case-control approach, univariate classification procedures, regression analysis or ARIMA time-series models. Multivariate models are rarely used. Consequently there is often a lack of correction for common statistical problems in time series (e.g., serial correlation).

3. Empirical framework

The variables used to evaluate the effect of the changes in speed limits in Spain (all measured on a monthly basis and are used on a logarithmic scale in later models, except binary type variables) can be divided into three groups (see Table 1).

A) Endogenous variables: fatalities in road accidents (Fatal in Table 1) and gasoline and diesel consumption for transport (Consumption). In order to use consistent time series that were as long as possible, we used the definition of deaths within the first 24 h after the accident, instead of the Vienna Convention definition (30 days after the accident). The available time series span from January 1995 to August 2012 (Source: Spanish National Statistics Institute, INE; and Spanish Road Traffic Directorate General, DGT).

B) Dummy exogenous variables: an ample set to estimate a number of intervention variables and outlier effects seen in the data. The most important, with their definitions, are:

b.1) Speed: takes into account the change in speed limits on highways (from the 7th of March 2011 to the 30th of June 2011). Several options have been tried out empirically, but the final version is one step over the whole period with a value of 75% in the first month, in order to take into account the fact that change took place after the first week in March.