The 'fundamental law of highway congestion' and air pollution in Europe's cities.

(Extended abstract)

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Abstract: In this paper we confirm the 'fundamental law of highway congestion' for the cities of Europe. Our identification strategy is based on four different historical transportation networks in Europe that we use as instruments and on panel data techniques. We decompose the traffic increase and we find that the increase in traffic was mainly caused by the increase in capacity rather than the increase in coverage. We also find that the increase in traffic congestion is higher for the cities without tolls and for the cities without subways, which substantiates congestion pricing and public transit as policies against congestion. We also estimate that traffic increases the concentration of some of the most harmful urban air pollutants. For nitrogen oxides, the estimated elasticity is approximately 0.10, while solphur dioxide and fine particulate matter also seem to increase considerably with an increase of road traffic. The estimated effect on pollution is also higher for the cities without tolls and for the cities without subways. These findings have major implications for policy given the severity of traffic congestion and air pollution in Europe's cities.

Key words: air pollution, congestion, highways, tolls, Europe, cities
JEL classification: R4, O1, Q5

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Introduction

Outdoor air pollution kills 3.3 million people, mostly in cities, every year (Lelieveld et al., 2015). That's more than HIV, malaria and influenza combined – yet the sparse coverage of official data means many cities are not even monitored. Emissions of air pollutants in cities are, in part, driven by where and how people live (e.g. central vs. in suburbs), work (e.g. close to work place vs. long commutes), and how they travel (e.g. private cars vs. public transportation) (Hilber and Palmer, 2014). In fact, EU's environmental legislation is working to ensure that European citizen's enjoy cities with clean air and to promote better green infrastructure. Besides air pollution, another critical issue that European cities have to address is traffic congestion. The cost of road congestion in Europe is estimated to be over €110 billion a year (about 1 percent of the GDP) and it is also mainly concentrated in cities (Christidis and Rivas, 2012).

While EU Regional and Cohesion Funds have financed a significant amount of the immense highway network development in the last few decades, there is no integrated study that analyses the impact of highway construction on traffic congestion and the subsequent environmental costs imposed by the increased traffic on urban air pollution in Europe's cities. Nevertheless, one of the main criticisms to the extension of an intra-metropolitan road network is that such policies may not generate any real improvements in accessibility, because of the induced demand effect or the 'fundamental law of highway congestion' (Downs, 1962, 1992) i.e. the travel speed on an expanded highway reverts to its previous level before the capacity expansion. In this paper, we confirm the 'fundamental law of road congestion' and estimate the effect of highway congestion on urban air pollution for the metropolitan areas of the EU28 countries (except for Cyprus and Malta), Norway and Switzerland in the period 1985-2005.

Traffic congestion and environmental pollution figure as two of the three most important negative externalities related to car travel (Shefer and Rietveld, 1997). These two road transport externalities share the same 'external cost' nature, as the use of a vehicle generates negative side effects on the rest of the economy. However, the level of urban pollution in itself does not usually reduce the level of car use, in contrast to congestion which discourages car use directly. So there is no inherent feedback mechanism. Second, the environmental damage can often be reduced with 'filter' technology and regulatory policies, i.e. changes in the technology (engine, vehicle design) that reduce the level of emissions per km or other EU policies (Air Quality Standards, Low Emission Zones (LEZ) etc.). "Pollution can be reduced without changing car use, which is not possible for congestion as it is a function of the number of vehicles using an infrastructure at a particular time, so either trips have to be suppressed or relocated to another infrastructure or another moment". (Proost and Van Dender, 2012).

Based on this logic, the first goal of this paper is to test the 'fundamental law of highway congestion' by estimating the elasticity of vehicle kilometres travelled (VKT) with respect to highway lane km. Given the feedback mechanism of traffic congestion, in order to estimate the causal effect of highway construction on traffic congestion, we need to overcome several identification issues. We are able to overcome such issue by means of instrumental variables, using four different historic transportation networks in Europe as instruments, together with panel data techniques. In order to estimate the subsequent effect of traffic congestion on urban air pollution, we mainly have to deal with improvements in technology and the changes in regulation. We use a fixed effects approach together with instrumental variables and we estimate the effect of the road traffic on three of the most dangerous air pollutants related to road transport, namely, nitrogen oxides (NO_X), particulate matter (PM_{10}) and sulphur dioxide (SO_2).

There has been considerable research undertaken on the impact of transportation on suburbanization or 'urban sprawl' and its effects on greenhouse gas emissions (Glaeser and Kahn, 2004, 2010, Gaigné et al., 2012, Blaudin de Thé and Lafourcade, 2016). There has also been some work on the effects of transportation on air pollutants that are harmful for health. Kahn (1996) found large differences in vehicle emissions across model years, makes, and sizes, while Gendron-Carrier et al. (2016) investigate the relationship between the opening of a city's subway network and its air quality. In the intersection between these two strands of literature, the theoretical paper of Proost and Van Dender (2012) discusses the economics of local air pollution, energy supply and climate change, with a focus on road transport, and Hilber and Palmer (2014) focus on the impact of different explanatory variables that both the theory and the existing empirical literature suggest that may affect air pollution concentration at the city level.

The 'fundamental law of highway congestion' has also been tested empirically in the context of the US and Japan (Duranton and Turner, 2011, Hsu and Zhang, 2014). Both these papers find an elasticity of VKT with respect to highway lane km of approximately one. However, it is not straightforward why the fundamental law should also hold for the cities of Europe. Europe is much more dense than the US[1]. Specifically, European cities seem to be rather compact compared to most American cities and they are also characterised by a lower degree of car-dependency and the widespread use of public transportation. Therefore, one might expect that the reaction of the demand side to an increase in the supply of road transport might be different.

Analysing these effects for the whole of Europe is methodologically complicated. Finding valid instruments for such a big and heterogeneous area as Europe is challenging. However, we are able to study heterogeneous effects based on the existence of tolls and subways. Finally, we decompose the effect of the highway expansion to the effect of coverage, which comprises the heart of the EU goals of increasing regional connectivity and the capacity effect, which seems to drive most of the induced demand effect.

[1]The average population density of the 25 states of the European Union (EU) in 2005 was about 117.5 inhabitants per km^2 compared to just 31.6 in the US.

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