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From restricting the use of cars by license plate numbers to congestion charging: Analysis for Medellin, Colombia

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ABSTRACT

In Medellin, Colombia, as in several cities in Latin America and other developing countries, a driving restriction policy according to the license plate number has been applied as a strategy to reduce congestion and other externalities associated with car use. Despite the apparent initial success of the policy, locally called *pico y placa,* the problems of congestion and pollution have re-emerged over time. In response, local authorities are considering removing this driving restriction and replacing it with a congestion charge policy, also known as road pricing.

To evaluate the impact of the policy implementation on drivers' behaviour, we estimated a hybrid choice model including latent variables. The model was used to analyse the influence of congestion charging policy factors such as tolls and schedules on the modal split during the morning peak hour.

The elasticities analysis shows a high tendency of car drivers to change their departure time to avoid paying the toll. A suggested charge of COP 6000 (USD 3.33) and a more extensive charging schedule compared to the current *pico y placa* schedule reduces the car market share by about 37% which is similar to the car use reduction generated by a two-digit *pico y placa* policy in the short term.

1. Introduction

For addressing the problems of congestion, pollution and other externalities associated with car use, several major Colombian cities, such as Bogota, Medellin, Cali, Bucaramanga, Cartagena, Cúcuta, Pereira, and Ibagué, among others, implemented a driving restriction policy based on the last digit of the license plate. This policy is locally known as *pico y placa* (which roughly translates to *peak and plate*). The first city that applied the policy was Bogotá, then it spread to Medellin and other cities in the country due to apparent success in its early stages. The measure does not involve monetary expenditures for users (except a fine if breached), so it is less unpopular than congestion charging.

Other Latin American cities have implemented car restrictions similar to *pico y placa*, mainly with the purpose of reducing air pollution or congestion problems. In Santiago de Chile, vehicles without catalytic converters have experienced driving restrictions in the fall and winter since 1986. Currently, the restriction also applies to vehicles with catalytic converters during environmental emergency days (Bull, 2003). However, the measure has not had a positive impact on reducing pollution levels (Fresard, 1998) or diminishing the use of cars in the city (De Grange and Troncoso, 2011). Furthermore, the restriction does not affect low-income and high-income drivers equally since the former do not have the possibility to purchase a second car to avoid the ban (Fresard, 1998).

In Mexico City, a policy equivalent to *pico y placa* called "*Hoy no circula*" (which translates as *Do Not Circulate Today*) has been in effect since 1989. The policy prohibits drivers from using their vehicle for one day a week in the central area of the city based on the last digit of their license plate. The measure has not had a significant impact on reducing pollution levels in the long term. Indeed, air quality has worsened on the days when the restriction does not apply, particularly on weekends (Davis, 2008; Gallego et al., 2013a; Gallego et al., 2013b; Eskeland and Feyzioglu, 1997). Other Latin American cities prohibiting the circulation of vehicles depending on the last digit of their license plates are Sao Paulo in Brazil since 1997 (Hochstetler and Keck, 2004; Jacobi et al., 1999; Biezus and Rocha, 1999); La Paz since 2003; San Jose since 2005, and Quito since 2010. The measure was also applied in Caracas between 1979 and 1988.

Outside Latin America, Manila (Thomson, 1988) and Beijing during the Olympic Games in 2008 implemented similar measures. In the latter

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case, the immediate results showed improvement in levels of congestion in the city, but not in pollution levels and a high rate of breach of the restriction (Sun et al., 2014; Wang et al., 2014). The policy became permanent and today cars in Beijing are banned from circulating for one day per week.

Cantillo and Ortúzar (2014) performed an analysis of the vehicular restriction according to plate number in four Latin American cities: Bogota, Medellin, Santiago and Mexico City. They showed that it is only apparently effective in the short term. The policy generates a social loss associated with a higher willingness to pay for using their cars by those restricted drivers. Therefore, in the medium and long term, many drivers choose to buy another car not restricted on the same days as the one they already have. Also, the typical reaction of planners when congestion problems resurface is to intensify the measure by increasing the number of license plate numbers with the restriction or extending schedules. More recently, Nie (2017) proved that vehicular restriction is not the first-best policy and cannot even be a second-best policy because it may never improve the system cost.

Medellin adopted *pico y placa* in 2005 for 20% of vehicles (two plate numbers) between 6:30 and 8:30 a.m. and from 5:30 to 7:30 p.m. In 2008, the city extended the measure to 40% of the cars (four plate numbers) and 20% of two-stroke motorcycles. Currently, the measure applies between 7:00 and 8:30 a.m., and between 5:30 and 7:00 p.m., in an area of 36.8 km^2 corresponding to 36% of the urban city (see Fig. 1).

Fig. 2 shows the evolution of the rate of new cars registered per 1000 inhabitants and the modal split in the city of Medellin (Ministerio de Transporte, 2011; Area Metropolitana del Valle de Aburra, 2012). Immediately after the implementation of the car restriction in 2005, the use of cars was similar to that of 2000. Meanwhile, during the following years, private vehicle ownership (cars and motorcycles) increased, while public transport use decreased.

Sarmiento and Zuleta (2009) and Posada et al. (2011) showed that because of *pico y placa* Medellin does not have a defined rush hour. They argue that many drivers moved some of their trips to schedules without restriction. Additionally, a before/after traffic flow analysis on nine of the most important intersections in the city shows a short-term decrease in congestion, but in the mid-term (two years) traffic flows returned to the values observed before implementation. Analysing the same data, Posada et al. (2011) also concluded that initially, some drivers rescheduled their trips outside rush hour as the result of the implementation of the ban. They showed that the policy also became obsolete because it encouraged an increase in the purchase of private vehicles.

Other studies conducted in Bogotá support the inconvenience of vehicle restriction policies Bocarejo (2008) examined the economic impact of *pico y placa* in Bogotá, suggesting that the driving restriction during peak hours may have resulted in a loss in the user's utility of about 118 million euros per year. Cantillo and Ortúzar (2014) made a contrast between vehicles registered and per capita GDP of Bogotá and the rest of Colombia between 1998 and 2005 (the year when *pico y placa* spread to other cities in the country). They demonstrated that the growth rate of the fleet was higher in Bogotá during this period, even though the increase of per capita GDP was lower than the rest of the country. The former may be explained, at least partially, by the implementation of *pico y placa*. More recently, Zhang et al. (2017) developed a theoretical model of the effects of license plate driving restriction on air quality and contrasted their results with the historical air pollution statistics of Bogota. They found that, under certain circumstances, it is possible that the driving restriction policy increases air pollution.

Fig. 1. Restricted area in Medellin.

Given the obvious failure of the driving restriction policies in Bogotá and Medellin, those cities have begun to study the possibility of removing *pico y placa* and replacing it with a congestion charge policy (Universidad Nacional de Colombia, 2012; Secretaría Distrital de Movilidad de Bogotá, 2014). The National Government (Departamento Nacional de Planeacion, 2011, 2015) supports both studies.

Most experts agree that congestion charging is the most appropriate policy to deal with the problems associated with transport externalities.[1] With such a policy, car users are charged for the externalities they generate, encouraging drivers to change short-term aspects of their conduct. Additionally, revenues from these charges can be invested properly; for example, improving public transport or financing infrastructure projects. Despite all their advantages, and after the successful systems designed for Singapore, London and Stockholm, very few congestion charging policies have been implemented. Among these are a few highways in the United States and some European cities like Veleta, Trondheim, Oslo, Bergen, Rome, Milan and Durham. The main difficulty that has prevented congestion charging from being implemented in most cities is the lack of acceptance by the general public (Grisolía et al., 2015).

Several factors affect the acceptance of congestion charging. The lack of confidence or clarity in the use of the resulting revenue (Kim et al., 2013; Grisolía et al., 2015); an inadequate outreach strategy about the benefits of the measure (Hensher and Li, 2013; Eliasson and Jonsson, 2011; Hensher, 2013); the lack of information provided by the media (Ardiç et al., 2013); and the perception that the measure is a regressive tax (Levinson, 2010; Teubel, 2000) are some of those factors. The acceptance of congestion charging is also affected by measurable characteristics of individuals (Kottenhoff and Brundell-Freij, 2009; Gehlert et al., 2011). Attributes of the policy such as the value of the toll, schedules and charging zone (Kockelman and Kalmanje, 2005; Grisolía et al., 2015) could also be important.

Additionally, there are underlying factors and perceptions of individuals affecting people's behaviour when confronted with congestion charging policy. The environmental concerns (Janssens et al., 2009; Eliasson and Jonsson, 2011); awareness of the adverse effects of car use; and the perceived effectiveness and fairness of the measure (Jones, 2003; Schade and Schlag, 2003; Steg, 2003; Eliasson and Jonsson, 2011; Di Ciommo et al., 2013), are some of those latent factors.

Planners and local decision makers in Colombian Cities have preferred *pico y placa* to congestion charging. Plate restriction does not require huge investments or an increase in the institutional capacity for its implementation and control (Rivasplata, 2013). Also, the vehicle restriction policy has certain levels of acceptance by most sectors of society. The seemingly positive results of the measure in the short term and because it only affects a minority of the population (those who own car) are reasons that favour its acceptance in Latin American cities (Mahendra, 2008, 2011). Because of this preference and other political motives, the congestion charging initiatives for Bogotá and Medellin have not

[1] See Lindsey y Verhoef (2001), Rouwendal and Venhoef (2006), Parry (2009), Verhoef and Small (2007) and de Palma and Lindsey (2011) for a detailed review of the congestion charging policy.