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The effect of transport policies on car use: A bundling model with applications

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ABSTRACT

Borrowing from the bundling literature, the paper presents a novel model of vertical and horizontal differentiation applied to transport decisions: households differ in their preferences for transportation modes — cars vs public transport — and in the amount of travel. Using few observables, the model is then used to interpret and compute policy costs associated to the effects of two major transport policies: the driving restriction program introduced in Mexico-City in November of 1989 and the public transport reform carried out in Santiago-Chile in February of 2007. Both policies had the unintended impact of increasing the number of cars on the road; and their associated transport costs are estimated, respectively, to be about 5% and 9% of the value of the vehicle stock at the time of implementation.

1. Introduction

Air pollution and congestion remain serious problems in many cities around the world, particularly in emerging economies because of the steady increase in car use (EIU, 2010). This trend has also contributed to increasing carbon emissions. Latin American cities have experimented with different policies in an effort to contain such trend. In November of 1989, for example, authorities in Mexico City introduced Hoy-No-Circula (HNC), a program that restricted drivers from using their vehicles one weekday per week. More recently, in February of 2007, authorities in the city of Santiago-Chile embarked in a city-wide transportation reform, Transantiago (TS), with the idea of improving and increasing the use of public transport. As shown in Table 1,[1] other major efforts in Latin America are of the same type, either driving restrictions or reforms in public transportation; there is total absence, so far, of more market-oriented instruments such as road pricing and pollution taxes.[2]

Have these policies been effective in persuading drivers to give up their cars in favor of public transport, and hence, in reducing congestion and pollution? The problem with evaluating these policies is that it is not always easy to construct a counterfactual against which the performance of the policy can be contrasted upon (Small and Verhoef, 2007), and more so if we are interested not in the immediate or short-run effect of the policy but in its long-run effect, i.e., whether and how fast households adjust their stock of vehicles. In this paper we develop a novel, yet simple, model of a household's transportation-decision problem that can serve as theoretical framework for empirical applications.

The model distinguishes short from long-run impacts of a transportation policy that can take different forms.[3] In constructing the model we (partially) borrow from the bundling literature (e.g., Armstrong and Vickers, 2010), so we capture in a simple way the essential elements of a household's problem which are the allocation of existing vehicle capacity, if any, to competing uses (peak vs off-peak hours) and how that capacity is adjusted in response to a policy shock. Households are both horizontally and vertically differentiated: they differ in their preferences for transportation modes — cars vs public transport — and in the amount of travel. Some households will find it optimal to purchase the car-bundle (i.e., use the car for both peak and off-peak hours), others to rely exclusively on public transportation (bus-bundle), yet others to "two-stop shop" (e.g., car for peak travel and buses for off-peak travel).[4]

One of the advantages of the model is that it can be calibrated and utilized for policy simulations (including estimations of policy costs)

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[1] A description of the transport policies in the table can be found in Ide and Lizana (2011).

[2] The political economy of this absence is beyond the scope of the paper but it is nevertheless an interesting area for more research. Caffera (2011) touches on the issue but in the specific context of pollution control from industrial sources.

[3] Throughout the paper, we understand for short run the period right after a policy shock, say, first month, and long-run as the time it takes most agents to adjust their stock of vehicles as a response to the shock. There can be longer-run effects (e.g., changes in agents' location within the city) but our model does not consider them.

[4] Note that only the car-bundle comes with a discount because the same car can be used for both peak and off-peak travel.

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Table 1
Transport policies in Latin America.
Source: Ide and Lizana (2011).

Program	City	Start year	Type [a]	Scope
Restricción Vehicular	Santiago	1986	DR	Gradual
Hoy No Circula	Mexico D.F.	1989	DR	Drastic
Metrobus-Q	Quito	1995	PT	Gradual
Operação Rodizio	Sao Paulo	1996	DR	Gradual
Pico y Placa	Bogotá	1998	DR	Gradual
Transmilenio	Bogotá	2000	PT	Gradual
Pico y Placa	Medellín	2005	DR	Drastic
Metrobus	México D.F.	2005	PT	Gradual
Restricción Vehicular[b]	San José	2005	DR	Gradual
TranSantiago	Santiago	2007	PT	Drastic
Pico y Placa Quito	Quito	2010	DR	Drastic

[a] DR: driving restriction; PT: public transportation reform.
[b] The program suffered a temporary interruption in June–July of 2009.

using few observables at the city level, namely, the fraction of households owning either none, one, or more cars, the share of car trips at peak hours, the share at off-peak hours, and the ratio of peak trips over off-peak trips (we also need to make an assumption about the distribution of horizontal and vertical preferences in the population). Unlike other existing models (see, e.g., Basso and Silva (2013) and the references cited therein), our model is particularly well equipped to study the effects of policy interventions that affect car utilization such as driving restrictions. Existing models that aggregate preferences at the level of a representative agent (Parry and Small, 2009) or by income (Basso and Silva, 2013), would miss much or all of the action that our model captures, for example, that two households of similar income may have quite different responses.[5]

The model provides several results, which help interpret empirical findings. First, the model illustrates how little informative the shot-run impact of a policy can be. Take a driving restriction policy, for example, which the model captures with a reduction in vehicle capacity. The short-run impact (i.e., before any household has adjusted its stock of vehicles) is unambiguous and as expected, at least qualitatively: a reduction in car trips during both peak and off-peak hours. Depending on parameter values (e.g., price of cars), the long-run impact of the policy can go either way, however. If cars are relatively expensive, the reduction in car trips can remain in the long-run or even extend if enough households find it optimal to return their cars. Conversely, if cars are less expensive (or because households decide to buy older and cheaper cars to by-pass the restriction), the policy can result in an increase in the number of vehicles in the long-run. Similar arguments apply to a public transportation reform, which the model captures with a change in the variable cost of using public vis-à-vis private transportation. Regardless of the direction of the relative price change, its short-run effect on car use is likely to be small and hard to detect empirically.[6] The long-run effect, however, can be shown to be substantial in either direction.

Second, the model shows that policy impacts can vary widely among different income groups, which is important for policy design and evaluation. It shows, for example, that a driving restriction policy like HNC is likely to have its greatest impact in middle-income groups, where households were more likely to buy a second car, and lower in high- and low-income neighborhoods but for different reasons. High-income households have already sufficient car capacity to cope with the driving restriction while only a few low-income households own a car, and those that do, cannot afford a second one. A public transport reform like TS that increases the cost of using public transport uniformly across the city is also likely to have very heterogeneous impacts: lowest among the rich that relies less on public transport and highest among the poor.

The model also allows us to understand whether the effect of policy intervention on car use varies depending on the hours of the day — peak vs off-peak hours. This distinction is important when in the empirical application one may only be able to estimate policy impacts at peak hours. Finally, the model is useful for computing transport costs that policies impose on households due to changes in the relative prices of the different transportation options and see how much they change as households adjust to them over the long run.

Our model is then applied to two major policy interventions –HNC and TS– following the empirical results of our companion paper Gallego et al. (2013). Based on hourly concentration records of carbon monoxide, which comes primarily from vehicle exhaust, in Gallego et al. (2013) we document how household responses to both HNC and TS have been ultimately unfortunate — more cars on the road and higher pollution levels — but also remarkably similar in two important aspects: on how policy responses vary widely among income groups and on how fast households adjust their stock of vehicles, when they do. These empirical results are largely consistent with the regularities that our bundling model predicts both across time and income groups. We also use the model to compute the transportation costs associated to these two interventions. Despite some households adjusted to these policies by purchasing additional car capacity, the model shows that the costs inflicted by these policies remain largely unchanged in the long run. The reason for this latter is that households that decided to buy an additional (or first) car because of the policy were households that before the policy were not that far from buying that additional (or first) car anyway (they didn't do it before because buying a car is a lumpy investment). In the case of TS, these transport costs amount to approximately 9.5% of the value of the stock of vehicles in 2007 (or $126 million annually in 2007 U.S. dollars) and in the case of HNC these costs reach 5.3% of the stock value of the time.

The rest of the paper is organized as follows. Section 2 describes HNC and TS in more detail. The bundling model is presented in Section 3. The application of the model to HNC and TS –including a summary of the empirical strategy and results that are in our companion paper– is in Section 4. We conclude in Section 5.

2. Two major transport interventions

In this section we provide a brief description of the two transport interventions we will apply the model to: HNC and TS. While the two policies are of different nature — one affected the cost of purchasing a car by restricting its use while the other made its use relatively cheaper — and implemented in different cities, and almost 18 years apart, both amount to one-time drastic interventions like no other in the region in that they changed the relative prices of transport options at once and for the entire city.

2.1. HNC in Mexico-City

HNC was established on November 20 of 1989, as a response to record levels of air pollution and congestion in Mexico-City (Molina and Molina, 2002). The program banned every vehicle — except taxis, buses, ambulances, fire trucks and police cars — from driving one weekday per week, from 5 am to 8 pm, based on the last digit of its license

[5] The predictions of our model are even richer than that of Eskeland and Feyzioglu (1997) that was specifically designed to understand the effects of HNC. Their model predicts that households that would like to sell their cars because of the restriction must be of low income while the ones that would like to buy an extra car must of high income. The driving forces in our model are preferences for car vs public transport (which naturally is highly dependent on income but not exclusively) and amount of travel which can vary greatly across households.

[6] Litman (2011) explains that cross elasticities between public and private transportation are very low in the short-run (0.05). Furthermore, the 2006 Origin–destination survey for the city of Santiago (EOD-2006 for its initial in Spanish), for example, shows that most of the (passenger) cars in the city (799,811) must be already in use to cover an equivalent number of morning trips (706,518).