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A Contingent Valuation Approach to Estimating Regulatory Costs

Mexico's Day Without Driving Program

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RESOURCES FOR THE FUTURE

A Contingent Valuation Approach to Estimating Regulatory Costs: Mexico's Day Without Driving Program

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Abstract

Little is known about the cost of environmental regulations such as residential zoning restrictions and recycling mandates that target households instead of firms, partly because of significant methodological and data challenges. We use a survey-based approach, the contingent valuation method, to measure the costs of Mexico City's Day Without Driving program, which seeks to stem pollution and traffic congestion by prohibiting vehicles from being driven one day each week. To our knowledge, ours is the first study of an actual regulation to use this approach. We find that the Mexican program's costs are substantial: up to US $103 per vehicle per year, about 1 percent of drivers' annual income. Recent research has questioned whether programs for driving restrictions in Mexico City and several other megacities actually have environmental benefits. Our results suggest that whatever benefits these programs may have, they can be quite costly.

Key Words: contingent valuation, driving restrictions, regulatory cost

JEL Classification Numbers: Q52, R48, O18

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1. Introduction

A considerable empirical literature analyzes the social costs of environmental regulations that apply to firms (Pizer and Kopp 2005). Far less attention has been devoted to measuring the costs of environmental regulations that target individuals, including recycling mandates, residential zoning, and restrictions on sport fishing and the use of other natural resources. Estimating such costs is particularly challenging. A conventional survey approach—that is, simply asking individuals to self-report regulatory costs—is problematic for several reasons. In many cases the regulations' main effect will be on time use, which means that the value of time needs to be estimated. Also, monetizing inconvenience costs is challenging. And finally, respondents may strategically overstate costs in expectation that doing so will somehow spur regulatory relief, a phenomenon highlighted in the literature on firm-level regulation (Hammitt 2000; Spulber 1988). Moreover, whereas analyses of firm-level regulations can avoid such bias by using a revealed cost approach—that is, regressing historical production cost data onto contemporaneous environmental performance data (McClelland and Horowitz 1999; Morgenstern et al. 2002)—that tactic is impractical the case of individual-level regulations, for obvious reasons. A review of the literature on estimating environmental regulatory costs concludes,

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> Analyses of regulatory impacts on households are [rare]—and fraught with difficulty. It is hard to identify, let alone measure, the "technology" for pollution control activities and the immediate cost to households of environmental regulation. (Pizer and Kopp 2005, 4)

We use the contingent valuation (CV) method to estimate the cost of an environmental regulation targeting individuals. CV is a survey-based method primarily used to value nonmarket goods (Carson and Hanemann 2005; Mitchell and Carson 1989;). To date, it has been used almost exclusively to value environmental and health-related goods, such as clean air, clean water, and scenic beauty (e.g., Carson et al. 2003; Krupnick et al. 2002). A CV survey describes a program or project that would generate a change in the nonmarket good—for example, a municipal sewage project that would improve local surface water quality—and then asks respondents questions about their willingness to pay (WTP) for it. The survey is designed to reduce the influence of strategic responses and hypothetical bias. Given a representative sample, the CV survey data can be used to calculate total WTP of the program or project.

We adapt this method to measuring environmental regulatory costs by developing a CV survey that describes a program that would exempt individuals from an environmental regulation, and we administer it to a random sample of individuals subjected to the regulation. We use their responses to calculate the total WTP for rescinding the regulation, which is a measure of the cost the regulation imposes on households.

To our knowledge, Cropper et al. (2014) provide the only other application of the CV method to estimate regulatory costs. The authors focus on a regulatory program that restricts driving on high ozone days in the Washington, D.C., metropolitan area. However, this program is hypothetical, not real. As far as we know, ours is the first application of the CV method to estimate the costs of an actual regulatory program or policy. Note that the CV method has not yet been used to estimate regulatory costs in part because that this approach is feasible only when the decisions at issue (here, transportation choices) are made by individuals who participate in the survey. Most environmental regulations apply to firms, not individuals, and as a result, most analyses of the costs of environmental regulation focus on firms. CV and other stated preference survey methods have been used to investigate the potential effects of future policy changes—in particular, changes in transportation policy. For example, Li and Hensher (2012) review studies that have used CV and other stated preference methods to value the benefit of reduced crowding in transportation. However, these studies do not estimate private costs of an actual policy change.

We focus on Mexico City's well-known Day Without Driving (*Hoy No Circula*, HNC) program, which aims to reduce vehicular air pollution and traffic congestion by prohibiting drivers from using their vehicles one day a week based on the last digit of the license plate. The program affects roughly 5 million drivers. We examine both the magnitude and the incidence of the costs that HNC imposes on drivers.

Our study purports to make two contributions. First, as discussed above, it is among the first to use the CV method to estimate regulatory costs. This approach has the potential to help fill a gap in our understanding of environmental regulations targeting households and individuals.

Second, our study can inform transportation policy. Driving restrictions programs like HNC have been implemented in at least a dozen megacities worldwide, including Beijing, Bogotá, Quito, Medellín, San José, São Paulo, and Santiago. Tens of millions of people are now subject to such regulations. Recently, rigorous quasi-experimental evaluations of the benefits of some of these programs have appeared (Bonilla 2013; Carillo et al. in press; Davis 2008; Gallego et al. 2013a; Lanlan et al. 2013; Lin et al. 2013; Viard and Fu 2015). Most find that driving restrictions have negligible, perverse, or very mixed effects because drivers adopt a variety of strategies to circumvent restrictions, including purchasing additional cars that are old and highly polluting. Rigorous evidence on the cost of these program and the incidence of these costs could help build political will for reform, particularly if it verified that—as intuition suggests for Mexico—costs are significant and that the drivers who shoulder the greatest burden are from socioeconomic strata that can least afford adaptive measures like purchasing additional vehicles and using taxis.

The remainder of the paper is organized as follows. The second section presents background on HNC and briefly reviews studies of its benefits and costs. The third section presents our analytical framework. The fourth section describes our CV instrument. The fifth section presents our results and the sixth section discusses them. And the last section considers the implications of our study for research and transportation policy.

2. Day Without Driving Program

2.1. Rules and Implementation

HNC prohibits nonexempt vehicles from driving anywhere in the Federal District and 19 neighboring counties (*municipios*) of Mexico State from 5 a.m. to 10 p.m. one weekday per week and one Saturday per month, depending on the last digit of their license plate (Table 1; Figure 1).[1] Exemptions are granted to public service vehicles such as ambulances and school buses and to two types of private vehicles on the grounds that they generate relatively little pollution: certain cars and trucks that are relatively new and clean—specifically, most makes and models built within the last two to six years—and all cars and trucks up to eight years old that are able to pass emissions tests.

Table 1. Hoy No Circula restricted days

Final digit of license plate	Restricted weekday	Restricted Saturday
5, 6	Monday	1st
7, 8	Tuesday	2nd
3, 4	Wednesday	3rd
1, 2	Thursday	4th
9, 0*	Friday	1st

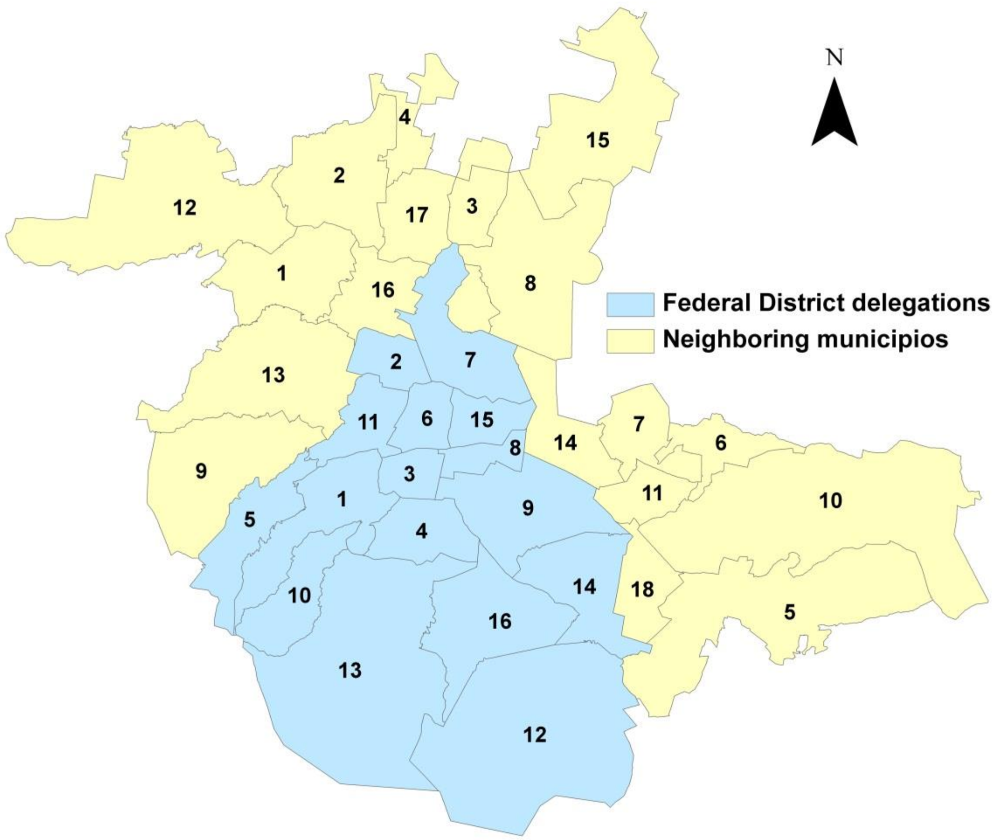
*Also includes temporary plates and vanity plates

All vehicles are required to display a state-issued hologram sticker—typically referred to as a hologram— indicating whether they are exempt. Those that are not exempt display a 2-hologram. Those that are exempt only because they are relatively new display a 00-hologram and those up to eight years old that have passed emissions tests display a 0-hologram.

HNC grew out of a program established in 1984 that aimed to cut pollution and traffic congestion by inviting drivers to voluntarily refrain from using their vehicles one weekday per week. In late 1989, Federal District authorities converted this voluntary program into a mandatory one. Since then, major modifications have included rescinding exemptions for taxis and minibuses (1991), restricting additional vehicles on days with high ozone concentrations (1996), granting exemptions to relatively new and clean vehicles (1996), making the criteria for exemptions more stringent (2004 and 2008), extending the program to Saturdays as well as weekdays (2008), including vehicles registered in other states (2008), and tightening restrictions on vehicles more than 15 years old (2014) (Duran and Sosa 2014; GDF-SMA 2010).

[1] The HNC program rules were changes slightly in August 2014. This section describes the rules in place in 2013, when our survey was administered. The main change since then was to bar vehicles more than 15 years old from driving every Saturday, instead of just one Saturday per month.

Figure 1. Hoy No Circula program geographic extent*



*The 19th neighboring municipio (Texcoco) is not shown in the map

By all accounts, enforcement of HNC restrictions is strict and rates of compliance are high (Davis 2008; Eskeland and Feyziouglu 1997; Gallego et al. 2013a). Monitoring compliance is relatively easy and sanctions are significant: violators are fined roughly US $200 and can have their vehicle impounded for two days. Although bribing policemen to avoid sanctions is possible sometimes, it generally is not an attractive option since the bribe is commensurate with the fine and violators can be fined more than once on the same day (Davis 2008).

2.2. Evaluations

Several analyses of HNC have been published in academic journals: Eskeland and Feyzioуglu (1997), Davis (2008), and Gallego et al. (2013a, 2013b). All focus on econometric estimates of the program's environmental causal effects in the years just after it was put in place, and all find that benefits were limited. Eskeland and Feyzioglu (1997) conclude that HNC spurred increased gasoline use mostly likely because households bought additional vehicles to circumvent the new restrictions. As for costs, they write, "There is thus ample evidence that the ban imposed high compliance costs for households, much higher than those of alternative market-based polices such as gasoline taxes" (400). Using a richer set of outcome and control variables, Davis (2008) finds that HNC did not reduce air pollution or gasoline sales and actually had perverse effects on bus ridership (which decreased), vehicle sales (which increased), and the composition of the vehicle fleet (which accumulated more older vehicles). Davis also presents a back-of-the-envelope estimate of the program's costs based on an averting expenditures approach. Focusing solely on the increase in vehicle sales spurred by the HNC program, he finds that it cost US $342 million per year during the first four years the program was established. He characterizes this figure as an underestimate because it ignores costs borne by people who do not buy vehicles. He concludes,

> Thus, overall the evidence indicates that the social costs of HNC are large, likely in excess of … $130 per vehicle [affected by HNC] annually … [Hence], the HNC is a program that substantially altered transportation choices for millions of individuals yet yielded no apparent improvement in air quality, making it difficult to justify on the basis of cost-effectiveness. (78–79)

Using a similar approach, Gallego et al. (2013a) confirm Davis's overall conclusions regarding long-run environmental benefits but also find that just after the program was implemented—before households had a chance to fully adapt—it spurred a significant reduction in air pollution. In a complementary paper, Gallego et al. (2013b) use a numerical simulation model with few observables to estimate the effect of the program on the magnitude and incidence of the social costs of the HNC program. They find short-run total costs of US $132 million per year. Furthermore, they find that these costs were higher for middle-income households than for low- and high-income households. The reason, they hypothesize, is that only a relatively small proportion of low-income households owned vehicles and therefore were less affected by the HNC, while high-income households already had sufficient vehicle capacity to adapt to the program.

In addition to these journal articles, unpublished nonacademic analyses of the HNC program have appeared (Clean Air Institute 2007; Encuesta Estatal 1990; GDF-SMA 2004, 2010; González and Ángel 2008).[2] Most are assessments by various Mexican government agencies aimed at informing decisions to extend or modify the program.

3. Analytical Framework

We use a CV survey to estimate the annual costs that the driving restrictions program imposes on households over a five-year window starting in 2013, the year our survey was administered. Before discussing the analytical framework that underpins this approach, it is helpful to consider the ways driving restrictions can affect household behavior and welfare. There are three possible effects. First, driving restrictions can change a household's transportation choices (travel behavior and vehicle ownership) by limiting its choice set. For example, driving restrictions can prevent a household from driving a car every day, causing it to reduce or reschedule driving, increase travel by other modes with different associated travel times, sell its car, or keep it and buy a second car. Second, driving restrictions can change a household's travel time indirectly by changing the total number of vehicles on the road on any given day. For example, if driving restrictions succeed in reducing congestion, they can reduce a household's overall commute time. Both the first and the second effects of driving restrictions have to do with what in transport economics is referred to as the "generalized travel cost," which comprises the opportunity costs of time devoted to travel, the direct pecuniary costs of travel, and nonpecuniary costs from, for example, discomfort (Bruzelius 1981). Third, driving restrictions can change environmental quality, and thus household welfare. For example, if

[2] Encuesta Estatal (1990) presents results from a 1989 survey that asked households their opinion about a voluntary pilot driving restrictions program that preceded the mandatory HNC program. Although more than 90 percent of respondents approved of the voluntary program, only half favored making it mandatory. GDF-SMA (2004) reviews the performance of HNC and speculates about the likely consequences of proposed modifications limiting exemptions to vehicles less than nine years old. Clean Air Institute (2007) analyzes the likely effects of extending weekday driving restrictions to Saturdays and concludes that an extension would probably generate significant environmental benefits. It does not consider the costs of the modification except to say that the overall effect will be progressive because vehicle ownership in Mexico City is concentrated in the wealthiest segments of the population. González and Ángel (2008) argue that the intent of HNC has changed, from limiting the number of vehicles on the road to encouraging vehicle turnover and the use of cleaner vehicles. This evolution has been accomplished by exempting newer and cleaner vehicles from the program. Finally, GDF-SMA (2010) favorably reviews the first 18 months of the Sabatino program that in 2008 extended weekday driving restrictions to Saturdays.

driving restrictions succeed in reducing vehicular emissions and improving air quality, they can directly benefit a household.

We are interested in measuring the household cost that arises from the first effect—that of limiting households' transportation choice set. The second and third effects are potential benefits of such regulation. Hence, our aim is to use the CV method to isolate and estimate the first effect, holding the other two effects constant. We illustrate this point with the following simple specification of household *i*'s indirect utility function:

$$\mathrm{v} = \mathrm{v}(\mathrm{GC}\,[\mathrm{q}_{i}, \mathrm{T}(\mathrm{Q}_{\mathrm{i}})], \mathrm{E}[\mathrm{T}(\mathrm{Q}_{\mathrm{i}})], \mathrm{M}) \tag{1}$$

where *v* is indirect household utility, *GC* is the generalized travel cost, *T* is the traffic volume, *E* is environmental quality, *M* is income, q_i is an indicator variable equal to q_1 if driving restrictions apply to the household and q_0 if they do not, and Q_i is an indicator variable equal to Q_1 if driving restrictions apply to all other households and Q_0 if they do not. Hence, *GC* depends directly on driving restrictions and indirectly on driving restrictions through their effect on the traffic volume, whereas *E* depends indirectly on driving restrictions through their effect on traffic volume. We aim to estimate the cost of driving restrictions on household *i* by comparing (i) its indirect utility given driving restrictions that are in force and are applied to the household,

$$\mathrm{v} = \mathrm{v}(\mathrm{GC}\,[\mathrm{q}_{1}, \mathrm{T}(\mathrm{Q}_{1})], \mathrm{E}[\mathrm{T}(\mathrm{Q}_{1})], \mathrm{M}) \tag{2}$$

and (ii) its indirect utility given driving restrictions that are in force but are not applied to the household,

$$\mathrm{v} = \mathrm{v}(\mathrm{GC}\,[\mathrm{q}_{0}, \mathrm{T}(\mathrm{Q}_{1})], \mathrm{E}[\mathrm{T}(\mathrm{Q}_{1})], \mathrm{M}). \tag{3}$$

Obviously the second case is not directly observable, since all households are subject to driving restrictions. That, in a nutshell, is the reason we are relying on a survey method in which households are asked to state how they would respond to a scenario presented in the survey. This scenario (detailed in the next section) enables a household to pay to avoid the direct negative effect of a driving restrictions program (the direct effect that q_1 has on *GC*) without obtaining any potential benefits from reduced traffic volume or improved environmental quality (the indirect effects that q_1 has on *GC* through *T* and on *E* through *T*).

Following the literature, we will rely on a random utility framework (McFadden 1974) and discrete choice econometrics to estimate WTP. In our CV survey the scenario would thus be that a household could pay to avoid the direct negative effects of a driving restrictions program, without any effects on the traffic volume or the environment. A household's WTP is then implicitly given by

$$\mathrm{v}(\mathrm{GC}\,[\mathrm{q}_1, \mathrm{T}(\mathrm{Q}_1)], \mathrm{E}[\mathrm{T}(\mathrm{Q}_1)], \mathrm{M}) + \varepsilon_1 = \mathrm{v}(\mathrm{GC}\,[\mathrm{q}_0, \mathrm{T}(\mathrm{Q}_1)], \mathrm{E}[\mathrm{T}(\mathrm{Q}_1)], \mathrm{M} - \mathrm{WTP}) + \varepsilon_0 \quad (4)$$

where ε is random elements of the utility function that are not observable to the investigator. These unobservable elements could be individual characteristics, measurement error, and/or the heterogeneity of household preferences. The parameters of the indirect utility function can be estimated given assumptions about the form of the utility function and the distribution of the error terms coupled with the fact that the bid (cost of the program) varies randomly among the respondents (Haab and McConnell 2002).

This empirical approach is well known and thus we present only a brief sketch here. In the CV survey we use a closed-ended single-bounded format.[3] Suppose a survey respondent who is subject to driving restrictions is asked whether she would be willing to pay *t* dollars to be able to drive her car whenever she wants. The probability that she replies affirmatively is given by

$$\mathrm{P[yes]} = \mathrm{P}[(\mathrm{GC}\,[\mathrm{q}_0, \mathrm{T}(\mathrm{Q}_1)], \mathrm{E}[\mathrm{T}(\mathrm{Q}_1)], \mathrm{M} - \mathrm{t}) - \mathrm{v}(\mathrm{GC}\,[\mathrm{q}_1, \mathrm{T}(\mathrm{Q}_1)], \mathrm{E}[\mathrm{T}(\mathrm{Q}_1)], \mathrm{M}) + \varepsilon_0 - \varepsilon_1 > 0] \quad (5)$$

The WTP implicitly defined above can then be calculated from the estimated parameters of the utility function.

As noted above, our approach estimates the annual costs that HNC imposes on households over a five-year window starting in 2013. As a result, it does not capture any costs incurred before 2013, including those related to adaptation measures that subsequently reduced

[3] In general, a closed-ended format is preferred mainly because of its incentive compatibility properties (Carson and Groves 2007).

costs—for example, purchasing an additional vehicle to drive on restricted days, and moving closer to public transportation. In other words, our approach captures costs *conditional* on households' past adaptation investments.

4. Contingent Valuation Survey

4.1. Design

To design our CV survey instrument, we conducted six focus groups with six sets of Federal District drivers, administered a pilot survey, and consulted with key regulatory stakeholders, including representatives of the Mexico State Environmental Secretariat (Secretaría del Medio Ambiente), which oversees HNC.

The final version of the CV survey has an introduction and five sections. Part 1 asks questions about the vehicles and drivers in the household, the respondent's access to public transportation, and their current travel behavior. The objectives are to remind respondents about factors affecting their WTP for an HNC exemption and to collect data needed for the econometric analysis (Section 5). Part 2 of the survey briefly lists the main features of HNC.

Part 3 describes the scenario that underpins the CV question—a new regulatory program that gives drivers the opportunity to purchase an exemption from HNC restrictions called a B-hologram. As discussed above, the authorities already offer type 0, type 00, and other exemptions for various reasons. Therefore, we expected a new exemption to be plausible.

The description of the B-hologram program in Part 3 of the survey reads as follows. The text in brackets is added here for clarity but was not included in the survey.

> Authorities are analyzing the possibility of withdrawing one hundred thousand type 0-holograms [which identify exempt vehicles] from highly polluting vehicles and replacing them with type 2-holograms [which identify nonexempt vehicles]. To make this policy more attractive, authorities will issue fifty thousand new permits that will allow people to drive on all days regardless of the year, make or model of the vehicle. These permits will be called B-holograms.
>
> To distribute these holograms, authorities will invite drivers of vehicles randomly selected from the entire population of Mexico City and from its Metropolitan Area. These people may acquire one B-hologram for their vehicle.
>
> Card 2 [which the enumerator has handed to each respondent] shows the characteristics of the B-hologram.

- Each B-hologram will exempt one vehicle from HNC for five years. It cannot be used on taxis or on public transportation.
- The B-hologram is not transferable to other vehicles or with the sale of the vehicle.
- The buyer agrees to pay an annual fee for the B sticker together with the payment for the annual license plate registration fee, and if they do not, they will lose the hologram and their vehicle will not be able to circulate on any day of the week for the remaining period of the validity of the B-hologram.
- The B-hologram will not change the number of smog checks or their stringency. They will remain the same as they are now.
- The B-hologram program will not increase air pollution or traffic, because it removes two polluting vehicles for each one that is authorized.

The B-hologram program in our survey was designed to be plausible and to ensure that responses to the CV question reflected the actual costs respondents incurred as a result of HNC restrictions and not other factors. To provide a rationale for the program, we cast it as a means of compensating Federal District metropolitan area drivers for the cancelation of 100,000 type 0-hologram exemptions held by highly polluting vehicles. The implication was that the B-hologram program was a political quid pro quo. Participants in focus groups and the pilot survey confirmed that this explanation was, in fact, plausible.

We limited the scope of the B-hologram policy to 50,000 vehicles so that the net effect on air pollution and traffic congestion (in a city with more than 4 million vehicles) would be negligible. Our broad aim was to ensure that the WTP did not reflect any environmental effects of the B-hologram program.

Furthermore, we specified that the program would have a net effect of rescinding rather than granting exemptions (100,000 type 0-holograms rescinded and 50,000 type B-holograms issued) to reinforce the point that the program would not exacerbate air pollution or traffic congestion. In focus groups, participating drivers repeatedly expressed strong reservations about paying for an exemption that generated such effects.

The choice of five years as the duration of the B-hologram was a compromise. On one hand, focus group discussions suggested that a longer duration would make it difficult for respondents to calculate and discount private benefits. On the other hand, a shorter duration would limit the ability of our CV question to capture the cost HNC imposes on drivers by pushing some to "prematurely" replace eight-year-old vehicles bearing type 0-holograms with newer vehicles to obtain a new type 00 or type 0 exemption.[4]

We limited eligibility for the B-hologram program to noncommercial vehicles because we expected the costs of HNC to be far greater to drivers of commercial vehicles than to noncommercial vehicle drivers. Reliably estimating commercial drivers' costs would require identifying and surveying a sufficiently large sample of such drivers.

We specifically prohibited transferring B-holograms so that respondents' WTP would not reflect potential profits from selling the exemption. Existing 0- and 00-holograms also are not transferable.

We required drivers to make five annual payments for the B-hologram, rather than a one-time payment, to relax liquidity constraints, an issue raised in focus groups. We required drivers to make these payments along with their annual vehicle registration fee to reduce transaction costs. The marginal transaction costs for the B-hologram payment are negligible. This provision was also meant to ameliorate concerns about corruption in a newly established exemption program, another issue raised in focus groups. We imposed a severe penalty for not making all five annual payments—inability to drive any day of the week—so that all respondents would be thinking about "buying" the same good, a five-year exemption from HNC restrictions.

We included language about smog checks to ensure that respondents would not factor the cost of such checks into their responses to CV question. Under existing HNC rules, drivers of all vehicles except those with type 00-holograms must pass smog checks. We wanted to emphasize that a B-hologram would not affect this requirement. Finally, we included language about the environmental effects of a B-hologram to drive home the point that they would be negligible.

Part 4 of the survey asks respondents whether and exactly how a B-hologram would change their travel behavior. The purpose was to twofold: to encourage respondents to carefully consider how they would benefit from a B-hologram—or equivalently, the cost the program imposes on them—and to generate data useful in interpreting and validating answers to the CV question.

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[4] A B-hologram that is valid for *n* years capture this effect for *n* vehicle vintages. For example, a B-hologram valid for one year enables drivers of eight-year-old vehicles to forgo the cost of prematurely replacing their vehicles for one year, a B-hologram valid for two years enable drivers of both seven- and eight-year-old vehicles to forgo that cost, and so forth. A B-hologram valid for five years enables the drivers of vehicles of five different vintages to forgo this cost.

Part 5 of the survey presents the actual CV question. The question was preceded by a reminder about the characteristics of the B-hologram, its potential cost savings, and a "cheap talk" script (Cummings and Taylor 1999). The entire question reads,

> If you were randomly chosen to participate in the B-hologram program, we want to know the total amount you would pay to obtain a B-hologram for your vehicle. Remember that the B-hologram allows you to avoid restrictions on circulating for five years, for which you must commit to pay an annual fee during those five years. The annual fee is paid together with the payment for the license plate registration fee.
>
> Before you answer, please consider that the Hoy No Circula program can:
>
> - affect the mode of transport that you use to go to work and school, to do errands and other activities;
> - affect the days you choose to travel; and
> - affect the buying and selling of vehicles
>
> Remember that the B-hologram will not change your inspections. Card 2 contains a summary of the characteristics of the program.
>
> Before responding, please also consider that if you spend this money paying for a B-hologram, you are not going to be able to spend money on other things. In other studies, we have seen that people sometimes respond to survey questions with very high amounts because they have not carefully considered the other things they could buy with the money. Others give very small amounts because they do not think about all benefits. It is important to us that you answer the following questions as carefully and accurately as possible.
>
> Now, if the cost of buying a B-hologram for your vehicle were [randomly selected bid] pesos per year total, would you be willing to pay this amount?

The cheap talk script discusses both positive and negative hypothetical bias. The main reason is that with our type of good—a regulatory exemption—the direction of a hypothetical bias is not clear. In most applications of the CV method, a positive bias is expected because of warm-glow/purchase of moral satisfaction associated with a public good that has altruistic value (Andreoni1990; Kahneman and Knetsch 1992). However, a regulatory exemption is not such a good, and as a result, hypothetical bias may be lower (Murphy et al. 2005). In addition, a cheap talk script that is either neutral or (like ours) discusses both negative and positive hypothetical bias is less susceptible to a demand effect (Aadland and Caplan 2006; Carlsson et al. 2011).

The bid vector is discussed below. Finally, Part 6 of the survey asks questions about the socioeconomic characteristics of drivers and their households.

4.2. Administration

Using enumerators trained by the authors, Levanta SC, a professional survey research firm, administered the survey face-to-face to a random sample of 2,500 drivers inside the area affected by HNC (Figure 1). Levanta administered the survey in three phases: (i) August 23–25, 2013 (n = 250); (ii) August 30–September 8 (n = 1,000); and (iii) September 22–29 (n = 1,250).

We used 2010 census data (INEGI 2010) along with a three-stage cluster strategy to select a random sample of drivers in the Federal District metropolitan area affected by HNC (Figure 1). In the first stage, we selected a random sample of 250 census tracts (*Áreas Geográfico Estadísticas Básicas*, AGEBs) from the metropolitan area (including Federal District delegations and 19 adjacent Mexico state municipios), each of which was expected to generate 10 completed surveys. To improve the chances that selected AGEBs could meet this quota, we sampled only from AGEBs with more than 5 blocks (a subdivision of AGEBs) containing at least 10 households that owned vehicles. In the second stage, we randomly selected 2 blocks within each AGEB. To improve the chances of securing a sufficient number of completed surveys from these blocks, we sampled only from blocks with at least 10 households that owned vehicles. Finally, in the third stage, we randomly selected five households in each block. In cases where originally selected households (blocks) were not, for whatever reason, able to complete a survey, we selected contiguous households (blocks). and in cases where an originally selected AGEB did not generate sufficient data, we randomly selected a replacement AGEB.

In each household in our sample, we administered surveys to drivers who were financially responsible (i.e., they paid for gasoline and maintenance) for a car, truck, or van that was not a government or for-hire vehicle. In cases where selected households owned more than one vehicle, and where the drivers of each were available to respond to the survey, we randomly selected one driver. Each driver in our sample was asked whether he or she would be willing to pay a randomly assigned amount (bid) for a B-hologram.

The bid vector was based on both results from the pilot study, which used an open-ended question format, and on results from the first two phases of the survey. The bid vector used for the first phase was 100, 400, 600, 1,000, or 1,700 pesos. Based on the distribution of responses to the highest bid levels, we increased the highest bid to 2,000 pesos for the second phase of the survey, and to 2,700 pesos for the final phase.

5. Results

5.1. Descriptive Statistics

5.1.1. Sample

From our initial sample of 2,500 completed surveys, we dropped 338 (14 percent) that were missing data for the variables used in our regression analysis, leaving 2,145.

5.1.2. Household, Driver, and Vehicle Characteristics

Table 2 defines the variables used in our regression analysis and presents descriptive statistics. Although the definitions of most variables are straightforward, a brief explanation of three may be helpful. *Socioeconomic level* is a statistic widely used in Mexican market and public opinion research (López Romo 2011). It is a weighted index of responses to eight standard questions about the household, all of which were included in our survey—specifically, about the number of rooms, bathrooms, light bulbs, vehicles, showers, and gas stoves in the household, the type of flooring, and the highest level of schooling of the household head. *7–8 years old* is a binary dummy variable that identifies drivers of vehicles that are seven or eight years old. Such vehicles are generally about to lose a 0-hologram exempting them from HNC restrictions, which are issued only to vehicles less than nine years old. Hence, the drivers of these vehicles would need to replace their vehicles in the next two years to continue to enjoy their exemptions.

Finally, *HNC cost* is an estimate of the total annual cost of HNC restrictions to each survey respondent based on his or her answers to questions about the pecuniary and time costs related to work or school travel, and the pecuniary and time costs related to nonwork or nonschool travel. We used interviewees' reported monthly income to monetize time costs (along with an assumption that all respondents worked nine hours per day, five days per week, and 48 weeks per year).

Turning to the descriptive statistics in Table 2, we see among other things that the average size of the household was 4.0 members, with 1.6 licensed drivers. The average number of vehicles was 1.1, and on average, respondents' vehicles were 11.3 years old. Ten percent of the vehicles were seven or eight years old, 74 percent were mainly used to commute to work or school, and 68 percent were purchased used. Fifty-seven percent of these households had at least one vehicle subject to HNC restrictions. As for driver characteristics, 81 percent of our respondents were male, 77 percent were married, and 58 percent had at least a high school education. On average, respondents stated that HNC restrictions cost them 7,119 pesos (US $552) per year.

Table 2. Household, driver, vehicle characteristics (n = 2,145)

Characteristic	Description	Mean	s.d.
Household			
Members	Number of members	4.03	2.08
Licensed drivers	Number of licensed drivers	1.63	0.90
Vehicles	Number of vehicles	1.14	0.44
2-hologram	0/1 = 1 if owns car with 2-hologram	0.57	0.50
High socioeconomic level	0/1 = 1 if socioeconomic level is 6 or 7*	0.21	0.41
Medium socioeconomic level	0/1 = 1 if socioeconomic level is 4 or 5*	0.67	0.47
Federal District	0/1 = 1 if in Federal District	0.54	0.50
Driver			
Male	0/1 = 1 if male	0.81	0.39
Married	0/1 = 1 if married	0.77	0.42
High school	0/1 = 1 if high school or more education	0.58	0.49
HNC cost	Stated annual cost of HNC (1000 pesos)*	7.11	20.19
Vehicle			
Age	Age of vehicle (years)	11.27	8.65
7–8 years old	0/1 = 1 if 7–8 years old*	0.10	0.30
Main use work or school	0/1 = 1 if main use is work or school	0.75	0.44
Bought used	0/1 = 1 if purchased used	0.68	0.47

*See Section 5.1.2 for additional explanation.

5.1.3. Expected Effects of a B-hologram

Part 4 of the survey asked respondents whether and how a B-hologram would change their travel behavior. The responses shed light on the benefits of an exemption from HNC, or equivalently, on the costs of the program. In general, these responses indicate that for most drivers, a B-hologram would cause them to make significant changes in their travel behavior and would have significant benefits.

We asked separate questions about travel for work/school and for nonwork/school. To streamline the survey, we asked questions about work/school travel of only the respondents likely to have the highest costs, specifically, the 798 respondents using vehicles without an HNC exemption to commute to work or school. Two-thirds of these drivers said that an exemption from HNC would cause them to change the mode of transportation they used for work/school travel at least one day a week, and 63 percent said it would change their choice of which days to commute at least one day per week (Table 3). Fifty-three percent said it would reduce their pecuniary expenditures—by an average of 218 pesos (US $17) per week—and 68 percent said it would reduce the time they spent commuting—by an average of 169 minutes per week. Finally, 73 percent said it would enable them to avoid inconvenience associated with public transportation.

Table 3. Effect of B-hologram on work and school commuting*

B-hologram would …	n	Value
Change mode of transport used to commute (%)	798	66.8
Change choice of which days to commute (%)	798	62.5
Change which vehicle driven on restricted day if >1 car (%)	798	7.9
Change travel in some other way (%)	798	11.5
Save you money on trips to work and school? (%)	798	52.6
How much money per week? (pesos)	420	217.5
Save you time on trips to work and school? (%)	798	67.9
How much time per week? (minutes)	542	168.7
Eliminate inconveniences associated with public transport? (%)	798	72.6

*Sample limited to 798 drivers likely to incur highest costs from HNC restrictions—those using vehicles without HNC exemption to commute to work or school.

We asked questions about nonwork/school travel of all 1,212 respondents driving a vehicle without an HNC exemption regardless of whether they used it to commute to work. Fifty-two percent reported that an exemption from HNC would cause them to change the mode of transportation they used for nonwork/school travel at least one day a week, and 58 percent said it would change their choice of which days to engage in such travel one day per week (Table 4). Thirty-eight percent said that it would reduce their pecuniary expenditures—by an average of 232 pesos (US $18) per week—and 52 percent said it would reduce the time they spent on such travel—by an average of 171 minutes per week. Finally, respondents reported it would cause them to take two additional nonwork trips per week.

Table 4. Effect of B-hologram on nonwork/school travel

B-hologram would …	n	Value
Change mode of transport to for nonwork/school travel (%)	1,212	52.2
Change choice of which days to do nonwork/school travel (%)	1,212	57.8
Change nonwork/school travel in some other way (%)	1,212	12.2
Cause you to take this many more nonwork trips per week	1,212	2.0
Save you money on nonwork/school travel? (%)	1,212	37.6
How much money per week? (pesos)	456	235.5
Save you time on nonwork/school travel? (%)	1,212	52.2
How much time per week? (minutes)	632	170.5

*Sample limited to 1,212 drivers using vehicle without HNC exemption.

5.1.4. Contingent Valuation Question

The percentage of yes-responses to our CV question is decreasing in the bid with the exception of the extreme right tail of the distribution (Table 5 and Figure 2). Even though, as noted above, we increased the highest bid for the third phase of the survey (from 2,000 pesos to 2,700 pesos), the share of yes-responses remained approximately one-fifth. It is difficult to determine whether this anomaly reflects actual preferences or hypothetical bias expressed as yea-saying (Blamey et al. 1999). On one hand, a subset of the respondents could face a substantially higher cost than the rest of the population, and we had included a cheap-talk script in the survey to discourage yea-saying. But on the other hand, respondents can overstate their willingness to pay in any stated preference survey. We think it is important to alert readers to this possibility. As discussed below, to address this concern, we provide conservative estimates of HNC's cost.

Table 5. Responses to bids; number of respondents (row percentage); n = 2145

Bid	No	Yes	Total
100	80	351	431
	(19)	(81)	(100)
400	131	287	418
	(31)	(69)	(100)
600	187	231	418
	(45)	(55)	(100)
1000	265	180	445
	(60)	(40)	(100)
1700	28	12	40
	(70)	(30)	(100)
2000	134	33	167
	(80)	(20)	(100)
2700	179	47	226
	(79)	(21)	(100)
Total	1004	1141	2145
	(47)	(53)	(100)

Among the 1,004 respondents who said no to their bid, only 13 percent reported in a follow-up question that they thought the CV question was unrealistic (Table 6). Others gave the reasons one would expect, including owning a new vehicle with an exemption (29 percent), inability to pay (39 percent), and a belief that the benefits were lower than the costs (38 percent). Of the 1,004 respondents who said no to their bid, 267 (27 percent) reported in a follow-up question that they would be willing to pay something for a B-hologram, on average 414 pesos (US $32).

Figure 2. Percentage yes-responses by bid (n = 2,145)

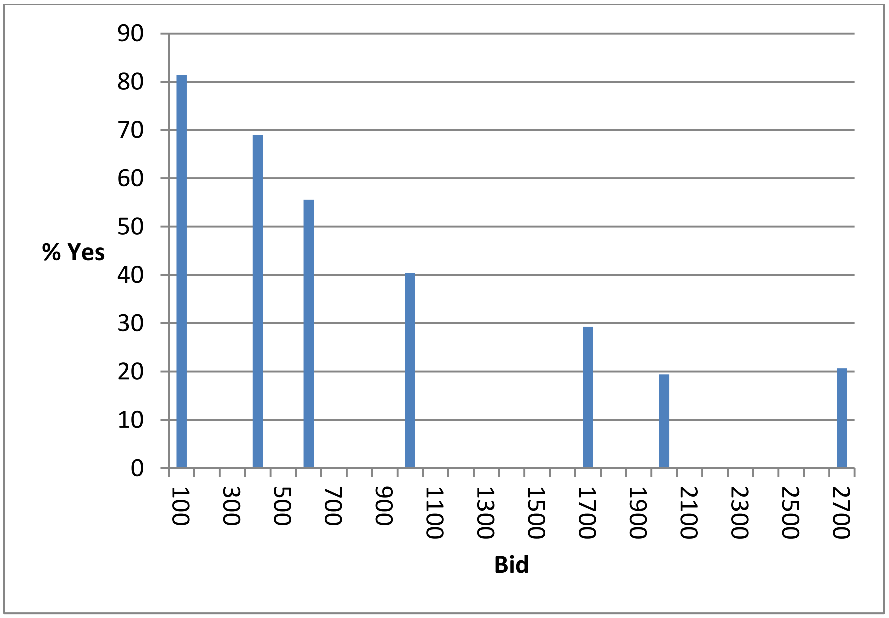

Table 6. Interviewees' reasons for no responses to their bids (n=1,032)*

Reason	Percentage yes
Have new vehicle	29.2
Not able to pay	38.9
B-hologram is not worth bid	37.5
B-hologram boosts pollution	26.2
Not confident in government administration of program	34.5
Not realistic question	1.2

*Respondents could select more than one reason.

5.2. Willingness to Pay

We use responses to the closed-ended CV question to estimate average WTP for an exemption from HNC restrictions. To begin, we estimate models in which the only independent variable is the CV bid. We estimate two such models.[5] The first, which generates unconditional

[5] As noted above, the regression samples we use exclude observations that are missing data for the variables used in any of our econometric models (n = 2,145). WTP estimates are similar if we instead use all observations that include responses to the CV question (n = 2,485). Results available upon request from the authors.

WTP, includes the entire sample of 2,145 respondents. The second model, which generates conditional WTP, includes only those 1,408 respondents with a positive WTP. This subsample comprised the 1,141 respondents who said yes to their bid and the 267 respondents who said no but nonetheless had a positive WTP. These 267 respondents were identified by means of a follow-up question (respondents who said no to their bid were asked whether they would be willing to pay any positive amount for a B-hologram). We estimate both unconditional and conditional WTP using a probit model (Table 7). In the unconditional model, the bid is the only explanatory variable. In the conditional model, the logarithm of the bid is the only explanatory variable: this specification restricts WTP to be positive (Haab and McConnell 2002).[6]

Table 7. Mean and median willingness to pay (WTP): probit model results; dependent variable = 1 if response to contingent valuation question was yes, and 0 otherwise (s.e.)

Variable	Unconditional WTP[a]	Conditional WTP[b]
Intercept (α)	0.686***	0.561***
	(0.043)	(0.045)
Bid/1000 (β_1)	-0.690***	
	(0.039)	
Ln (Bid/1000) (β_2)		-0.796***
		(0.055)
Mean WTP	993***	4448***
	(42)	(798)
Median WTP	993***	2022***
	(42)	(167)
Nobs	2145	1408

*** p<1%
[a]Sample includes all respondents.
[b]Sample includes only respondents with WTP > 0.

In both models, the coefficient of the bid variable is, as expected, negative and highly significant. Thus, the probability of a yes-response decreases as the level of the bid increases. In the unconditional model, which includes all survey respondents, estimated mean and median

[6] For the unconditional model, estimated mean and median WTP is simply the ratio between the coefficients of the intercept and the bid. For the conditional model, median WTP is estimated as $\exp(\frac{\alpha}{\beta_2})$ and mean WTP as $\exp(\frac{\alpha}{\beta_2})\exp(\frac{1}{2*(\beta_2)^2})$, where α is the intercept and β_2 is the coefficient of the log-bid variable.

WTP is 993 pesos (US $77) per year. Thus, the unconditional model implies that on average, a driver in our sample is willing to pay roughly 1,000 pesos per year for an HNC exemption.

However, a sizable share of the respondents (34 percent) had a zero WTP. In the conditional model, which included only respondents with a positive WTP, mean WTP was 4,448 pesos (US $345) per year and median WTP was 2,022 pesos (US $157) per year. We estimate unconditional WTP from the conditional model by multiplying conditional WTP by the fraction of respondents with a positive WTP (66 percent). This generates a mean WTP of 2,920 pesos (US $226) per year, and a median WTP of 1,327 pesos (US $103).

Note that mean WTP in the conditional model is substantially larger than median WTP, a common phenomenon in a log-bid model. In our case, this feature results from the fat right tale of the WTP distribution, which in turn reflects the fact that roughly half of respondents with a positive WTP said yes to the highest bid (in the full sample, the share was around a quarter). As noted above, this response pattern could reflect either actual preferences or yea-saying. To control for such bias, in calculating total WTP we rely on median unconditional WTP as well as mean unconditional WTP, since the median is less sensitive to skewed distributions. The median generates a more conservative WTP estimate.

To calculate total annual WTP for all drivers in the Federal District metropolitan area (Figure 1), we multiply estimated median or mean unconditional annual WTP (993 or 1,327 pesos) by 4.732 million, the number of vehicles in the metropolitan area for 2013, the year in which our survey was administered (INECC 2014). The result is a total cost of 4.7 billion to 6.3 billion pesos (US $367 million to $490 million) per year.

5.3. Determinants of Willingness to Pay

To identify driver and household characteristics that are correlated with WTP, we estimate a two-equation model. In first equation, the dependent variable is a binary dummy variable equal to one if the respondent had a positive WTP, and independent variables are household, driver, and vehicle characteristics. We use all 2,145 respondents in our sample. The aim is to identify characteristics associated with a positive WTP. In the second equation, the dependent variable is a binary dummy variable equal to one if the respondent said yes to the bid, and independent variables are the natural log of the bid along with household, driver, and vehicle characteristics. We use only the 1,408 respondents with a positive WTP. Again we use the natural log of the bid to restrict WTP to be positive (Haab and McConnell 2002). The aim of this second equation is to identify characteristics correlated with WTP. Note that WTP observations equal to zero are actual zeros and not due to selection, which implies we have a corner solution model. As a result, this model can be estimated as either a selection model, in which the equations are estimated jointly, or a two-equation model, in which they are estimated independently. We present results from the latter. The main reason is that selection models are generally highly sensitive to the ability of the data to explain the probability of a positive WTP in the first equation (Carlsson and Johansson-Stenman 1999; Leung and Yu 1996). Both the first and the second equations are estimated as binary probits. We employ two specifications of each equation: one that includes *HNC cost*, the stated cost of driving restrictions, as an explanatory variable (Model B), and one that does not (Model A). The reason is that the stated cost of driving restrictions could be correlated with other covariates.

The results from the first equation, which aims to explain the probability of a positive WTP, indicate that all other things equal, drivers are more likely to have a positive WTP if they live in households with more members, more licensed drivers, more vehicles, a vehicle with a 2-hologram (i.e., one that is restricted from driving one day a week), a vehicle that is seven or eight years old (and therefore about to lose an HNC exemption), and one mainly used for work or school (Table 8). The magnitude of the marginal effects indicates that having a vehicle with a 2-hologram or one that is seven or eight years old is particularly important in explaining positive WTP. In Equation 1B, *HNC cost* is statistically significant: a higher stated cost of the program increases the likelihood of a positive WTP. Compared with the marginal effects in Model 1A, there are some changes in the statistical significance and magnitude, which is to be expected, since *HNC cost* is likely affected by the same household, driver, and vehicle characteristics as the dependent variable (probability of a positive WTP).

In Equations 2A and 2B, which purport to explain WTP, the only independent variable that is statistically significant at the 5 percent level is *ln(bid)* (Table 9). Hence, we are not really able to explain the variation in stated WTP.

Table 8. Explaining positive willingness to pay (WTP); probit model results—marginal effect (s.e.); dependent variable = 1 if WTP positive, 0 otherwise

Variable	**Model**	
	1A	**1B**
Household characteristics		
Members	0.015***	
	(0.006)	0.015***
		(0.006)
Licensed drivers	0.049***	
	(0.014)	0.046***
		(0.014)
Vehicles	0.067**	0.068**
	(0.029)	(0.029)
2-hologram	0 .154***	
	(0.030)	0.078***
		(0.031)
High socioeconomic level	-0.071	-0.084
	(0.047)	(0.047)
Medium socioeconomic	-0.021	-0.026
level	(0.036)	(0.036)
Federal District	-0.041**	-0.036*
	(0.021)	(0.021)
Driver characteristics		
Male	-0.000	-0.006
	(0.027)	(0.027)
Married	-0.016	-0.010
	(0.025)	(0.025)
High school	0.008	0.006
	(0.025)	(0.025)
HNC cost		
		0.008***
		(0.001)
Vehicle characteristics		
Age	-0.002	-0.003*
	(0.002)	(0.002)
7–8 years old	0.110***	
	(0.0314)	0.108***
		(0.031)
Main use work or school	0.061***	0.025
	(0.025)	(0.025)
Bought used	-0.041	-0.035
	(0.025)	(0.025)
Nobs	2145	2145
Pseudo R2	0.036	0.061

*** p<1%, ** p<5%, * p<10%.

Table 9. Explaining willingness to pay (WTP); probit model results—marginal WTP and coefficient estimates (s.e.); dependent variable = 1 if response to contingent valuation question was yes, 0 otherwise

Variable	Model 2A	Model 2B
Household characteristics	*Marginal WTP*	
Members	98.4	94.7
	(124)	(119)
Licensed drivers	417	386
	(323)	(310)
Vehicles	702	673
	(551)	(534)
2-hologram	-1286*	-1529*
	(789)	(818)
High socioeconomic level	-521	-546
	(981)	(943)
Medium socioeconomic level	-852	-851
	(898)	(871)
Federal District	475	469
	(489)	(472)
Driver characteristics		
Male	-445	-454
	(677)	(656)
Married	-110	-62.5
	(586)	(563)
High school	-213	-232
	(565)	(546)
HNC cost		0.019
		(0.015)
Vehicle characteristics		
Age	41.9	35.8
	(41.9)	(40.5)
7–8 years old	-738	-731
	(680)	(653)
Main use work or school	366	230
	(539)	(532)
Bought used	-638	-568
	(636)	(610)
Other	*Coefficients*	
Ln(Bid)	-0.809***	-0.809***
	(0.056)	(0.056)
Constant	6.075***	6.106***
	(0.456)	(0.457)
Nobs	1408	1408
Pseudo R2	0.232	0.233

*** p<1%, ** p<5%, * p<10%.

6. Discussion

Using a CV survey, we estimate the WTP to avoid the costs of the HNC program to be 993 to 1,327 pesos (US $77 to $103) per vehicle per year, depending on the econometric specification. In some ways, the higher estimate is more credible because it takes into account the difference between respondents with a zero WTP and those with a positive WTP. At the same time, we do find indications of a potential problem with yea-saying in the survey, which means that a more conservative estimate might be preferred.

Given the number of vehicles in the Mexico City metropolitan area in 2013, our estimates imply that the total WTP to avoid the negative impacts of HNC is 4.7 billion to 6.3 billion pesos (US $367 million to $490 million) per year. These WTP estimates are substantial. Median individual WTP represents roughly 1 percent of the annual median income in our sample (90,000 pesos). Total WTP represents roughly 3 percent of the 2013 gross domestic product (GDP) of Mexico City and 2 percent of the GDP of both Mexico City and Mexico state (INEGI 2015). Of course, all of our WTP estimates should be interpreted with care because they reflect stated behavior, not actual behavior. However, even the more conservative estimates are substantial.

How do these estimates of the costs households incur due to HNC compare with other findings? Although Davis's (2008) figure of $113 per vehicle per year (2013 US $) appears to line up well with our WTP estimates, it captures very different types of costs over a different period. It is based on the cost of the additional vehicle purchases spurred by the HNC program during its first four years (1990–1994). By contrast, our estimate excludes all costs incurred prior to our 2013 survey and covers a much wider array of types of costs, including those related to lost time and inconvenience. Our total cost estimates are about four times larger than those of Gallego et al. (2013b), which, as noted above, are based on a numerical simulation modeling using few observables. Despite these differences, Davis (2008), Gallego et al. (2013), and our study all agree that HNC's costs are substantial.

The distributional incidence of HNC social costs is particularly interesting. To begin with, it is important to point out that the population in this survey is vehicle drivers. Thus, by definition, poor households that cannot afford a vehicle do not incur costs. In that sense, HNC has a progressive effect: that is, richer households bear a disproportionate share of the costs. However, if we restrict attention to vehicle drivers, our results suggest a regressive effect. Neither the WTP for an HNC exemption or the likelihood of having a positive WTP for an exemption is correlated with *socioeconomic level* (Tables 8 and 9). Hence, the cost of the regulation is not significantly different for rich and poor drivers, and therefore represents a larger fraction of income for poorer drivers.

7. Conclusion

We conclude with a brief discussion of the implications of our study for future research on regulatory costs and for transportation policy. As for future research, in general, the main methodological problems with the CV method stem from its uses in valuing nonmarket goods that have nonuse values. In such cases, altruistic concerns and warm glow can give rise to positive hypothetical bias. When CV is used to estimate regulatory costs, however, the nonmarket good in question—a regulatory exemption—is quite different, and altruistic concerns and warm glow are unlikely to be major concerns.

Rather, our experience suggests that the principal issue in using the CV method to estimate the regulatory costs is likely to be designing a CV scenario in which granting an exemption from the regulation does not seem (i) implausible, (ii) unfair, or (iii) likely to exacerbate or ameliorate the problem that the regulation was designed to address. The first and second issues are always a concern in any type of CV study; the third is perhaps unique to the application of this method to regulatory costs.

All three issues were repeatedly raised in early focus groups for our study. In our case, plausibility was enhanced by the fact that HNC rules already grant multiple types of exemptions. We addressed the issue of the plausibility of an additional exemption by casting it as a quid-pro-quo for a government decision to rescind some existing exemptions (i.e., those granted to highly polluting vehicles). We addressed the issue of fairness by stipulating that the drivers to whom B-holograms would be offered for sale would be randomly selected.

As discussed in Section 3, the third issue—crafting a CV scenario with negligible effects on pollution and congestion—must be addressed to isolate the regulation's costs from its potential benefits when eliciting WTP. Doing that proved somewhat challenging. From focus groups, we knew that many drivers viewed HNC as an effective means of stemming pollution and congestion. It was therefore important that our CV scenario described the program in a neutral way and not undermine its perceived benefits. Ultimately, we stipulated that the B-hologram program would offer relatively few exemptions (0.05 million) compared with the number of vehicles in the Mexico City metropolitan area (4.7 million). To reinforce the idea that the B-hologram program would not exacerbate pollution, we stipulated that the government would rescind twice as many exemptions as it would create.

An additional issue in using the CV method to estimate regulatory costs is likely to be deciding on the duration of the exemption offered for sale. As noted above, a longer duration may make it difficult for respondents to calculate and discount private benefits, but a shorter one limits the ability of the CV question to capture the costs of infrequent, lumpy investments in adaptation—in our case, "prematurely" replacing vehicles with 0-holograms with newer ones to maintain an exemption. In our case, we settled on an exemption with a five-year duration.

Finally, what are the implications of our findings for transportation policy? As discussed in the introduction, recent research has questioned whether HNC and other driving restrictions programs actually have the intended environmental benefits. Several studies have found that the strategies drivers adopt to adapt to the program, including purchasing additional vehicles and rescheduling driving, can negate or even reverse intended benefits. The results of the present study suggest that whatever benefits these programs may or may not have, they can be quite costly. Moreover, costs of the regulation may be disproportionately borne by drivers from poorer households. Although additional evidence from programs other than HNC is needed to determine whether and how our results generalize, the findings should give pause to policymakers currently using or considering the use of driving restrictions to address vehicular pollution and congestion.

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