Mandatory Helmet Use and the Severity of Motorcycle Accidents: No Brainer?

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Abstract

We study the impact of mandatory motorcycle helmet use laws on the severity and volume of road accidents in Uruguay by exploiting a change in the enforcement of the traffic law. Using event-study, differences-in-difference and synthetic control methods, we report a sharp increase in helmet use and a 40 percent reduction in the incidence of serious or fatal motorcyclist accidents. We find no evidence of other behavioral responses in terms of either the volume or type of accidents. We show that additional costs of enforcement for the relevant government agencies were negligible and estimate the health benefits of the policy.

Key words: Law Enforcement; Safety and Accidents; Helmet Use

JLE: I12; I18; R41; H89

1. Introduction

Road traffic accidents are the leading cause of death for children and young adults worldwide. According to the World Health Organization, 1.35 million people die yearly as a result of these accidents. For most countries, the associated costs have been estimated at roughly 3% of GDP (WHO, 2018). A disproportionate share of these costs is borne by inhabitants of low- and middle-income countries. In an effort to curb the substantial human and material costs imposed by road traffic accidents, countries have implemented a panoply of different regulations, from mandatory seat-belt and helmet use laws to vehicle speed limits among many others. For several decades, economists have studied the effectiveness of seat belt use laws in particular because these can in theory modify actual and perceived risks of driver behavior, thus inducing potentially unexpected changes in accidents that may render regulation ineffective or counter-productive. This is known as the Peltzman hypothesis after this author showed evidence of increases in pedestrian accidents as a result of seat belt regulation (Peltzman, 1975). While evidence in support of the Peltzman hypothesis has been elusive in more recent studies of the consequences of seat belt use, examples of inadvertent consequences of protection gear have been documented in other activities.[5]

In this paper, we study the impact of a change in the enforcement of mandatory helmet use regulation in Uruguay on the severity and volume of road accidents involving motorcyclists and other road users. Mandatory helmet use laws for motorcyclists are common but not universal and enforcement varies substantially between nations, with widespread enforcement issues in middle- and low-income countries. The potential effects of helmet use on the perceived consequences of speedy driving and other forms of risk taking are similar to those hypothesized in the case of seat belts. Yet there is limited evidence in the economics literature on the direct and indirect impact of enforcement on injury rates for motorcyclists. By using detailed administrative data on all reported road accidents in Uruguay, we can estimate these effects and study the impact of enforcement on the volume and type of accidents taking place, both for motorcycles, other vehicles and pedestrians.

Our empirical strategy is based on quasi-experimental variation in enforcement induced by changes in national laws in Uruguay. Mandatory helmet use was introduced in Uruguay in 2007 as

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[5] For example, Chong and Restrepo (2017) study the effect of protective gear in Ice Hockey on player behavior. Pope and Tollison (2010) find increased on-track accidents in NASCAR as a result of the introduction of new safety regulations.

part of the National Traffic Law, yet two departments – Uruguay is divided in 19 territorial jurisdictions called departments – refused to enforce this regulation. This situation changed when the Misdemeanors Act was passed by Parliament in 2013. As a consequence of this act, the department of Soriano started to enforce helmet use for motorcycle drivers and passengers. This induced an arguably exogenous change in enforcement that can be exploited for the purpose of our analysis.

We document the effect of this change in enforcement on accident severity, type and volume in the next two years after 2013. Our findings indicate a substantial reduction in severity of motorcycle accidents, with a 5 to 7 percentage point reduction in serious and fatal accidents and a similar increase in the fraction of accidents resulting in minor injuries. Contrary to what the Peltzman hypothesis suggests, we find no effect on either accident volumes or the type of accidents taking place as a result of the change in enforcement. Using our coefficients in combination with estimates of hospitalization costs in the country and the value of statistical life, we can obtain an estimate of the health benefits resulting from enforcement of the helmet use law. By comparing these with motorcycle registration numbers, we also compute the nuisance cost of helmet use that would make helmet use indifferent for motorcyclists.

A small set of studies in economics have looked specifically at the effects of helmet use in traffic accidents.[6] Perhaps the closest to our work is Dee (2009), which provides estimates of the effect of the introduction/removal of helmet use laws in US states on fatalities, using a panel specification.[7] Total fatality effects are meant to incorporate both the direct effect of helmet use plus potential compensating behavioral adjustments by drivers. Dickert-Conlin et al. (2011) find evidence of increased availability of organ donations by deceased motorcyclists in US states that repeal mandatory use laws. Carpenter and Stehr (2011) find evidence of reduced fatalities as a result of the introduction of mandatory bicycle helmet use laws for the young. However, they also report a substantial reduction in cycling. Chong and Restrepo (2017) report differences in behavior in ice hockey players when using protective gear, finding behavioral responses consistent with the Peltzman hypothesis.

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[6] Studies in the fields of accident prevention and medicine have also looked at this question using a variety of empirical methods. Some recent examples include Houston and Richardson (2008), Peng et al. (2017), Olsen et al (2016) and Lee (2018).

[7] Dee (2009) also provides complementary results using a within-vehicle specification similar in spirit to the analysis in Evans (1986).

Our paper contributes to this literature by testing for both the effect of helmet use on injuries and type of accidents in a context in which the reform is imposed centrally rather than locally, which arguably avoids the potential endogenous choice of implementing a policy at the state level that affects most US papers. Perhaps more importantly, we provide the first causal estimates of the effect of helmet use on injury severity outside of the USA. This is particularly important given that enforcement issues are especially acute in low and middle-income countries.

Our paper also relates to previous studies in economics estimating the impacts of seat belt use on health outcomes for drivers or non-drivers. Motivated by the work in Peltzman (1975), Loeb (1995) uses time-series data for Texas to study the effect of seat-belt use laws on the fraction of accidents resulting in serious injuries. Cohen and Einav (2003) and Carpenter and Stehr (2008) improve the empirical strategy by exploiting a US state panel. They respectively study the impact of seat belt laws on fatalities and injuries for vehicle occupants and non-occupants. While we also exploit longitudinal variation by jurisdictions to estimate our effects of interest there are important differences relative to these studies. Of course, we look at mandatory helmet use instead of seat belt use. In addition, the use of administrative data on individual accidents allows us to investigate effects on the types of accidents taking place. More importantly, we have information on injury type, which allows us to document impacts on serious and minor injuries and changes in composition between them.

Finally, our paper relates more broadly to the literature on policy solutions to the problem of road traffic accidents. Van Benthem (2015) uses historical changes in speed limits in the United States to obtain optimal limits, incorporating the impact of accidents as well as other factors (e.g. air pollution). Hansen (2015) uses regression-discontinuity methods to study the impact of punishment for driving under the influence on recidivism. In an exception relative to the largely US-centered literature, Aney and Ho (2019) study the impact of the Chinese Road Traffic Safety Law on the volume of accidents, fatalities and the severity of accidents. Our paper adds credible estimates of this change in policy to the limited economics literature on policy solutions to traffic problems outside of the United States. The context of our study is important because motorcycle deaths – as well as low rates of helmet use – are particularly concentrated in developing countries.

2. Background and Data

2.a. Road Accidents, Regulation and Enforcement

Road traffic accidents are the leading cause of death for children and young adults aged 5–29 years worldwide. The burden of road traffic injuries and deaths is disproportionately borne by vulnerable road users and those living in low- and middle-income countries, where the growing number of deaths is fueled by increases in transport motorization. Between 2013 and 2016, all low-income countries experienced an increase in the number of road traffic deaths (WHO, 2018). Despite the heavy costs imposed by road accidents, many countries still lack funded strategies, lead agencies and adequate enforcement of existing traffic regulation.

Globally, those using motorized two-and three-wheelers – mainly motorcycle riders – represent 28% of all traffic-related deaths. The heavy burden of deaths born by these road users is, at least in part, a result of them being less physically protected than car occupants. This additional risk for motorcycle users also affects the distribution of traffic-related deaths worldwide, as motorcycle use is generally more prevalent in developing countries.[8] Figure 1 shows a negative relationship between fatalities in motorcycle accidents and GDP per capita.[9] Our empirical analysis below focuses on Uruguay, which shows one of the worst rates in motorcycle accidents relative to its income level.

Tackling road safety problems in a context of increasing motorization is an important challenge for many developing economies. Even if adequate regulations are in place, these may be ineffective without the resources to ensure they can be successfully enforced. For example, in most countries helmet use is formally mandatory for motorbike drivers and passengers. Yet these regulations often co-exist with low use rates: Argentina, Bolivia, Iran, Peru and Uganda, all have mandatory helmet use laws and yet in these countries over 30% of drivers, and roughly 60% of passengers, do not wear helmets (WHO, 2018). The situation if often worse: in India and China, helmets are used by 30% and 20% of drivers, respectively. Both countries have had mandatory helmet laws for over a decade.

That is not to say that mandatory helmet laws are universal. In the United States, many states only require helmet use for young riders (e.g. under the age of 20). The states of Illinois, Iowa and

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[8] According to the 2014 Spring Pew Global Attitudes Survey, motorcycle ownership rates are regularly above 50% in developing East Asian economies, but less than 30% in developed countries.
[9] Detailed information on p.c. GDP and motorbike fatality rates by country can be found in Appendix Table A1.

New Hampshire do not require helmet use at all. In many of the countries that do have mandatory helmet laws, these laws do not specify standards for these helmets.

Figure 1 – Motorcycle Fatalities and Economic Development
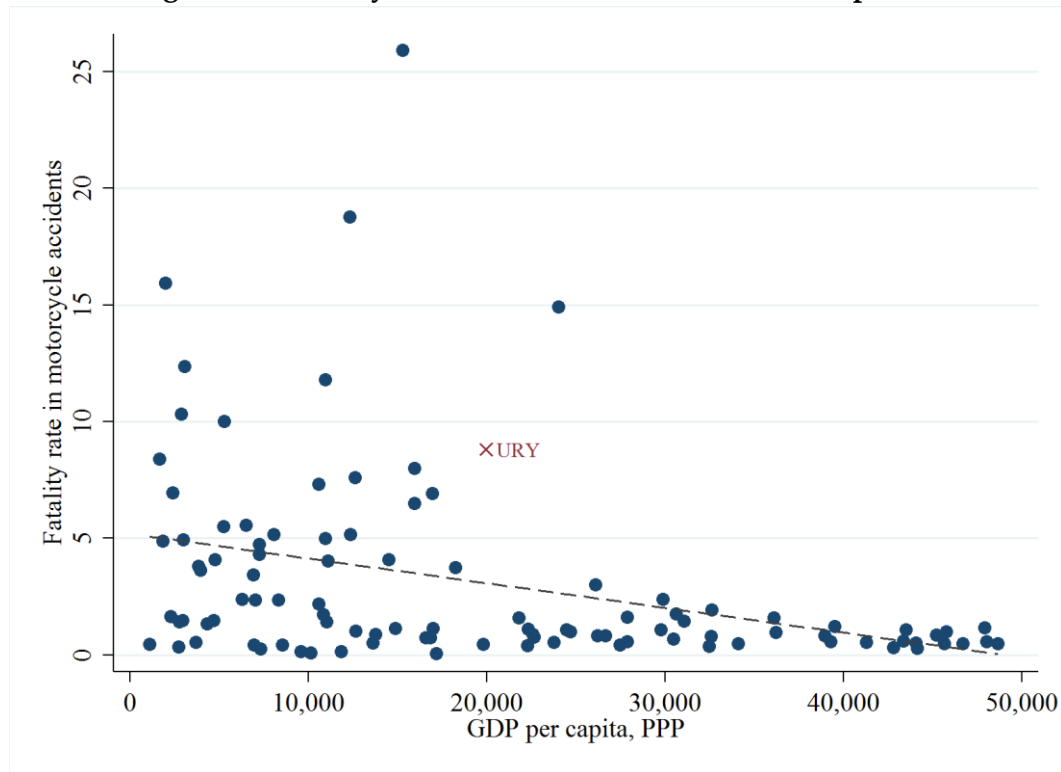
Note: Dots correspond to countries with GDP per capita < 50.000. Vertical axis represents deaths of motorcyclists per 100.000 people. GDP per capita measured in dollars of 2013, at purchasing power parity. Dashed line corresponds to a linear regression estimated over the scatter plot. Sources: World Health Organization, World Bank.

2.b. Helmet Use and Motorbike Accidents

When a motorcycle is involved in a collision, the rider is often thrown from the vehicle. In this event, a motorcyclist that is wearing a helmet has a lower risk of suffering traumatic brain injuries. There are typically three reasons for this. In the first place, the helmet cushions the impact and therefore reduces the deceleration of the skull. In turn, this limits the speed of the impact between the brain and the skull. Secondly, a helmet spreads the force of the impact over a greater surface area so that it is not concentrated on a small area of the skull. Finally, helmets act as a mechanical barrier between the head and the object.

These three functions are met by combining the properties of four basic components of the helmet: *The shell* is the strong outer surface that distributes the impact over a large surface area. *The impact-absorbing liner* is the soft foam-and-cloth layer that sits next to the head. It helps keep the head

comfortable and the helmet fitting snugly. Finally, the *retention system* or *chin strap* is the mechanism that keeps the helmet on the head in a crash.

In the event of an accident, bikers who do not wear helmets generate additional hospitalization costs by requiring greater number of medical and surgical interventions and longer recovery times. The disability that often results from these head injuries leads to additional individual and social costs (WHO, 2006).

2.c. Natural Experiment

On November 2007, the Uruguayan Parliament approved a new National Traffic Law – Law number 18.191 – which required mandatory helmet use for motorcyclists in all 19 departments of the country.[10] However, the departments of Soriano and Cerro Largo decided not to monitor the use of helmets – effectively ignoring this aspect of the law – arguing that the Uruguayan Constitution devolves transit control to the departmental jurisdiction.

In the beginning of 2013 – where our sample period starts – both departments had substantially lower rates of helmet use than other departments in the country. The percentage of motorcycle accidents in which the biker was wearing a helmet was 7.9% and 21.2% for Soriano and Cerro Largo, respectively. The average for other departments stood at roughly 75%. Moreover, the usage of helmet by motorcyclists was particularly low in Mercedes (the capital city of Soriano) and Melo (the capital city of Cerro Largo) – respectively, 3.1% and 5.7%. These cities have comparable numbers of registered motorbikes and automobiles per capita, and similar helmet usage figures pre-2013.[11]

In August 2013, Parliament approved Law number 19.120 – the Misdemeanors Act – which includes an article establishing a specific punishment for motorcyclists not using a helmet, consisting of community work. The national police force is responsible for enforcing this law. Thus, Parliament transferred the responsibility for monitoring helmet use from the municipal to the national level. Since the Misdemeanors Act was approved, the Mayor of Soriano gradually let people know the department would enforce mandatory helmet use. On November 1, 2013, the municipality of Soriano

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[10] A map of Uruguayan departments including the percentage of helmet use can be found in Appendix Figure A1.

[11] See Table A2 and Figure A1 in the Appendix.

started monitoring motorcyclists, while the department of Cerro Largo remained steadfast in its position and, to this date, does not require helmet use.

2.d. Data

We employ data drawn mainly from the UNASEV database.[12] The database has detailed information about accidents where police intervened, including the date, time and location of the accident. The database includes information about the people involved in the accident, such as age, gender, role in the accident – if the person was a passenger or a driver – consequence of the accident – death, serious injury, minor injury or unharmed – and if the person wears helmet or seat belt if applicable. While the report is filled by the police that intervened in the accident, the variable that explains the health consequences of the accident is filled by medical service personnel. They are responsible for identifying if the person is slightly or seriously injured, with the difference depending on whether the person had one or more of their vital organs compromised. Deaths are registered to have happened as a consequence of an accident if the fatality is either at the time of the accident or at the medical center within 30 days of the accident taking place. In Uruguay during the period under consideration – from 2013 to 2015 – 203,725 persons were involved in traffic accidents. Excluding pedestrians, we have 175,759 observations in our database (Table A3 in the Appendix). Nearly 40 percent of those observations involved motorbikes, and 12 out of 100 people suffering motorbike accidents ended seriously injured or dead, more than doubling the rate observed for other vehicles (see Panel A of Table A3 in the Appendix). In Mercedes and Melo, 3,378 persons suffered motorbike accidents in this period (see Panel B of Table A3).

Finally, in addition to data on accidents we collect information on daily time of sunset , school holidays and national holidays to account for time factors that could affect traffic volume and accidents.

In Table 1 we show the descriptive statistics for all reported motorbike accidents in this period, splitting the sample by helmet usage. Wearing a helmet is associated with a significant reduction in the probability of being seriously injured in motorcycle accidents. A rider wearing a helmet faces a 3.8 pp lower probability of being seriously injured or dead after a motorbike accident. These estimates do not account for the potential endogeneity of helmet use. A motorcyclist makes several decisions

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[12] National Division of Road Security (*Unidad Nacional de Seguridad Vial*).

when riding her motorcycle: the speed, respecting traffic signs, whether or not she is going to drive under the effects of alcohol or drugs, and if she will be wearing a helmet. Thus, helmet usage is an (endogenous) choice variable. Riders who decide to use a helmet self-select themselves into the treatment, so there can be observable and unobservable factors that confound the use of a helmet and the severity of an accident. For example, Table 1 shows non-helmet riders are disproportionately young, male, and riding at night. In the next sections of the paper we will try to estimate the *causal* effect of using a helmet on the probability of serious injuries and fatalities.

Table 1 – Descriptive Statistics: Motorbike Accidents by Helmet Use

Variables	No helmet			Helmet			Mean Differences
	Mean	SD	Obs.	Mean	SD	Obs.	
Serious injury or death	0.14	(0.35)	16,863	0.10	(0.30)	52,043	0.038***
Slight injury	0.60	(0.49)	16,863	0.69	(0.46)	52,043	-0.095***
Unharmed	0.26	(0.44)	16,863	0.21	(0.40)	52,043	0.057***
Male	0.75	(0.43)	16,789	0.68	(0.46)	51,922	0.063***
Age	27.22	(13.76)	14,801	32.02	(14.15)	50,242	-4.806***
At night	0.32	(0.47)	16,863	0.27	(0.44)	52,043	0.053***

Notes: Data from UNASEV (*Unidad Nacional de Seguridad Vial*, Uruguay). Period: 2013-2015. * $p<.1$, ** $p<.05$, *** $p<.01$

3. Empirical Analysis

Our empirical analysis has three main goals. The first is to evaluate the consequences of the change in enforcement of the mandatory helmet law, identifying effects on helmet use and the severity of road accidents. The second objective is to estimate the effect of helmet use itself on accident severity, using the policy change as a source of exogenous variation. Finally, we want to document any other noticeable changes in driving behavior resulting from the change in policy. We can tackle these objectives by exploiting the abrupt change in enforcement of helmet use in the department of Soriano. This strategy requires finding a suitable control group with which to compare this department.

For this purpose, we use three different strategies. On the first place, we conduct two parallel event-study analyses of the evolution of helmet use and the incidence of serious accidents in

Mercedes and Melo. These towns constitute, respectively, the administrative capitals of the departments of Soriano and Cerro Largo, both of which refused to enforce the mandatory helmet law in 2007. Next, we use data on the universe of accidents in Uruguay in a specification with locality fixed effects where localities in Soriano constitute the treatment area. Finally, we then use department-level data to conduct an analysis of the differential evolution of serious injuries in motorbike accidents in Soriano based on the synthetic control method (Abadie and Gardeazabal, 2003).

Alongside the results of these analyses, we also report the impact of the change in enforcement on the number and cause of accidents.

3.a. Event-Studies in Two Cities: Mercedes and Melo

In early 2013, Mercedes and Melo were the only department capitals in the country where municipal traffic inspectors did not enforce the helmet use law. As discussed above, Mercedes started enforcing that law in November 2013. To provide an initial illustration of the effects of the policy change, we report two event-study graphs comparing helmet use and the severity of motorbike accidents for Mercedes and Melo in Figures 2 and 3. Comparing both cities is especially relevant because motorbike accidents are more common in urban environments, and most traffic inspectors operate in and around urban areas.

In Figure 2, we plot the evolution of the percentage of people involved in motorcycle accident who was reportedly wearing a helmet in both cities. We use this variable as a proxy of helmet use.[13] The solid line corresponds to Mercedes, and the dashed line to the city of Melo. We observe initial levels of helmet use are remarkably low in both cities, oscillating under 10%. In the figure, November 2013 is indicated with a vertical solid line. Precisely in this period, the rate of helmet use jumps to almost 100% in Mercedes, while the figures for Melo remain very low. This difference is sustained throughout the next two years. This indicates that the change in enforcement prompted a persistent increase in helmet use in the city of Mercedes.

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[13] Police reported helmet use rates may be more responsive to changes in enforcement than actual helmet use if motorcyclists are classified as wearing a helmet when they were not. This means that we will may overstate changes in helmet use as a result of the policy, but understate the effects of helmet use on serious accidents.

Figure 2: Helmet Use in Mercedes and Melo
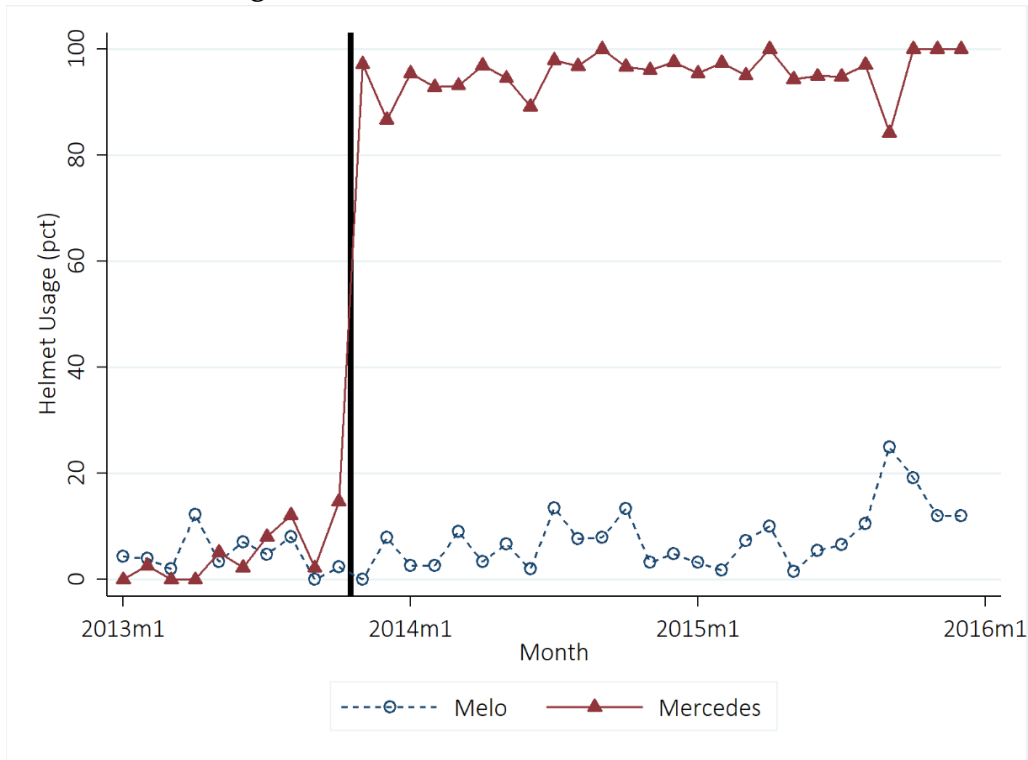
Note: Helmet usage measured as the percentage of all motorbike accidents where the driver was wearing a helmet. Vertical line corresponds to November 2013. Source: own calculations based on data from UNASEV (*Unidad Nacional de Seguridad Vial*, Uruguay). Period: 2013-2015.

The evolution of the fraction of motorcyclists involved in accidents that experience serious or fatal injuries for both cities is reported in Figure 3. We report 3-months moving averages to smooth out some of the short run fluctuations. We can observe that - before the change in enforcement – the fraction of serious accidents for both cities evolve in parallel with an upward trend, with the level being consistently higher in Mercedes. In the months before November 2013, the fraction of motorbike accidents resulting in serious injury for this city oscillated around 10%. Five months after the policy was introduced, serious injuries only occurred in 2% of motorbike accidents. Between late 2014 and 2015, the figure would recover to a level of around 4%. In this period, the rate of serious injury in Melo was twice as large as the one for Mercedes. The fact that this divergence broadly coincides with the change in policy indicates that the increase in enforcement resulted in reduced injuries for bikers.

Figure 3: Serious Injuries and Fatalities in Mercedes and Melo
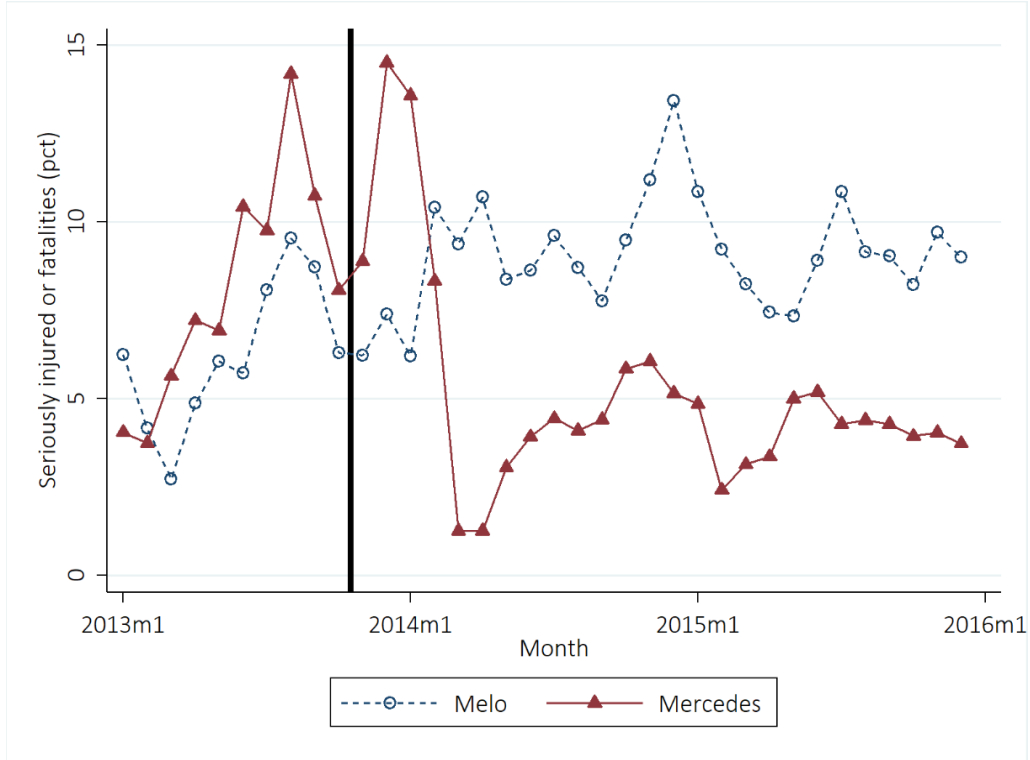
Note: Seriously injured or fatalities is defined as a percentage over the number of motorcyclist accidents in each city. The series were smoothed with three months moving averages. Vertical line corresponds to November 2013. Source: own calculations based on data from UNASEV (*Unidad Nacional de Seguridad Vial*, Uruguay). Period: 2013-2015.

An interesting feature in Figure 3 is that the decline in serious accidents in Mercedes does not occur immediately but takes roughly 5 months after the change in enforcement. In the first three months after the introduction, there is an increase in the ratio of serious injuries. Given the changes reported in Figure 2, we know this transition is not induced by a slow and progressive change in helmet use. One plausible explanation is that bikers took some months to adapt to the limited visual and auditory acuity resulting from the use of a suitable helmet. In that adaptation period, serious accident rates could even exhibit a short-term increase.

We can use our individual-level dataset and exploit the variation reported in Figures 2 and 3 to obtain quantitative estimates of the effect of enforcement on helmet use and the incidence of serious injuries. For this purpose, we estimate:

$$Y_{it} = \alpha + \beta(Mercedes_i \cdot Post_t) + \gamma_1 Mercedes_i + \gamma_2 Post_t + \delta_t + \theta' X_{it} + \epsilon_{it} \qquad (1)$$

The outcome variable Y_{it} be either a dummy taking value 1 if the individual i involved in an accident in month t was wearing a helmet, or a dummy taking value 1 if the individual suffered major or fatal

injuries as a result of the accident. Variable $Mercedes_i$ takes value 1 if an accident took place in the city of Mercedes (as opposed to Melo), and $Post_t$ takes value 1 after November 2013. Variables δ_t and X_{it} corresponds to date or driver level controls, respectively. In δ_t we include dummies for public holidays, day of the week, hour of the day, month of the year and year effects. In X_{it} we include age and gender of the driver.

Table 2: Motorbike Accidents in Mercedes and Melo

	(1)	(2)	(3)
Panel A		Use of helmet	
Mercedes x Post	0.871***	0.869***	0.867***
	(0.019)	(0.019)	(0.020)
Observations	3,354	3,354	3,175
R-squared	0.764	0.769	0.768
Panel B		Serious injuries and fatalities	
Mercedes x Post	-0.070***	-0.072***	-0.068***
	(0.022)	(0.022)	(0.023)
Observations	3,378	3,378	3,198
R-squared	0.006	0.025	0.032
Gen. Contr.	No	Yes	Yes
Driv. Contr.	No	No	Yes

Note: The variable Mercedes x Post is a dummy that takes the value 1 when the accident took place in Mercedes after November 1st, 2013. All regressions include a dummy for Mercedes, a dummy for Post November 1st 2013 and a constant. General controls include a dummy for school and public holidays; a full set of day-of-week-specific fixed effects, hour-of-day fixed effects, month-of-year fixed effects and year fixed effects. Driver controls include dummies on gender and age of the driver. Data period: 2013-2015. Robust standard errors in parentheses. *p<.1; **p<.05; ***p<.01.

Estimates for β under different sets of controls are reported in Table 2. In Panel A, we report the effect of the increase enforcement on helmet use. As illustrated in Figure 2, this effect is positive and large, with the probability of using helmet increasing by roughly 87 percentage points after the policy was introduced. In Panel B, we report that the probability of having a serious or fatal injury was reduced by roughly 7 percentage points in Mercedes after the change in enforcement. Reassuringly, in both cases the coefficients are stable across specifications, indicating that controls have very little impact on our estimates. These results indicate that the increased enforcement policy was both successful in promoting helmet use and in reducing accidents.

3.b. Difference-in-Difference Estimates

We now move beyond the narrow analysis of Mercedes and Melo and use our data for the universe of road accidents in Uruguay to study changes in helmet use and serious accidents in Soriano. For this purpose we estimate the following specifications:

$$Y_{it} = \alpha_j + \delta_t + \beta\,Post_t \cdot T_i \cdot Moto_{it} + \gamma_1 Post_t \cdot Moto_{it} + \gamma_2 Moto_{it} \cdot T_i + \gamma_3 T_i \cdot Post_t + \varepsilon_{it} \quad (2)$$

$$Y_{it} = \alpha_j + \delta_t + \beta\,Post_t \cdot T_i + \varepsilon_{it} \quad (3)$$

As above, the outcome variable Y_{it} in both equations can be either a dummy for individuals wearing a helmet, or a dummy taking value 1 for individuals suffering major or fatal injuries as a result of the accident. Parameters α_j and δ_t, correspond to locality and month-year effects, respectively. Variable $Moto_{it}$ corresponds to a dummy taking value 1 if the individual involved in an accident i in month t was riding a motorbike.[14] Finally, T_i takes value 1 if the accident took place in one of the localities in Soriano – our treatment area – and $Post_t$ takes value 1 in all periods after November 1st 2013. In the case of model (2), we use a triple interaction term to identify the effect of the enforcement policy on our outcome by simultaneously comparing the before and after change in this outcome for bikers in Soriano with the corresponding change for other vehicles, and the change for bikers in the rest of the country. Model (3) is estimated on our subsample of bikers and is a standard differences-in differences specifications where the $Post_t$ and T_i variables have been replaced with time dummies and locality fixed effects. In the case of this model, the assumption required to estimate parameter β is the usual assumption of parallel trends in the absence of treatment.

In addition to estimating equations 2 and 3 directly, we can use them as first stages in a two stage least squares specification to estimate the effect of helmet use on serious injuries. The first stage will have the helmet dummy as the outcome, and the second stage outcome will be our serious injury dummy.

Estimates from these specifications are reported in Table 3. Columns 1 and 2 correspond to equation (2) and columns 3 and 4 correspond to equation (3). Columns 1 and 3 omit locality fixed effects, which are included in columns 2 and 4. In panel A, the outcome variable is our helmet use

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[14] This variable takes value 0 for individuals who were either riding a motorbike without helmet, or riding a vehicle that does not require helmet use (e.g. cars). Vehicles included in our accidents database are cars (48.9%), motorbikes (39.8%), trucks (3.4%), buses (3.1%), bicycles (2.4%), carts (0.13%), and other vehicles (2.4%).

dummy. We observe consistent positive estimates for β of roughly 0.9 across specifications. This is in line with the results illustrated in Figure 2, indicating helmet use in Soriano went from close to zero to almost full compliance in a few months. Panel B provides reduced-form results for the effect of the enforcement of the mandatory helmet law on serious accidents. We find a negative and significant effect of roughly -0.05, which is interpreted as showing that the probability that a motorbike accident results in a serious injury was reduced by 5 percentage points as a result of the policy. This effect is large, as the baseline probability of having a serious or fatal injury for bikers is 11.3%. Note that the effect is slightly smaller to the one reported when comparing Mercedes and Melo, presumably because the probability of serious injury is higher in cities.

Panel C of Table 3 shows our IV estimates of the causal effect of helmet use. Note that these coincide with the ratio between the reduced-form coefficients in panel B over the first-stage estimates in panel A. The effects of interest oscillate around 5%, indicating that helmet use reduces the probability that a motorbike accident results in a serious or fatal injury by roughly 40 percent. Note that this estimated effect is slightly *larger* than the difference in probability of serious injury obtained from the mean comparison in Table 1. This suggests that helmet use is negatively correlated with other dimensions of risk-taking behavior in the road.

The reduction in the prevalence of serious injuries as a result of motorbike accidents can operate through either a change in the type of accidents bikers are involved in, or a change in accident severity conditional on accident type. If helmet use is behind the reduction in serious or fatal injuries, we expect a positive effect on minor injuries as a result of the change in enforcement. Accidents that would have resulted in a serious injury if a helmet was not used may result in a minor injury instead. To explore this, we reproduce the previous analyses using an indicator taking value 1 if an accident results in minor injuries as the dependent variable. Results are reported in Table 4. In panel A, we estimate model 1 using data for Mercedes and Melo only. We find a substantial increase of roughly 8 percentage points in the probability that motorbike accidents result in minor injuries in the city of Mercedes after the helmet law was enforced. In panel B, we obtain IV estimates of the effect of helmet use on the probability of having minor injuries using data for all locations in the country. We find positive and significant effects of helmet use on minor injuries, again pointing to a transfer of serious to minor injuries as a result of the change in enforcement.

Table 3: Differences-in-Differences Estimates for all Locations

	(1)	(2)	(3)	(4)
A) First-Stage	Helmet D.	Helmet D.	Helmet D.	Helmet D.
Post x Treatm. x Moto	0.885***	0.887***		
	(0.0290)	(0.0270)		
Post x Treatm.			0.904***	0.887***
			(0.0297)	(0.0366)
B) Reduced-Form	Serious D.	Serious D.	Serious D.	Serious D.
Post x Treatm. x Moto	-0.0490***	-0.0479***		
	(0.00932)	(0.0116)		
Post x Treatm.			-0.0450***	-0.0468***
			(0.0123)	(0.0111)
C) TSLS Estimates (IV)	Serious D.	Serious D.	Serious D.	Serious D.
Helmet D.	-0.0553***	-0.0541***	-0.0498***	-0.0528***
	(0.00954)	(0.0122)	(0.0123)	(0.0109)
Observations	174,696	174,696	68,906	68,906
Vehicle	All	All	Motorbike	Motorbike
Town FE	No	Yes	No	Yes

Note: Columns 1 and 2 estimated with the full sample of accidents in the UNASEV dataset (excluding pedestrian accidents). Columns 3 and 4 estimated using the sub-sample of motorcycle accidents. In Panel A, the dependent variable is a dummy taking value 1 if the victim of the accident was reportedly wearing a helmet at the time of the accident. In Panels B and C, the dependent variable is a dummy taking value 1 if the accident victim experienced a serious or fatal injury. Panel C reports instrumented variable estimates of the effect of helmet use on serious accidents as discussed in the text. Columns 2 and 4 include locality fixed effects. Standard errors clustered at the locality level. *p<.1; **p<.05; ***p<.01

We can also study whether the change in enforcement lead to a change in the quantity or types of vehicle accidents in the road. To study the impact on accident volumes, we first aggregate total number of accidents at the locality-month level and then estimate whether localities in the department of Soriano experienced an increase in the volume of accidents after 2013. Results are reported in panel A of Table 5 and show no significant effect of increased enforcement on accident volumes for total accidents, motorbike accidents or accidents involving other vehicles. Point estimates are negative and small in absolute value – less than 0.01 of a standard deviation – in all columns. Results reported in panel B of Table 5 show that increased enforcement also had no impact on the types of accidents that were reported. In this case we compute the share of all accidents corresponding to collisions, falling

(e.g. from a motorbike) or other causes. We find no statistically significant effect of increased enforcement on the type of accidents taking place.[15]

Table 4: Minor Injuries and Helmet Use

Panel A: Mercedes and Melo	(1) Minor D.	(2) Minor D.	(3) Minor D.
Mercedes x Post	0.118***	0.0829**	0.0806**
	(0.0396)	(0.0376)	(0.0381)
Observations	3,354	3,354	3,175
R-squared	0.009	0.017	0.037
Gen. Contr.	No	Yes	Yes
Driv.Contr.	No	No	Yes
Panel B: All Localities (2SLS)	Minor D.	Minor D.	Minor D.
Helmet D.	0.0232	0.0630***	0.0840***
	(0.0294)	(0.0222)	(0.0100)
Observations	174,696	68,906	68,906
Vehicle	All	Motorbike	Motorbike
Town FE	Yes	No	Yes

Note: Panel A coefficients estimated with the sample of all reported motorcycle accidents in Mercedes and Melo. Panel B estimated using all accidents in column 1, and all motorcycle accidents in columns 2 and 3. The dependent variable in all specifications is a dummy taking value 1 if the accident resulted in a minor injury. In panel A we include driver level controls and an additional set of dummies to account for school holidays and day-of-the-week effects. Columns 1 and 3 of Panel B include locality fixed effects. Standard errors clustered at the locality level in parentheses. *p<.1; **p<.05; ***p<.01

Hence, we conclude that enforcement of the mandatory helmet use law lead to a reduction in serious or fatal accidents and an increase in accidents resulting in minor injuries. We interpret this as a concomitant change in the relative probabilities of both types of accidents. The fact that there are no discernible changes in the volume and type of accidents, suggests there are no other first-order behavioral responses to the law, at least in terms of driver behavior.[16]

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[15] It is worth noting that the share of accidents by type is only defined for locality-month pairs featuring at least one accident. This implies that the sample used to produce the estimates in panel B of Table 5 is heavily selected. Yet the fact that there is no effect of increased enforcement on accident volumes, implies that this sample selection should not have a substantial effect on our estimates.

[16] Using a sub-sample of the UNASEV dataset, we also explore the effect of the change in enforcement on the number of pedestrians involved in traffic accidents. Difference-in-differences estimates are negative, small and statistically insignificant (results available upon request).

Table 5: Number and Type of Accidents in all Locations

A) Accidents by Vehicle	(1) Total Accidents	(2) Moto. Accidents	(3) Other Vehicles
Post x Treatm.	-0.539	-0.157	-0.382
	(1.360)	(0.487)	(0.927)
Observations	16,776	16,776	16,776
B) Accidents by Cause	Collision	Falling (e.g. from Motorbike)	Other
Post x Treatm.	-0.0657	0.0610	0.00473
	(0.0749)	(0.0691)	(0.0527)
Observations	6,002	6,002	6,002

Note: Panel A estimates obtained from a month-locality panel including locality fixed effects. In column 1, the dependent variable is the total number of people involved in traffic accidents in a locality-month pair. In column 2, the dependent variable is the total number of people involved in motorcycle accidents and in column 3 the number of people involved in accidents for other vehicles. Panel B estimates obtained from a month-locality panel including localities with at least one accident in a month-locality pair. The dependent variable is the fraction of motorcycle accidents arising from collisions, falling (e.g. from the motorcycle), and other causes. All specifications include locality fixed effects and year-month effects. Standard errors clustered at the locality level in parentheses. *p<.1; **p<.05; ***p<.01

3.c. Synthetic Control

The estimates reported in previous sections essentially result from comparing changes in an outcome (e.g. serious accident rate) between locations in Soriano and two control groups – the city of Melo in section 3.a., and the rest of the country in section 3.b. These control groups are obvious choices, but they are also arbitrary. We can use the data-driven synthetic control method – as described in Abadie et al. 2010 – to select a suitable control group and use that to estimate the difference in the rate of serious injuries induced by the policy.

For our synthetic control analysis, we use aggregated data at the department level. The outcome of interest is the number of victims of serious motorbike accidents per capita at the department level. The treatment group is the department of Soriano. A synthetic control is built by selecting positive weights for non-treated cross-sectional units in order to minimize a quadratic loss function based on unit characteristics, including usually values of the outcome before the treatment period. In our case, the cross-sectional units are departments, and the predictors for serious injury

rates in the loss function include the outcome in the first quarter of 2013, the number of motorbikes per capita, the share of rural population, the natural logarithm of population and average household income. We then use the algorithm described in Abadie and Gardeazabal (2003) to select the cross-sectional weights. The resulting weights take non-zero values for the departments of *Artigas* (0.448) and *Río Negro* (0.552).

We construct the accumulated difference in serious accidents between the department of Soriano and our synthetic Soriano control. This is represented as the black solid line in Figure 4. We observe that in the months before November 2013, the line is flat. Note that only the first quarter is used to select the synthetic control, so the fact that there is no observable trend in the two subsequent pre-policy periods indicates no substantial change between treatment and control departments before the enforcement of the mandatory helmet law in Soriano. Starting in the last quarter of 2013, we observe a progressive change in the accumulated number of serious accidents per capita. The line continues to diverge downward over time. While this method does not yield suitable standard errors for a conventional hypothesis test, we follow the synthetic control literature and use a permutation method to gain insights into whether this diverging trend could occur by accident. For this purpose, we construct a synthetic control for each of the other departments in our sample and calculate the accumulated difference in serious motorbike accidents per capita in each case. These are plotted in Figure 4 as solid grey lines.[17] We can observe that, while some of these lines diverge significantly from a flat path, none of them veers as far from this path as the solid black line for Soriano. This indicates that Soriano is an outlier in the trend of accumulated serious motorbike accidents per capita relative to all other departments. We interpret this as resulting from the enforcement of the mandatory helmet law in Soriano from November 2013.

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[17] Note that the department of Soriano is not included as a potential control unit in this exercise.

Figure 4 – Synthetic Control: Accumulated Serious Accidents p.c.
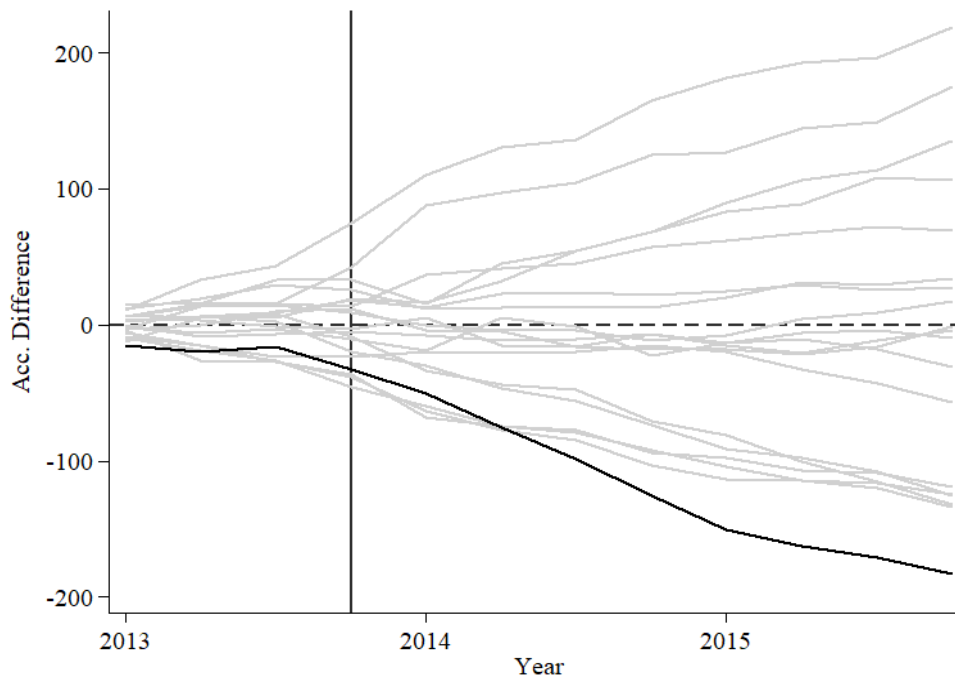
Note: Solid line represents accumulated difference in the per capita number of motorbike accidents resulting in serious injuries between the department of Soriano and a synthetic Soriano control constructed using the method detailed in the text. Grey lines represent the accumulated difference between observed numbers and synthetic controls for other departments.

We can also use the synthetic control method to determine whether the change in enforcement resulted in a change in accident volumes after 2013. For this purpose we modify the analysis above and build a synthetic department in order to match the number of motorbike accidents per capita before the policy was put in place in Soriano. Results from this exercise are reported in Figure A2 in the Appendix. The solid line represents the evolution of the accumulated difference in the number of accidents per capita between Soriano and the synthetic control. The grey lines represent the same figures for other departments. We observe that the accumulated difference for Soriano is fairly flat and does not stand out relative to those from other departments. This confirms the notion – already expressed in Table 5 – that increase enforcement had no discernible effect on the number of motorbike accidents.

4. Discussion and Conclusions

4.a. Valuation of the Change in Enforcement of the Mandatory Helmet Use Law

We can use our estimates and additional information on health and administrative costs to outline a cost-benefit analysis of helmet use laws for Uruguay. The main benefits of the policy arise

from the reduction in serious injuries and fatalities from motorcycle accidents. The main costs relate to: i) the administrative costs of enforcement paid by the relevant agencies and, ii) the nuisance costs of wearing a helmet for motorcyclists. The latter is particularly hard to estimate, but we can calculate which could be the magnitude of the costs that would be required to reverse the change in benefits.[18] The outcome of the cost-benefit analysis can then be obtained relative to this benchmark.

Health benefits resulting from the change in enforcement can be due to a reduction in the volume of serious accidents, and a reduction in the volumes of deaths. Paolillo et al. (2016) documents that roughly 1.5 out of 10 serious traffic accidents lead to a fatality. The same source estimates average intensive care hospitalization costs for serious traffic accidents in Uruguay to be USD 7,437. A quite conservative estimate for the value of a statistical life is USD 540,000 dollars.[19] Health benefits can be obtained by multiplying these figures times an estimate of the absolute reduction in serious injuries . The coefficient on the reduced-form effect of the policy on serious accidents in column 4 of Table 3 is 4.7%. The average number of yearly motorcycle accidents in Soriano is 610. Hence, the policy leads to a reduction of roughly 29 serious or fatal accidents per year. Using this number, we can compute estimated health benefits from the policy as $29 \times 0.15 \times 540,000 + 29 \times 0.85 \times 7,437$. This yields a figure of USD 2,532,322 per year in benefits arising from reduced hospitalization costs and deaths only. Assuming a 5% discount rate and a 30 year time horizon (as in Dee 2009), the present value of health benefits would be in the order of USD 41 million. This corresponds to USD 495 per capita.

It is worth noting that other health effects, such as psychological costs and permanent disability resulting from serious accidents, or reduced work hours for hospitalized patients, are likely to be substantial. Therefore, we consider these figures to be an underestimate of total health benefits.[20]

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[18] Standard revealed-preference valuation tools, such as the opportunity cost or compensating differential methods, cannot be applied to measure nuisance costs because there are no other markets compensating for these costs, or pricing a similar bad. Contingent valuation methods may be more successful in yielding a useful cost estimate, yet these are unavailable in our context.

[19] In the case of US, Dee (2009) employs a value of statistical life of 2 million dollars. Considering that Uruguayan GDP per capita is 27 percent of the US GDP per capita, we employ a conservative value of 540,000 dollars for our estimates.

[20] As discussed in section 3, the reduction in serious and fatal injuries comes at the expense of an increase in minor injuries. Minor injuries will impose costs of their own, although by definition they will not require hospitalization. These unaccounted costs are arguably higher for serious accidents, and so our estimate of net health benefits would still be a lower bound of total health costs, even after accounting for the increased number of minor injuries.

Figure 5: Personnel expense of the Municipal Transit Department
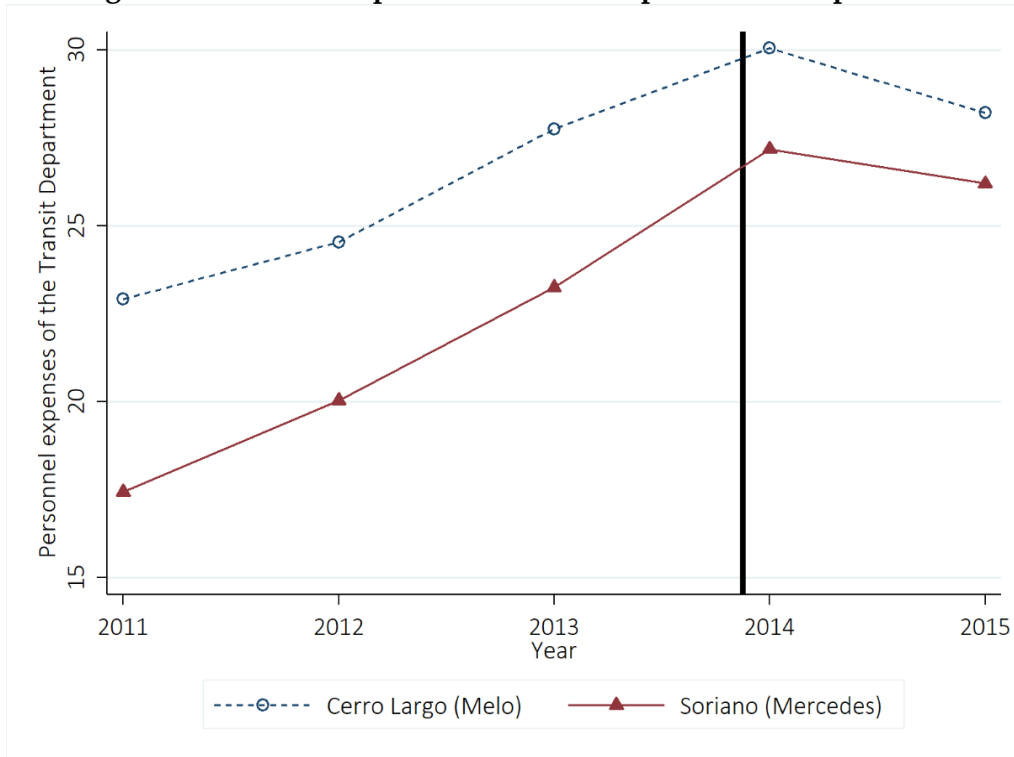
Note: Personnel expenses of the transit departments expressed in millions of 2015 Uruguayan pesos. Lines correspond to the evolution of expenses over time for Soriano (triangles) and Cerro Largo (circles). Vertical line corresponds to November 2013. Source: *Observatorio Territorio Uruguay (OPP)*.

Public enforcement of the helmet law requires the use of traffic inspectors to detect and to sanction violators. How much of Soriano's public resources were devoted to these tasks? Figure 5 reports personnel expenses of the Transit Department of the Municipality of Soriano and Cerro Largo. The parallel trends observed before the enforcement of the law do not change after it. In other words, Soriano achieved an abrupt increase in the compliance with the helmet law after 2013 without an escalation in personnel costs. Officials at the Soriano transit authority stated that enforcement of the law did not involve the deployment of additional human resources. Inspectors were already deployed within the city of Mercedes in order to enforce other transit rules (speed limits, traffic lights, etc.) and, after the law was enforced, the same inspectors just added another complementary task – the enforcement of the helmet law- to their daily activity. Information campaigns on helmet use were included on traffic safety campaigns already in place before the policy change. Hence, it is not surprising that we do not identify a significant administrative cost of enforcement in this case.

There were 26,435 registered motorcycles in Soriano in 2013. Nuisance costs of helmet for registered motorcycles resulting from the policy will be equal to this figure scaled by the change in helmet use, which is 89% (see panel A of Table 3). Our health benefits estimate is USD 2,532,322 per year. So, for

yearly nuisance costs per registered motorcycle under USD 108, the policy would have a positive net benefit. Because our estimate of health benefits is probably downward biased, this is a lower bound for break-even nuisance costs per motorcyclist.

Given this discussion, low levels of helmet use in the absence of appropriate enforcement during 2013 can be explained on three grounds: large nuisance costs, moral hazard or biased perception of risks. First, if nuisance costs of wearing a helmet – plus pecuniary costs of owning one – are well above USD 108 a year, then the laissez-fair outcome is that rational cyclists will choose not to wear a helmet. Second, cyclists may not internalize the full costs of serious injuries because of the pervasiveness of health and disability insurance. If this is the case, even if costs of helmet use are below USD 108 per year, it may still be optimal for drivers to not use a helmet. Finally, it is not obvious that motorcyclists have an accurate perception of the risks of driving without a helmet. The same outcome of low helmet use without enforcement would be observed if motorcyclists' subjective probabilities of serious accidents are lower than actual probabilities.

4.b. Conclusions

Mandatory helmet use laws for motorcyclists are a feature of transit regulation in many jurisdictions. Yet these are not universal and enforcement can often be extremely poor, particularly in low- and middle-income countries. This paper shows that changes in enforcement can lead to a substantial alleviation of the deleterious health consequences of motorcycle accidents. Our difference-in-differences estimates indicate that changes in the enforcement of helmet use laws in Uruguay lead to a substantial reduction of roughly 5 percentage points in the rate of serious or fatal injuries. Given the national base rate stands at roughly 12 percent for this period, this effect is sizeable. The reduction in serious accidents takes place at the expense of an increase of minor injuries, pointing squarely to a net reduction in accident severity. Accident numbers and the type of accidents taking place – both for motorcycles and other vehicles – do not appear to be affected by the change in policy. This further alleviates concerns that behavioral responses to helmet use – such as increased driving speeds or more reckless conduct by motorcyclists – counter the direct effect of using a helmet to prevent head trauma.

Combining our reduced-form estimates of changes in accident severity with costs of hospitalization and the value of statistical life, we calculate an approximate measure of the health benefits resulting from the change in enforcement. Given that direct enforcement costs by the

involved traffic control agencies were unaffected by the policy, the main costs of increased helmet use are associated to the nuisance these implements may generate for drivers. Substantial nuisance costs would be necessary to compensate for the policy's health benefits.
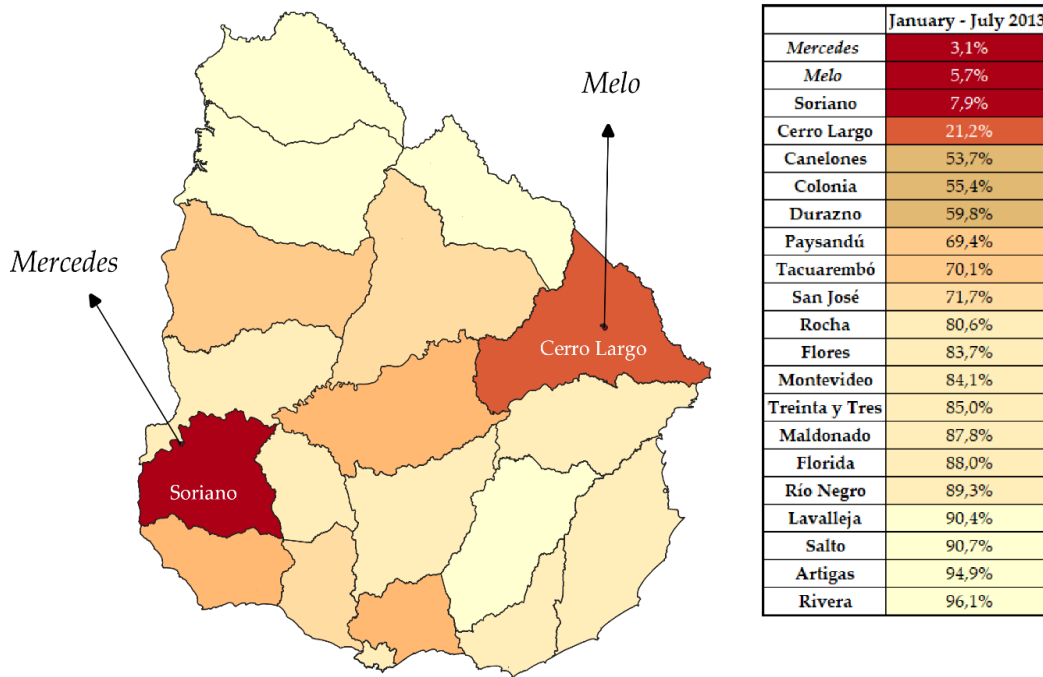
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Appendix

Figure A1 – Helmet Use by Department (Uruguay)

	January - July 2013
Mercedes	3,1%
Melo	5,7%
Soriano	7,9%
Cerro Largo	21,2%
Canelones	53,7%
Colonia	55,4%
Durazno	59,8%
Paysandú	69,4%
Tacuarembó	70,1%
San José	71,7%
Rocha	80,6%
Flores	83,7%
Montevideo	84,1%
Treinta y Tres	85,0%
Maldonado	87,8%
Florida	88,0%
Río Negro	89,3%
Lavalleja	90,4%
Salto	90,7%
Artigas	94,9%
Rivera	96,1%

Note: Polygons representing the 19 departments of Uruguay. Shades correspond to helmet use as measured by the fraction of motorbike accidents where the riders were wearing a helmet. The table also includes data for Mercedes (the capital city of Soriano) and Melo (the capital city of Cerro Largo).

Figure A2 – Synthetic Control: Accumulated Number of Motorbike Accidents p.c.
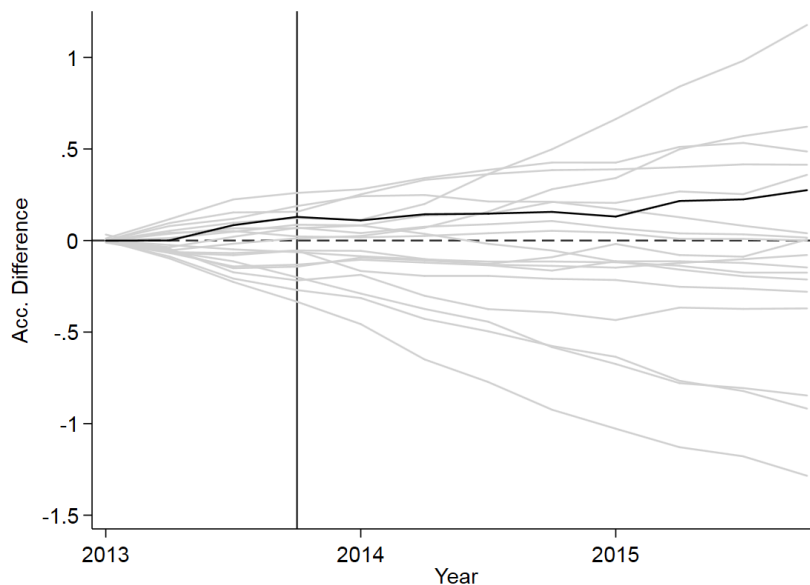
Note: Solid line represents accumulated difference in the number of motorbike accidents per capita between the department of Soriano and a synthetic Soriano control constructed using the method detailed in the text. Gray lines represent the accumulated difference between observed numbers and synthetic controls for other departments.

Table A1– Fatality rate in motorcycle accidents and GDP per capita.

Country	Fatality rate	GDP per capita	Year	Country	Fatality rate	GDP per capita	Year
Albania	2.18	10,571	2013	Lesotho	0.33	2,723	2013
Angola	0.42	6,970	2013	Libya	1.10	22,322	2013
Australia	0.97	45,794	2013	Lithuania	0.80	26,661	2013
Austria	1.15	47,922	2013	Luxembourg	1.51	95,591	2013
Azerbaijan	0.05	17,172	2012	Macedonia	1.01	12,656	2013
Bahamas	2.38	29,878	2013	Malawi	0.45	1,099	2012
Bahrain	0.28	44,168	2013	Malaysia	14.90	24,034	2013
Bangladesh	1.46	2,935	2012	Maldives	0.50	13,607	2013
Barbados	1.12	16,980	2013	Mali	4.85	1,856	2013
Belgium	1.06	43,520	2013	Malta	1.44	31,069	2013
Belize	5.15	8,072	2013	Marshall Islands	3.79	3,851	2013
Benin	15.92	2,002	2012	Mauritius	3.73	18,244	2013
Bhutan	0.25	7,317	2013	Mexico	0.74	16,848	2012
Bolivia	2.36	6,303	2013	Moldova	1.46	4,700	2013
Bosnia & Herzegovina	1.71	10,826	2013	Mongolia	4.02	11,094	2013
Brazil	6.49	15,971	2012	Montenegro	1.13	14,870	2013
Bulgaria	0.72	16,571	2013	Morocco	4.31	7,240	2013
Cambodia	12.35	3,068	2013	Namibia	0.14	9,578	2012
Canada	0.51	44,101	2012	Netherlands	0.46	48,666	2013
Chile	0.87	22,579	2013	New Zealand	0.94	36,220	2013
China	5.16	12,368	2013	Nicaragua	4.07	4,780	2013
Colombia	7.59	12,634	2013	Norway	0.48	67,056	2013
Costa Rica	4.06	14,525	2013	Oman	0.57	43,387	2013
Côte d'Ivoire	4.93	2,980	2013	Paraguay	11.78	10,950	2013
Croatia	1.59	21,807	2013	Peru	0.14	11,829	2012
Cyprus	1.76	30,621	2013	Philippines	5.53	6,527	2013
Czechia	0.68	30,486	2013	Poland	0.97	24,719	2013
Denmark	0.47	46,727	2013	Portugal	1.62	27,900	2013
Dominican Republic	18.76	12,322	2013	Romania	0.44	19,797	2013
Ecuador	1.39	11,037	2012	Russia	0.81	26,240	2013
Egypt	0.07	10,157	2013	San Marino	3.10	59,764	2013
El Salvador	2.36	7,027	2013	São Tomé & Príncipe	10.30	2,883	2013
Estonia	0.42	27,496	2013	Serbia	0.88	13,760	2013
Finland	0.53	41,294	2013	Singapore	1.66	81,648	2013
France	1.20	39,524	2013	Slovakia	0.56	27,898	2013
Georgia	0.42	8,542	2013	Slovenia	1.08	29,797	2013
Germany	0.84	45,232	2013	South Korea	1.92	32,616	2013
Ghana	3.61	3,940	2012	Spain	0.78	32,604	2013
Greece	3.00	26,098	2012	Sri Lanka	7.32	10,596	2013
Guatemala	4.73	7,249	2013	Suriname	7.99	15,957	2013
Guyana	3.42	6,930	2013	Sweden	0.47	45,673	2013
Honduras	1.32	4,323	2013	Switzerland	0.68	60,109	2013
Hungary	1.07	24,463	2013	Tanzania	6.95	2,397	2013
Iceland	0.31	42,821	2013	Thailand	25.89	15,287	2012
India	5.50	5,251	2013	Trinidad & Tobago	0.36	32,500	2013
Iran	6.91	16,955		Tunisia	4.99	10,948	2013
Ireland	0.56	48,067	2013	Turkey	0.38	22,311	2013
Israel	0.48	34,129	2013	Uganda	8.38	1,667	2013
Italy	1.58	36,131	2013	United Arab Emirates	0.29	63,839	2013
Jamaica	2.33	8,309	2013	United Kingdom	0.55	39,308	2013
Japan	0.82	38,974	2013	United States	1.59	52,782	2012
Kazakhstan	0.54	23,773	2012	Uruguay	8.80	19,943	2013
Kenya	1.41	2,776	2013	Zambia	0.52	3,701	2013
Laos	10.00	5,294	2013	Zimbabwe	1.64	2,287	2013
Latvia	0.75	22,677	2013				

Note: Data sources: Fatalities rate in motorcycle accidents, from World Health Organization. GDP per capita, at purchasing power parity, from World Bank.

Table A2 – Descriptive Statistics for Mercedes and Melo

	Mercedes	Melo
Total population	41,974	51,830
Total number of motorcycle or moped	12,420	12.828
Total number of automobile or van	4,900	6,130
Number of motorcycle or moped per capita	0.296	0.248
Number of automobile or van per capita	0.117	0.118

Note: Own calculations based on Uruguayan National Census 2011. Uruguay is divided in 19 departments. Mercedes is the capital of Soriano Department, and Melo is the capital of Cerro Largo Department. Both cities show similar ratios of motorcycles and automobiles.

Table A3 – Descriptive Statistics for Accident Database

Panel A - All localities

	All vehicles			Motorbikes		
Variables	Mean	SD	Obs.	Mean	SD	Obs.
Serious injury or death	0.06	(0.25)	175,759	0.12	(0.33)	69,969
Slight injury	0.38	(0.49)	175,759	0.66	(0.47)	69,969
Unharmed	0.56	(0.50)	175,759	0.22	(0.41)	69,969
Male	0.74	(0.44)	175,198	0.70	(0.46)	69,774
Age	37.05	(16.19)	166,139	31.01	(14.26)	66,073
At night	0.26	(0.44)	175,198	0.28	(0.45)	69,969

Panel B - Mercedes and Melo

	All vehicles			Motorbikes		
Variables	Mean	SD	Obs.	Mean	SD	Obs.
Serious injury or death	0.04	(0.20)	6,183	0.07	(0.26)	3,378
Slight injury	0.38	(0.48)	6,183	0.62	(0.49)	3,378
Unharmed	0.58	(0.49)	6,183	0.31	(0.46)	3,378
Male	0.67	(0.47)	6,160	0.60	(0.49)	3,363
Age	35.33	(17.14)	5,836	29.66	(15.42)	3,189
At night	0.26	(0.44)	6,183	0.28	(0.45)	3,378

Note: Own calculations based on UNASEV (*Unidad Nacional de Seguridad Vial*, Uruguay). Medical service personnel are responsible for identifying if the person is slightly or seriously injured, with the difference depending on whether the person has one or more of their vital organs compromised. Deaths are registered to have happened as a consequence of an accident if the fatality is either at the time of the accident or at the medical center within 30 days of the accident taking place. "At night" is a dummy variable that takes the value "1" if the accident occurred at night. "Male" and "Age" refer to the person that suffered the accident. Data: period 2013-2015.