The environmental cost and the accident externality of driving: Evidence from the Swiss franc's appreciation. *

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Abstract

This study investigates the effects of driving on air quality and road safety by exploiting exogenous variation in traffic flows associated with the Swiss franc's appreciation. During the Swiss franc's appreciation, the volume of cars crossing the Swiss-Italian border rose considerably (Bello, 2019). The higher purchasing power of Swiss francs in the EURO area induced more Italian workers to cross the border daily to work in Switzerland. Moreover, it increased the propensity for Swiss consumers to shop abroad. By using hourly data on traffic flows, road accidents, air pollution we show that the higher mobility across the border increased the concentration of oxides of nitrogen at peak hours during working days and the risk of road traffic accidents at late morning on both working days and non-working days. Specifically, the elasticity to the the number of cars of both variables of interest turns out to be larger than 1, providing evidence of an harmful externality. The results suggest the need for programs that treat jointly traffic congestion, air quality, and road safety. Moreover, the existence of an externality has important implications for optimal road use pricing.

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1 Introduction

The rapid growth of urban areas coupled with an increasing demand for urban transport services explain a major portion of the increasing trend in traffic jams observed in the last century. But the use of roads comes at a cost. Falling average speed of vehicle decreases the efficiency of fuel consumption and increases the amount of air pollution emission per vehicle mile of travel. Air quality in many large urban areas is in fact deteriorating and outdoor air pollution has become one of the main environmental health problems of developing and developed countries. On the other hand, congestion can be beneficial for road safety. Some empirical evidence suggested in fact a negative relationship between fatalities and traffic density. Specifically, the hypothesis is that at low level of traffic density, as the number of cars increases, the number of fatalities also increases, while in presence of congestion the number of fatalities start increasing at lower rate or even decreasing. This points at the great importance to investigate thoroughly the functional relationships between traffic congestion, traffic fatalities and urban air quality in order to implement policies which treat jointly these different aspects.

So far, most of the relevant literature has focused separately either on the relationship between car accident probability and traffic flows or on that between the latter and air pollution. For instance, Dickerson, Peirson, and Vickerman (2000) and Edlin and Karaca-Mandic (2006) investigated the existence of an accident externality of driving, which is defined as the difference between the marginal and the average accident rate and arising when the relationship between the risk of accident and the number of cars is not linear. Specifically, Dickerson, Peirson, and Vickerman (2000) used data from London and analysed the accidents-flow relationship across several type of roads and geographical areas and found that while there is a near-proportional relationship at low traffic flows, a driving externality is present in high traffic volume areas. Edlin and Karaca-Mandic (2006) provided similar evidence using data on insurance premiums in California. However, these studies, by not addressing the omitted variables problem (for instance, road characteristics and time varying factors may affect both traffic flows and accident probability), fail to provide evidence of a causal relationship. An exception is represented by Romem and Shurtz (2016), who estimated the effect of traffic volume on the probability of accident by exploiting exogenous variation in traffic flows stemming from religious observance of the Jewish Sabbath in Israel. They provided evidence of a non-linear relationship between traffic and accidents existing mainly on highly perilous roads.

Regarding the relationship between traffic volume and air quality deprivation, most recent studies have analysed the effects of driving restrictions or transport policies on the level of air pollution. Viard and Fu (2015), for instance, investigated the effects of the Beijing's odd-even policy restricting cars to drive only every-other-day and found that it improved air quality and reduced discretionary work time. However, Gallego, Montero, and Salas (2013) and Davis (2008) analysed similar policies implemented, respectively, in Latin America and in Mexico and found a no effect or even a negative effect of such policies on air quality.

This paper contributes to this foregoing literature by being able to identify an underlying causation between cross-border traffic and both road safety and air quality. We provides evidence of a accident and environmental externality of cross-border driving, whose size changes across time-intervals characterized by different volume of traffic. Particularly, the analysis focuses on Ticino, the southernmost canton of Switzerland, and exploits exogenous variation in traffic flows generated by the Swiss franc's appreciation.

Bello (2019) shows that the Swiss's franc appreciation affected mobility across the Swiss-Italian border. In response to a higher purchasing power of the Swiss wages more Italian workers decided to cross the border to work in Switzerland and the propensity for Swiss consumers to shop across the border increased. The number of vehicles along the border increased by 1.6-2.9% during specific time intervals. To analyse the effect that this rise in mobility had on the road safety and air quality level, we collect hourly data on the number of road accidents and on the concentration of oxides of nitrogen (NOx) for any municipality in Ticino, for the 2005-2015 period. We calculate the road distance between each municipality and the closest border post. By assuming that municipalities located closer to the border are more affected by cross-border commuting, we distinguish two groups of municipalities and perform a Difference in Differences analysis.

The findings show that the appreciation of the Swiss franc was associated with an increase in the monthly concentration of oxides of nitrogen and in the monthly car accident probability. The significance and the magnitude of the effect differs across time intervals and weekdays. At peak hours on working days, a 10% appreciation of the Swiss franc increased by 1.6-2.6% the level of traffic flows, but it had no effect on the probability of a car accident. However, falling traffic speeds drastically worsen air quality. The concentration of nitrogen oxides in fact increased by 3.1-3.4% on working days at peak hours. On the other hand, on late morning on working days and non-working days a 1.6-1.7% increase in traffic flows was associated with an increase of 3.3-7% in the car accidents probability, while it had no effect on air quality. The elasticity of pollution and car accident probability to the number of cars turns to be higher than 1, namely, 1.3-1.9 and 2-4, respectively. This provides evidence of an harmful externality associated with cross-border travel– one additional car on the road almost double the probability of a car accident and the concentration of Nox in the air.

This paper also contributes to the literature that studies the effect of economic variables, such as income level and unemployment rates, on health outcomes (Tihansky, 1974; Wagenaar, 1984; Grossman and Krueger, 1991). Recent papers have reported a positive health effects of economic crises in the short-run. Ruhm (2000), by focusing on US, showed that during downturns in the US the mortality decreased. Granados (2005) and Bertoli, Grembi, and Castello (2018) using Spanish data showed that that Great Recession reduced traffic accidents in Spain and changed their composition. These positive effects are mostly driven by a lower number of employed workers and a corresponding fewer need to drive. However, the effects that a recession or the level of employment rate of a country might have on the health risk in its neighboring countries has not been studied yet. The results of this paper provides some insights on this point.

The paper is structured as follows. Section 2 describes the identification strategy, the data and the empirical strategy. Section 3 presents the results. Finally, Section 4 concludes.

2 The data and the identification strategy

2.1 Data

This paper uses data on road traffic flows, road traffic accidents and air pollutant concentrations. The data regarding traffic flows and air quality are from the Sezione Mobilità del Canton Ticino. Specifically, the dataset consists of hourly information on the number of vehicles and on the concentration of the most important pollutants coming from 38 air monitoring stations and 60 traffic counting stations, for the years from 2005 to 2015. For the air quality analysis, we focus on data on nitrogen oxides because of the high frequency of missing values for the other pollutants. However, the concentration of oxides nitrogen is among the most common used indicator of air pollution – it is formed from the burning of fossil fuels (including vehicle emissions) and is associate with adverse health effects including respiratory problems and lung damage.[1] The dataset on traffic accidents comes from the Federal Roads Office instead and includes all accidents reported to the police in Switzerland in the 2005-2015 period. For any accident, there is information on date, time, location (municipality). Finally, I obtained daily data on EUR/SFr exchange rate from the Swiss National Bank.

[1]Nitrogen oxides also contribute to the formation of fine particles (PM) and ground level ozone.

2.2 Identification

In order to investigate the effect of cross-border traffic flows on the accident probability and the air quality level, we proceed as follows. First, we replicate the analysis provided in Bello (2019) and analyse the effect of the Swiss franc appreciation on the number of cars along the border. Second, we investigate the effect of exchange rate movements on both the accident probability and the air concentration of oxides nitrogen. Finally, we combine the two results and we estimate the effect of cross-border travel on road safety and air quality deprivation. In doing so, we address the omitted variable bias that would arise from regressing directly traffic volume on car accident probability and NOx emissions.[2]

Specifically, the identification strategy entails distinguishing two groups of municipalities in Ticino, according to their distance from the border, and comparing the patterns of the variables of interest between the two groups during the change in the Eur/Chf exchange rate. The two groups of municipalities are so identified: municipalities within 10 km of the border are in the *Treatment Group*, while the rest of them are in the *Control Group.* Air monitoring stations and traffic counting stations are divided into the two groups according to which municipality the station belongs. By comparing the two groups, it is possible to disentangle the impact of the monetary shock on both the car accident probability and the air pollutant concentration due to the rise in cross-border mobility from other effects that the exchange rate might have had. Moreover, since the changes in traffic flows are due to an exougenous monetary shock we can reasonably assume that they are uncorrelated to any other factors that influence the accident risk and the level of air pollution. This allows us to identify the causal effect of cross-border traffic flows on our variables of interests.

Figure 1 shows the location of air monitoring stations and of traffic counting stations, in the treated and control municipalities. The *Treatment Group* consists of 48 municipalities, while the *Control Group* is composed of 88 municipalities. In the analysis on traffic flows, I exclude the stations not active over the entire period of analysis as well as traffic-counting stations located on highways in order to exclude trade-related traffic flows. I end up with an unbalanced panel of 16 air monitoring stations and of 24 traffic counting station. 8 air monitoring stations and 11 traffic counting stations are in the *Treatment Group*, the rest in the *Control Group.*

[2]The bias would derive from omitting road characteristics or time-varying variables affecting simultaneously the two variables. For instance, lower level of traffic flows are observed at hours in which people are more tired and therefore more likely to be involved in a car accident. This would suggest, wrongly, the existence of a positive externality of driving.

2.3 Descriptive statistics

Figure 2 presents the evolution of the EUR/SFr exchange rate from 2000 through 2015. In the aftermath of the global financial crisis of 2008, the Swiss franc gained appreciably. Its value in euro terms passed, in fact, from 1,61 to 1,25. This was due to the special status of the Swiss franc as a typical safe haven currency. In an attempt to counteract the appreciation, the Swiss National Bank (SNB) on September 2011 decided to introduce a minimum exchange rate of CHF 1.2 per euro. To hold this ceiling, the SNB was forced to buy foreign currency in enormous quantities. Then in January 2015, in view of large quantitative easing packages from the European Central Bank, which would put substantial upward pressure on the Swiss Franc, the SNB announced that the minimum exchange rate for the Swiss franc against the euro would no longer be maintained and removed the cap. The Swiss franc immediately soared by 30% in value against the euro. The value of 1 euro fell to just Sfr 0.85.

Moreover, in order to provide evidence for the increase in traffic flows following the Swiss franc appreciation, in Figures 3, we show the correlation between the exchange rate and the average number of cars crossing a treated or control station. The figures show a clear increase in the average number of vehicles for the *Treatment Group* after the currency began to appreciate in 2008. The traffic flows seem to remain constant over time for the *Control Group* instead.

Finally, Tables 1, 2 and 3 provide summary statistics. Table 1 shows the hourly average number of cars during 5 time intervals (5-9am, 10am-1pm, 2pm-8pm, 9pm-11pm, 0am-4am), across the two groups of municipalities and for the two driving directions. Table 2 does so looking at the average probability that at least one car accident occurs in a given hour and Table 3 at the hourly concentrations of oxides of nitrogen (NOx).

3 Empirical Strategy

The first step consists of replicating the analysis provided by Bello (2019) and estimating the effect of the appreciation of the Swiss franc on the number of cars along the border. We aggregate the daily data at the monthly level, but we preserve the hourly structure of the data and distinguish working days from non-working days (Saturday and Sunday). We estimate the following model:

$$n_{iht} = \eta_1 \ln e_t + \eta_2 \ln e_t * Treat_i + \eta_3 X_t + \eta_4 After2007_t + f_i + m_t + \epsilon_{iht}; \quad (1)$$

where n_{iht} is the log of the monthly average number of cars crossing the traffic-counting station i at the hour h in time t (expressed in months).

We estimate the equation separately for working days and non-working days (Saturday and Sunday), for each travel direction and for 5 temporal intervals, namely 5-9am, 10am-1pm, 1pm-8pm, 9pm-11pm, and 12am-4am. Variable e_t represents the log of the EUR/SFr exchange rate, whereas $Treat_i$ is a dummy for traffic counting stations located within 10 km of the border. $e_t * Treat_i$ is the interaction term between the dummy and the exchange rate and measures the effect of our interest. X_t is a vector of control variables: the log of the Swiss GDP, the log of the Italian GDP and the log of the unemployment rate in Lombardy.[3] As in Bello (2019), we include a dummy for the period after full liberalization of the Swiss labour market to EU immigrants, namely after 2007 ($after2007_t$).[4] Finally, we include municipal fixed effects and month of the year fixed effects and indicate them with f_i and m_t, respectively.

In the second step, we turn at estimating the effect of the appreciation of the Swiss franc on road accident risk and air pollutant concentration level. For the car accident probability we convert the daily data in monthly totals and construct a binary variable equal to 1 if at least one accident occurs.[5] The hourly structure of the data is preserved.

Then, we estimate a probit model:[6]

$$p_{iht} = F(\eta_1 \ln e_t + \eta_2 \ln e_t * Treat_i + \eta_3 X_t + f_i + m_t + after2007_t + \epsilon_{iht}); \quad (2)$$

this time p_{iht} is a dummy variable that takes value 1 if at least one accident occurs in municipality i at the hour h in time t (expressed in months).

Finally, for the air pollutant concentration, we aggregate our daily data into monthly averages. Again, we preserve the hourly structure of the data and we distinguish 4 time intervals and working days from non-working days (Saturday and Sunday). We run the following model:

$$n_{iht} = \eta_1 \ln e_t + \eta_2 \ln e_t * Treat_i + \eta_3 X_t + f_i + m_t + after2007_t + \epsilon_{iht}; \quad (3)$$

where n_{iht} is the log of the monthly concentrations of NOx in municipality i at the hour h in time t (expressed in months).

[3]For the Swiss GDP, the Italian GDP and the unemployment rates I use quarterly data.

[4]In 2007, Switzerland fully opened its labor market to EU citizens. However, the liberalization was gradually implemented. With regards to cross-border workers three distinct phases can be identified: partial liberalization (1999-2004), full liberalization in border regions (2004-2007) and full liberalization anywhere in Switzerland (post-2007).

[5]We decide to use this approximation instead of the total number of accidents as of the monthly-hour-municipality observations in which an accident is observed, almost 86% have exactly one accident.

[6]In order to estimate the marginal effects we use the STATA's command dprobit, but the results are robust to the use of the .ado file inteff.ado supplied by Ai and Norton. The use of a linear model yields similar results in terms of magnitude of the coefficients.

3.1 Results on Traffic Flows

The results regarding the exchange rate effect on traffic flows are presented in Table 4. Traffic flows from Italy to Switzerland are analyzed in Panel 1 and from Switzerland to Italy in Panel 2. In line with the results provided in Bello (2019), the Table 4 in columns 1-2 show that a 10% appreciation of the Swiss Franc increased the number of cars crossing the Italian border by 2.7% more than in the rest of the canton in early morning, which corresponds to 16 additional cars per hour and per traffic counting station. In line with the cross-border labour supply hypothesis we find that the interaction term is negative and statistically significant also in column 7 Panel 2, which refers to the traffic flows from Switzerland to Italy during 2-8 pm, when, presumably, cross border workers are going back to Italy. The estimated effect is 1.6% and corresponds to 7 additional cars per hour. The interaction terms in columns 1-2 in Table 4, Panel 2 and columns 5-6 Table 4, Panel 1 are never statistically significant instead. Columns 4-6 of both panels refer to the second temporal interval (10am-1pm). The interaction terms appear negative and statistically significant. An increase of 10% in the EUR/SFr exchange rate is associated with an increase in the number of cars at late morning along the border of 1.6-1.8% (6 additional cars per hour and traffic counting station). The cross-border shopping hypothesis explains these results. The stronger the Swiss Franc, the higher the number of trips made by Swiss consumers to the less expensive Italian shops.[7]

3.2 Results on the car accident probability and air pollution

Table 5 presents the results on the monthly car accident probability. For any temporal interval there are again two columns, one for working days and one for non-working days. The interaction term turns out to be negative and statistically significant in columns 3 and 4, which speak at car accidents occurring during the second time interval (10am-1pm). A 10% appreciation of the Swiss franc is associated with a 0.4 and a 0.22 percentage points increase in the monthly car accident probability on working days and non-working days, respectively. In percentage terms, this corresponds to an increase of respectively 0.3% and 0.7%. Given a traffic volume of, on average, 400 cars per hour, an increase of 1.6%-1.8% in the number of vehicles produces an increase more than proportional in the car accident probability. Specifically, the elasticity turn out to be 1.8 for working days and 2.5 for non-working days. Thus, an additional car on the road doubles the probability of a car accident generating a negative and harmful externality. On the other hand, the rise in traffic flows found on working days

[7] In the appendix Table A.1 presents the results regarding night traffic flows.

during early morning and the evening, which are time-intervals characterized by a very high level of congestion, equal to around 560 cars per hour, and presumably of low traffic speed, does not translate into an increase in the risk of car crashes (columns 1 and 5).[8]

However, when we turn at analyzing the effect on air quality, we find evidence of a different pattern. Table 6 shows that the exchange rate positively affected the concentration of oxides of nitrogen in the air, especially at peak hours, on working days. A 10% appreciation increased NOx emissions of 3.4% and 3.1% on working days, respectively, during early morning and the afternoon (columns 1 and 5). The elasticity of the concentration of NOx to traffic flows ranges, this time, from 1.2 to 1.9. For the second time intervals no effect is found instead (columns 3 and 4). This is explained by the fact that the level of NOx emissions is mostly associate with congestion. During late morning, the rise in traffic flows was not large enough to decrease traffic speeds. Consequently, no effect on air quality is found.

4 Concluding remarks

Car accidents are predicted to become the seventh leading cause of death by 2030 and air pollution has been declared the largest environmental health hazard in Europe. Understanding patterns in these variables is thus relevant for health policy. The objective of the present work is to establish a causal relationship between traffic flows and both car accident risk and air pollution by exploiting variation in cross-border travel stemming from the Swiss franc's appreciation. The EUR/CHF exchange rate results in fact to be an important predictor of number of cars crossing the Swiss-Italian border Bello (2019). This paper shows that the appreciation of the Swiss franc was associated with a rise in the probability of road crashes and in the concentration of oxides of nitrogen during specific time intervals and days of the week. The effects on both variables is found to be double than the increase in traffic flows registered in the same period. These findings have important implications for governments and public policy that aim to promote road safety, improve air quality and implement optimal road pricing schemes.

[8]In the Appendix, Table A.2 presents the results for accidents occurring at night

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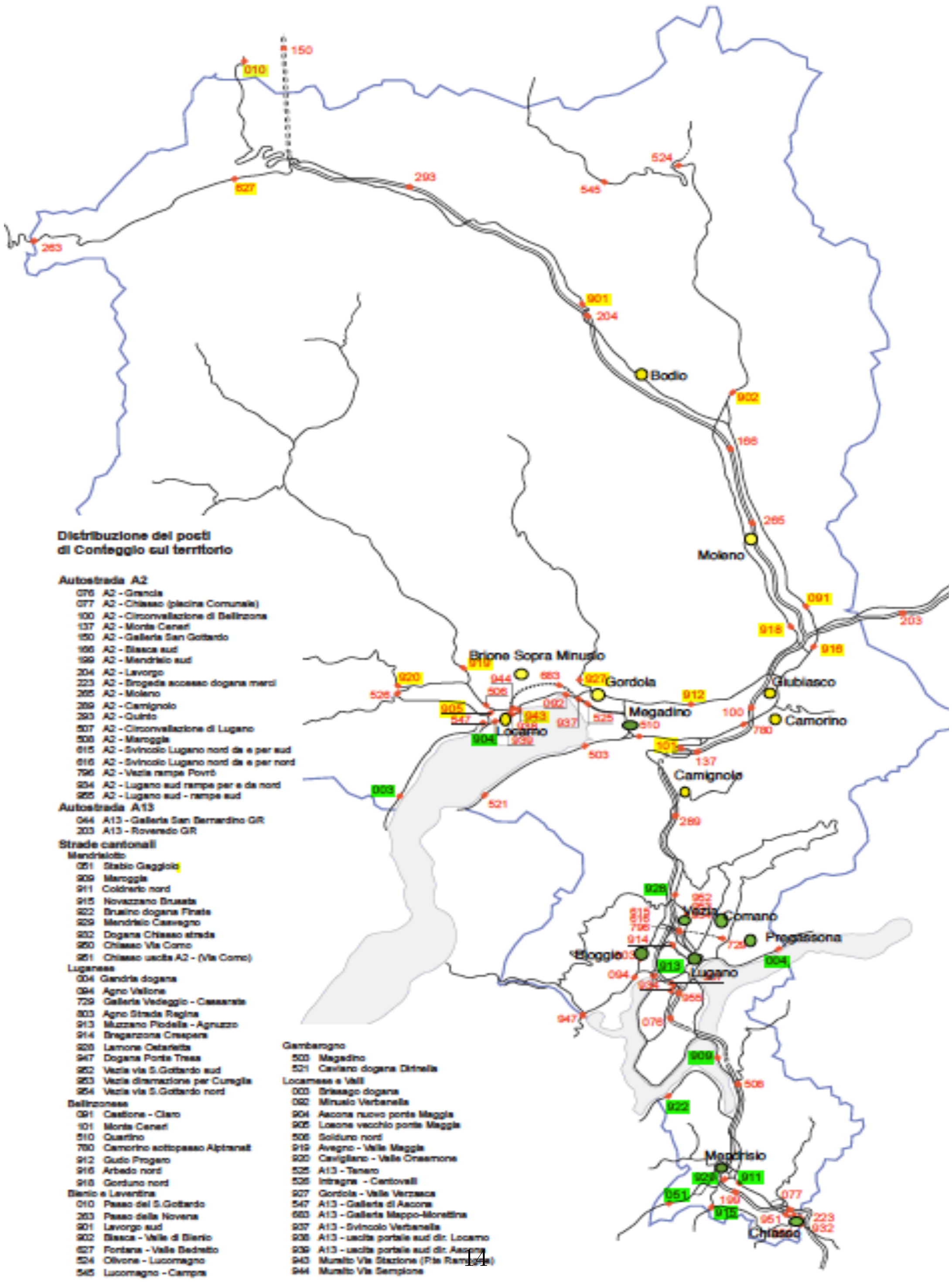
Figures

Figure 1: Distribution of traffic counting stations and air monitoring stations



Note. The map shows where the traffic counting stations and the air monitoring stations are located. The *Treatment Group* consists of the traffic counting stations (underlined in green on the map) or air monitoring stations (indicated by a green dot on the map) located within 10 km of the border, and the *Control Group* includes the rest of the traffic counting stations (underlined in yellow on the map) or air monitoring stations (indicated by a yellow dot on the map).

Figure 2: EUR/CHF Exchange rate, 2000-2015

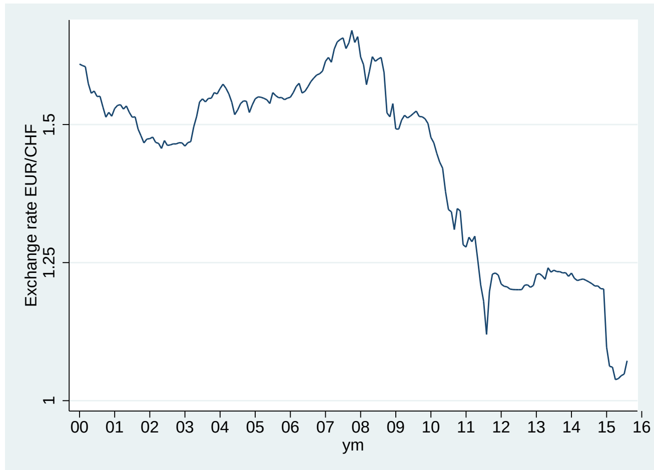
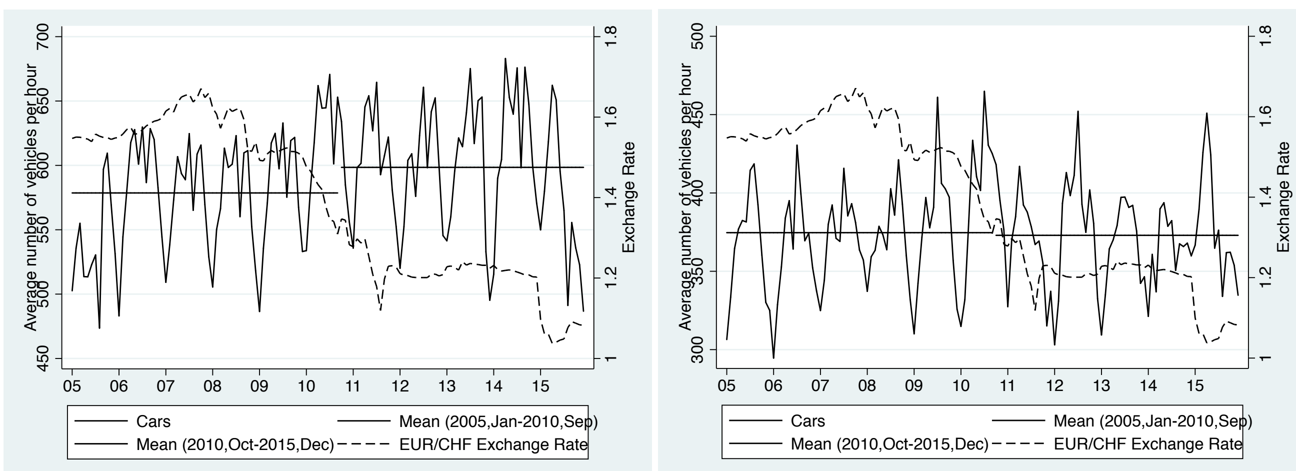


Figure 3: Annual and monthly variations in traffic flows



(a) *Treatment (<11 km)* (b) *Control (>10 km)*

Tables

Table 1: Descriptive statistics on the average number of cars

	24h	0-4am	5-9am	10am-1pm	2pm-8pm	9pm-11pm
Working days						
Cantonal roads, CH → IT						
	24h	0-4am	5-9am	10am-1pm	2pm-8pm	9pm-11pm
Control	206.3007	16.7531	237.9028	302.9989	310.1493	98.3369
sd	250.4359	25.3822	245.6195	257.6762	285.1338	105.3164
N	4.0e+04	8.4e+03	8.4e+03	6.7e+03	1.2e+04	5.0e+03
Treatment	319.5653	36.3079	239.1477	428.4857	576.6286	180.6486
sd	319.5235	33.4009	240.9429	280.9838	338.5098	108.3275
N	3.2e+04	6.7e+03	6.7e+03	5.4e+03	9.4e+03	4.0e+03
Cantonal roads, IT→ CH						
	24h	0-4am	5-9am	10am-1pm	2pm-8pm	9pm-11pm
Control	189.7291	16.3541	194.2229	286.0042	297.1843	92.1039
sd	223.9871	20.7984	213.2276	227.3380	253.6349	83.1136
N	4.0e+04	8.3e+03	8.3e+03	6.7e+03	1.2e+04	5.0e+03
Treatment	318.8395	25.3798	560.0630	446.1138	364.8378	128.8713
sd	318.1999	25.7494	323.6925	300.0824	294.2228	95.5605
N	3.2e+04	6.7e+03	6.7e+03	5.4e+03	9.4e+03	4.0e+03
Non-working days						
Cantonal roads, CH → IT						
	24h	0-4am	5-9am	10am-1pm	2pm-8pm	9pm-11pm
Control	166.5105	41.7847	106.0605	257.6917	272.4098	106.3891
sd	193.4165	60.9848	123.9801	206.0296	231.6127	113.2092
N	4.0e+04	8.4e+03	8.4e+03	6.7e+03	1.2e+04	5.0e+03
Treatment	236.7214	88.7975	141.9196	362.5955	374.3062	152.4008
sd	213.7509	70.9649	149.4765	223.7752	227.5684	91.9192
N	3.2e+04	6.7e+03	6.7e+03	5.4e+03	9.4e+03	4.0e+03
Cantonal roads, IT→ CH						
	24h	0-4am	5-9am	10am-1pm	2pm-8pm	9pm-11pm
Control	151.3935	42.8608	94.7327	249.5787	238.6098	92.2757
sd	164.5793	51.1852	108.1092	181.8757	188.3706	82.9123
N	4.0e+04	8.3e+03	8.3e+03	6.6e+03	1.2e+04	5.0e+03
Treatment	233.5758	53.4090	173.6116	377.7385	355.0689	158.0935
sd	222.0583	55.2434	148.6979	235.5496	243.7519	109.5937
N	3.2e+04	6.7e+03	6.7e+03	5.4e+03	9.4e+03	4.0e+03

Note. The symbol 'CH->IT' indicates north to south flows, and 'IT->CH' indicates south to north flows. The first group (*CLOSE*) includes traffic-counting stations located within a road distance of up to 10 km from the border, and the second group *FAR* includes the remaining traffic-counting stations. An observation is a traffic-counting station–month–year–hour. Source: Sezione Mobilità del Canton Ticino (2005-2015).

Table 2: Descriptive statistics on the monthly average probability of a car accident

Accidents						
Working days						
	24h	0-4am	5-9am	10am-1pm	2pm-8pm	9pm-11pm
Control	0.0614	0.0291	0.0544	0.0796	0.0836	0.0507
sd	0.2400	0.1681	0.2269	0.2706	0.2768	0.2194
N	2.8e+05	5.8e+04	5.8e+04	4.6e+04	8.1e+04	3.5e+04
Treatment	0.0885	0.0393	0.0808	0.1219	0.1233	0.0578
sd	0.2841	0.1943	0.2725	0.3272	0.3288	0.2334
N	1.5e+05	3.2e+04	3.2e+04	2.5e+04	4.4e+04	1.9e+04
Non-Working Days						
	24h	0-4am	5-9am	10am-1pm	2pm-8pm	9pm-11pm
Control	0.0164	0.0071	0.0140	0.0214	0.0232	0.0136
sd	0.1271	0.0838	0.1175	0.1448	0.1505	0.1160
N	5.6e+05	1.2e+05	1.2e+05	9.3e+04	1.6e+05	7.0e+04
Treatment	0.0263	0.0113	0.0226	0.0372	0.0372	0.0177
sd	0.1600	0.1055	0.1486	0.1892	0.1891	0.1317
N	3.0e+05	6.3e+04	6.3e+04	5.1e+04	8.9e+04	3.8e+04

Note. Years 2005-2015. The *Treatment Group* consists of municipalities within 10 km of the border, the *Control Group* includes the rest of municipalities. An observation is a municipality-month-hour. Source: Federal Roads Office.

Table 3: Descriptive statistics: Monthly average concentration of nitrogen oxides (NOx)

Nox						
Working days						
	24h	0-4am	5-9am	10am-1pm	2pm-8pm	9pm-11pm
Control	53.4663	23.7689	81.8830	48.3223	60.4439	46.1315
sd	53.2334	21.0035	71.0761	38.0937	54.1928	41.3596
N	1.4e+04	3.0e+03	3.0e+03	2.4e+03	4.2e+03	1.8e+03
Treatment	35.6259	20.3007	52.9112	33.3734	35.9428	34.6466
sd	34.6756	19.1396	45.2623	27.1910	34.0189	31.8499
N	1.9e+04	3.9e+03	3.9e+03	3.1e+03	5.5e+03	2.4e+03
Nonworking days						
	24h	0-4am	5-9am	10am-1pm	2pm-8pm	9pm-11pm
Control	36.2449	29.6710	46.3703	30.3626	37.1198	36.1160
sd	31.5219	24.0939	39.3376	24.4356	32.9113	28.0964
N	1.4e+04	3.0e+03	3.0e+03	2.4e+03	4.2e+03	1.8e+03
Treatment	21.8507	22.1256	25.6033	17.6029	20.5729	23.7834
sd	19.4383	19.7122	20.6704	14.6996	19.8360	20.0572
N	1.9e+04	3.9e+03	3.9e+03	3.1e+03	5.5e+03	2.3e+03

Note. Years 2005-2015. The *Treatment Group* consists of monitoring stations in municipalities within 10 km of the border, the *Control Group* includes the rest of stations. An observation is an air monitoring station-month-hour. Source: Sezione Mobiltà Canton Ticino.

Table 4: Monthly average number of cars

Panel 1: IT → CH, Day						
	(1)	(2)	(3)	(4)	(5)	(6)
	Mon-Fri	Sat-Sun	Mon-Fri	Sat-Sun	Mon-Fri	Sat-Sun
	5am-9am	5am-9am	10am-1pm	10am-1pm	2pm-8pm	2pm-8pm
ln e	-0.137	0.049	-0.010	0.025	-0.083	-0.039
	(0.118)	(0.097)	(0.060)	(0.070)	(0.067)	(0.063)
Treatment* ln e	-0.266*	-0.269**	-0.161*	-0.111	0.020	0.112
	(0.136)	(0.116)	(0.083)	(0.088)	(0.087)	(0.089)
Observations	15,037	15,015	12,040	12,024	21,063	21,032
R-squared	0.710	0.601	0.936	0.909	0.857	0.828
Panel 2: CH→IT, Day						
	(1)	(2)	(3)	(4)	(5)	(6)
	Mon-Fri	Sat-Sun	Mon-Fri	Sat-Sun	Mon-Fri	Sat-Sun
	5am-9am	5am-9am	10am-1pm	10am-1pm	2pm-8pm	2pm-8pm'
ln e	-0.082	-0.097	-0.032	0.022	-0.026	0.043
	(0.086)	(0.089)	(0.052)	(0.055)	(0.072)	(0.053)
Treatment* ln e	-0.181	-0.025	-0.177**	-0.163**	-0.165*	-0.001
	(0.158)	(0.118)	(0.069)	(0.075)	(0.085)	(0.065)
Observations	15,100	15,089	12,087	12,080	21,145	21,129
R-squared	0.647	0.555	0.942	0.917	0.825	0.828
Controls FE	YES	YES	YES	YES	YES	YES
Monthly FE	YES	YES	YES	YES	YES	YES
Station FE	YES	YES	YES	YES	YES	YES

Note. The dependent variable is the log of the monthly average number of cars crossing a specific station in a given hour. The symbol 'CH->IT' indicates north-to-south flows, and 'IT->CH' indicates south-to-north flows. CLOSE is a dummy for the traffic-counting stations located within a driving distance of up to 10 km from the border. Controls include the log of the Swiss GDP, the log of the Italian GDP, and the log of the unemployment rate in Lombardy. Monthly and traffic-counting station fixed effects, as well as a dummy for the period after 2007, are also included. Robust standard errors (in parentheses) are clustered at the traffic-counting station level. An observation is a traffic-counting station–month–year–hour. The following symbols indicate different significance levels: *** p<0.01, ** p<0.05, * p<0.1. Source: Sezione Mobilità del Canton Ticino (2005-2015).

Table 5: Monthly probability of an accident, Probit (MEs), Day

	(1) Wday 5am-9am	(2) NWday 5am-9am	(3) Wday 10am-1pm	(4) NWday 10am-1pm	(5) Wday 2pm-8pm	(6) NWDAY 2pm-8pm
ln e	0.002	0.001	0.066***	0.012	0.033**	0.001
	(0.012)	(0.008)	(0.018)	(0.011)	(0.014)	(0.009)
Treat* ln e	-0.001	-0.000	-0.040**	-0.022**	0.006	-0.003
	(0.012)	(0.008)	(0.017)	(0.009)	(0.014)	(0.009)
Observations	84,480	84,480	68,640	65,472	123,816	116,424
Pseudo R-squared	0.178	0.167	0.266	0.243	0.245	0.217
Mun FE	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES

*Note.*Years 2005-2014. The dependent variable is a dummy variable equal to 1 if at least one car accident occurs in a given hour. Treat is a dummy for municipalities within 10 km of the border. I control for log of the Swiss GDP, log of the Italian GDP, log of the unemployment rate in Lombardy and log of the unemployment rate in Italy. Monthly and municipality fixed effects, and a dummy for the period after 2007 are also included. Robust standard errors in parentheses clustered at the municipal level. An observation is a municipality-month-hour.

Table 6: Monthly average concentration of nitrogen oxides (Nox, mg/m3), Day

	(1) Wday 5am-9am	(2) NWday 5am-9am	(3) Wday 10am-1pm	(4) NWday 10am-1pm	(5) Wday 2pm-8pm	(6) NWday 2pm-8pm
ln e	0.078	0.061	0.326***	-0.010	0.365**	-0.199
	(0.151)	(0.146)	(0.088)	(0.152)	(0.136)	(0.207)
Treat*ln e	-0.346**	-0.276	-0.223	-0.059	-0.312*	0.028
	(0.159)	(0.161)	(0.197)	(0.163)	(0.178)	(0.172)
Observations	6,932	6,895	5,547	5,516	9,712	9,653
R-squared	0.722	0.842	0.791	0.801	0.849	0.819
Mun FE	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES

*Note.*Years 2005-2014. Years 2005-2014. The dependent variable is the monthly average concentration of nitrogen oxides in a given hour. Treat is a dummy for monitoring stations in municipalities within 10 km of the border. I control for log of the Swiss GDP, log of the Italian GDP and log of the unemployment rate in Lombardy. Monthly and station fixed effects, and a dummy for the period after 2007 are also included. Robust standard errors in parentheses clustered at the monitoring station level. An observation is an air monitoring station-month-hour.

Appendix

Table A.1: Monthly average number of cars, Night

Panel 1: IT → CH, Night				
	(1)	(2)	(3)	(4)
	Mon-Fri	Sat-Sun	Mon-Fri	Sat-Sun
	8pm-11pm	8pm-11pm	12am-4am	12am-4am
ln e	-0.234**	-0.254**	-0.022	-0.035
	(0.099)	(0.096)	(0.177)	(0.163)
Treatment * ln e	0.267	0.364**	-0.663	-0.232
	(0.167)	(0.162)	(0.560)	(0.539)
Observations	9,021	9,006	14,978	14,963
R-squared	0.903	0.927	0.750	0.806
Panel 2: CH→IT, Night				
	(1)	(2)	(3)	(4)
	Mon-Fri	Sat-Sun	Mon-Fri	Sat-Sun
	8pm-11pm	8pm-11pm	12am-4am	12am-4am
ln e	-0.078	-0.092	-0.181	-0.110
	(0.082)	(0.093)	(0.117)	(0.106)
Treatment* ln e	0.036	0.243	-0.026	0.152
	(0.110)	(0.144)	(0.652)	(0.665)
Observations	9,056	9,048	15,025	15,005
R-squared	0.903	0.941	0.794	0.823
Controls FE	YES	YES	YES	YES
Monthly FE	YES	YES	YES	YES
Station FE	YES	YES	YES	YES

Notes: The dependent variable is the log of the monthly average number of cars crossing a specific station in a given hour. The symbol 'CH->IT' indicates north-to-south flows, and 'IT->CH' indicates south-to-north flows. Treatment is a dummy for the traffic-counting stations located within a driving distance of up to 10 km from the border. Controls include the log of the Swiss GDP, the log of the Italian GDP, and the log of the unemployment rate in Lombardy. Monthly and traffic-counting station fixed effects, as well as a dummy for the period after 2007, are also included. Robust standard errors (in parentheses) are clustered at the traffic-counting station level. An observation is a traffic-counting station–month–year–hour. The following symbols indicate different significance levels: *** p<0.01, ** p<0.05, * p<0.1. Source: Sezione Mobilità del Canton Ticino (2005-2015).

Table A.2: Probability of an accident, Probit (MEs), Night

	(1) Wday 9pm-11pm	(2) NWday 9pm-11pm	(3) Wday 12am-4am	(4) NWday 12am-4am
Treat	-0.040***	-0.025***	-0.037***	-0.013***
	(0.005)	(0.003)	(0.002)	(0.001)
Treat*ln e	0.012	0.011	0.025***	-0.002
	(0.015)	(0.010)	(0.007)	(0.005)
Observations	49,896	48,708	83,160	77,880
Pseudo R-squared	0.169	0.144	0.159	0.143
Municipal FE	YES	YES	YES	YES
Monthly FE	YES	YES	YES	YES

*Note.*Years 2005-2014. The dependent variable is a dummy variable equal to 1 if at least one car accident occurs. Treat is a dummy for municipalities within 10 km of the border. I control for the log of the Swiss GDP, the log of the Italian GDP and the log of the unemployment rate in Lombardy. Monthly and municipality fixed effects, and a dummy for the period after 2007 are also included. Robust standard errors in parentheses clustered at the municipal level. An observation is a municipality-month-hour. The following symbols indicate different significant levels: *** p<0.01, ** p<0.05, * p<0.1. Source: Federal Roads Office.

Table A.3: Monthly average concentration of nitrogen oxides (Nox, mg/m3), Night

	(1) Wday 9pm-11pm	(2) NWday 9pm-11pm	(3) Wday 0am-4am	(4) NWday 12am-4am
ln e	0.030	-0.167	-0.206	-0.237
	(0.158)	(0.187)	(0.142)	(0.207)
Treat*ln e	-0.164	0.076	-0.080	-0.144
	(0.130)	(0.184)	(0.134)	(0.228)
Observations	4,164	4,136	6,931	6,891
R-squared	0.902	0.876	0.871	0.827
Station FE	YES	YES	YES	YES
Monthly FE	YES	YES	YES	YES

*Note.*Years 2005-2015. The dependent variable is the monthly average concentration of oxides of nitrogen in a given hour. Treat is a dummy for monitoring stations in municipalities within 10 km of the border. I control for the log of the Swiss GDP, the log of the Italian GDP and the log of the unemployment rate in Lombardy. Monthly and station fixed effects, and a dummy for the period after 2007 are also included. Robust standard errors in parentheses clustered at the monitoring station level. An observation is an air monitoring station-month-hour. The following symbols indicate different significant levels: *** p<0.01, ** p<0.05, * p<0.1. Source: Sezione Mobilità Canton Ticino