Case 2: The Impact of Crime Precaution Technology Adoption on Crime

Team 4

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Abstract

We study the causal impact of shutter adoption on burglary rates in the Netherlands. Using a geographic variation induced by the Maas and Waal rivers, we employ a regression discontinuity design to test the hypothesis that shutter adoption reduces crime. We show evidence that shutter adoption significantly decreases the probability that one is burgled; our baseline specification suggests that adopting shutters decreases the probability of being burgled by 0.4%. After establishing this causal link, we test whether shutter prevalence can be explained by a "social cohesion" mechanism by using a regression discontinuity design based on a historical boundary defined by the 1648 Treaty of Münster. We reject this social cohesion hypothesis, which lends more support for the geographic contagion hypothesis of shutter adoption.

Contents

1 Introduction

Societies and individuals invest significant time and capital into crime deterrence, where private expenditure can even outpace public expenditure (Shavell, 2015). Separately, there has been a marked decline in the rates of crime throughout the developed world since the 1980s, which has been the subject of many studies, including Donohue and Levitt (2008) and Colen et al. (2016). One of the salient explanations for the decline in crime rates is the adoption of crime-preventing technologies such as more secure windows in houses and engine immobilisers in cars (Vollaard and van Ours, 2011; van Ours and Vollaard, 2016). These papers exploit exogenous policy regime changes where consumers either do not have a choice (in the case of house protections) or do not realize they have a choice (in the case of engine immobilisers) over the level of crime prevention technologies they adopt.

This paper assesses the causal impact of a particular crime-precaution technology, the roll-down window shutter, on reducing the crime rate in the Netherlands. These externally mounted metal shutters provide very high levels of protection against burglaries since they are very difficult to remove or penetrate, and they completely cover the most obvious weakness of windows: the glass itself. They are very clearly visible, fairly costly, and once installed, permanent. Furthermore, our previous work documents a trend in which shutter adoption appears to spread largely due to spatial spillover effects. Therefore, understanding the impact of the shutter adoption on crime is not only important in its own right, but also motivates further study of the mechanisms that drive these spatial spillovers influencing the spread of precautionary measure adoption.

The main threat to causal identification between shutter adoption and crime is that crime rates are affecting adoption rather than vice versa. To circumvent this difficulty, our main empirical strategy uses the discontinuity in shutter adoption related to one's location relative to the natural geographic boundary based on the modern border formed by the Maas and Waal. The intuition for exploring the first discontinuity based on the Rivers is based on our previous work, which showed that the presence of the River made it less likely that shutters were adopted to the north, possibly due to a social contagion mechanism.

Using our baseline regression discontinuity design, we find that shutter adoption has a significant causal impact on reducing burglary rates. Furthermore, our analysis suggests that shutter adoption is broadly associated with lower "property" crimes, such as bicycle thefts or thefts from one's car. Conversely, shutter adoption has no effect on reducing "personal" crimes such as pickpocketing or assault.

After establishing the causal link between shutter adoption and burglary rates, we further explore the mechanism for shutter adoption. Having already explored suggestive evidence of the social contagion hypothesis on Day 1, we study a different mechanism that may explain the variation in shutter adoption – namely whether a notion of local trust or social cohesion, which we proxy by local religiosity, explains shutter prevalence. We test this alternative mechanism by assessing whether we can explain the causal link between shutter adoption and crime reduction equally well by using a regression discontinuity design based on the borders between Catholic and Protestant regions formed by the 1648 Treaty of Münster in 1648. This alternative treatment is based on the literature in economic history and cultural economics that demonstrates the diverging attitudes towards trust and neighborly cohesion between Protestants and Catholics makes the "intention to treat" Catholic zones a plausible predictor for shutter adoption. Based on our empirical results, we reject the hypothesis that cultural differences explain the causal effect

of shutter adoption on crime, thereby giving more support for the social contagion hypothesis.

This paper proceeds as follows: Section 2 describes the data used for analysis. Section 3 provides a detailed discussion of our empirical strategy; in particular, our motivation and implementation of the regression discontinuity design. Section 4 shows our preliminary results of the regression discontinuity analysis. Section 5 discusses our analysis of the alternative religion-based mechanism for shutter adoption based on the historical regression discontinuity. Section 6 discusses limitations and concludes.

2 Data

The data come from several surveys of households in the Netherlands conducted over the 2005-2008 period. The survey is representative at a national level, and we treat it as a cross-section in our analysis since we do not have a panel. The main topics of the survey are individuals' views on crime and safety, personal history with crime vicitimization, adoption of crime-deterring investments, and demographic variables.

2.1 Control variables

In the main regressions below, we include a range of control variables based on individual responses to the national crime surveys. For municipality-level regressions, these survey responses are aggregated by age group and reweighted to be representative of the true age structure of the municipality, as described in Section 2.2 below.

We include the ethnic origin (native, Western immigrant, Non-Western immigrant) as an indicator of local diversity, which may affect social cohesion and trust (e.g. Putnam (2007)), although there is disagreement on whether this effect exists in Europe (Gesthuizen et al., 2009). Moreover, higher education levels, and whether the main household income source is benefits or wage earnings, as well as household income categories are included as proxies for socio-economic status; the age structure is included because there is some evidence that age correlates with fear of crime (Mark, 1984; Ortega and Myles, 1987). Given that crime incidence varies greatly between urban centers and rural areas, we also control for the municipality population (in 2006).

2.2 Reweighting survey results by demographic characteristics

To assess heterogeneity in the causal impact of shutter adoption on crime, we examine municipality-level variables, including the average shutter prevalence within a municipality among other controls. In order to obtain the average shutter prevalence for each municipality, we can aggregate the individual-level survey data into shutter prevalence for each of the 4 age-groups described in the previous section for each municipality, and then take a weighted average of shutter prevalence based on the distribution of age-groups within the municipality. However, because the survey is representative at the national level, but not necessarily at the municipality level, we need to reweight each age-group's shutter prevalence by the true distribution of age-groups for each municipality rather than weighting shutter prevalence by the distribution of age-groups implied by the survey responses for each municipality.

To clarify this reweighting process, consider a simple example in which shutter prevalence in a particular municipality is 15% among survey respondents younger than 45 and 35% among survey respondents 45 or older, and that the crime survey has an equal number of respondents within

each of these age groups for this municipality. Without any reweighting, we would calculate this municipality's average shutter prevalence as $15\% * (.5) + 35\% * (.5) = 25\%$. However, if this municipality's true proportion of homeowners younger than 45 is 25% and its true proportion of homeowners older than 45 is 75%, then the municipality's true average shutter prevalence is $15\% * (.2) + 35\% * (.8) = 30\%$. Mathematically, we can summarize this reweighting procedure to calculate average shutter prevalence for each municipality m as:

$$E[S_m] = \sum_{i=1}^{4} E[S_m|A_i] \cdot P(A_{im}), \tag{1}$$

where $E[S_m]$ is defined as average shutter prevalence for municipality m that we are trying to calculate, and $E[S_m|A_i]$ is the shutter prevalence for age-group i within municipality m obtained from aggregating individual-level survey data. The 2008 Dutch shape file (gem_2008_gn3_WGS84) contains the true proportion of homeowners within each age-group i for each municipality m, defined as $P(A_{im})$ in Equation 1. Thus, after aggregating the survey respondents' shutter prevalence by age-group for each municipality, we use the true proportions from the shape file to calculate each municipality's average shutter prevalence using the reweighting procedure described above [1].

In addition to using this reweighting procedure to calculate average shutter prevalence by municipality, we use this same reweighting procedure to calculate all municipality averages of interest that we use in our subsequent analysis.

3 Empirical Analysis & Results

The geographical distribution of shutter adoption rates from South to North creates a natural discontinuity at the River Waal. Our previous work has shown that there are geographical spillovers in adoption rates, but this is impeded by the river. An illustration of the discontinuity we intend to exploit is shown in Figure 1. The river is widest at its mouth, and therefore it is most likely to form a geographical impediment to the spread of shutter adoption rates in the western half of the country[2].

3.1 Regression Discontinuity Design

In our analysis we will exploit geographic and historical discontinuities in the Dutch territory to employ a regression discontinuity design. In particular, we use a Fuzzy RD method, in which a discontinuous change in the expected value of a random variable d_i occurs at a cutoff value x_0 along a continuous underlying observable dimension x_i, such that we can separate observations into being "above" or "below" the cutoff.

In that case, we can estimate the following Fuzzy RD effect by evaluating the change in the

[1] Technically the shape file also provides the true proportion of people in the municipality younger than 15, but we will assume for simplicity that this younger group does not own homes, so we simply reweight the proportions of the 4 older age-groups described above so that they sum to 1 for each municipality.

[2] The restriction to the western half of the country limits our sample size to roughly half the original sample size, reducing it from 65,000 observations to 34,000 observations.

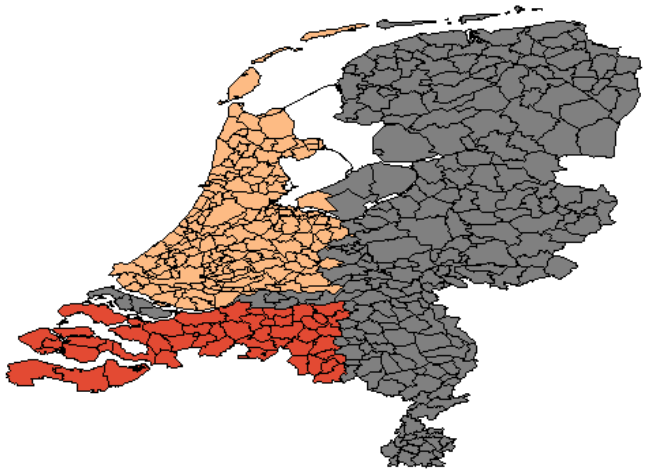


Figure 1: River Waal Border in The Netherlands

outcome variable as we approach the cutoff:

$$\tau_{FRD} = \frac{\lim_{x \to x_0^+} E[Y_i|X_i = x] - \lim_{x \to x_0^-} E[Y_i|X_i = x]}{\lim_{x \to x_0^+} E[d_i|X_i = x] - \lim_{x \to x_0^-} E[d_i|X_i = x]}$$

This estimate gives us the causal effect of the discontinuity under the assumption that there is in fact a jump in the discontinuity variable d_i, there would not have been a jump in the outcome variable without the forced jump in the discontinuous variable, the assignment to being above or below the cutoff is uncorrelated with the effects from the discontinuous jump, and the treatment in question only moves d_i into one direction at the cutoff. Under these assumptions, τ_{FRD} represents an estimate of a Local Average Treatment Effect. We can estimate τ_{FRD} using a linear regression framework of the form

$$Y_i = \alpha + \tau_{FRD} \cdot D_i + \beta(x_i - x_0) + \gamma(x_i - x_0) \cdot 1\{x_0 \leq X_i\} + \xi B_i + \epsilon_i,$$

where γ is the coefficient of interest - the size of the fitted discontinuity in the outcome variable, and B_i is a vector of control variables.

In the context of the main RD models estimated below, the continuous variable x_i is latitude or distance to the historical Catholic territory boundary, the cutoff occurs at x_0, where this is the latitude corresponding to the rivers Waal and Maas, or to the border of the former Generality States. The "jump" variable d_i is the shutter rate, and the outcome variable of interest Y_i is the property crime rate.

Considering the necessary assumptions for the RD design to deliver a LATE, the location of the rivers and the historical territorial control are plausibly exogenous discontinuities that would be expected to change the effective contagion as a result of the spread of visible shutters - rivers impede the mobility of people and the visibility of shutters - and culture and politics as result of territorial control can affect trust and preferences for privacy, which affect the prevalence of shutters. At the same time, there is no strong a priori reason why crime rates should vary discontinuously at these borders otherwise, so it is at least plausible that the assumptions mentioned above are realistic in the cases discussed in this paper.

Table 1: Comparison of Covariates: North and South of Rivers

	North of Rivers	South of Rivers	p value
Age 15-24	0.149	0.154	0.090
Age 25-34	0.150	0.135	0.119
Age 35-44	0.200	0.196	0.325
Age 45-54	0.191	0.182	0.029
Age 45-64	0.156	0.166	0.323
Age 65-74	0.092	0.112	0.000
Age $\geq$ 75	0.062	0.057	0.135
Ethnic origin	1.294	1.163	0.000
Higher ed.	0.228	0.211	0.000
Income <10K€	0.052	0.052	0.711
Income 10K€-20K€	0.154	0.151	0.020
Income 20K€-30K€	0.227	0.228	0.140
Income 30K€-40K€	0.195	0.207	0.165
Income >40K€	0.259	0.261	0.114
Income not reported	0.113	0.101	0.107
Benefit recipient	0.059	0.055	0.088
Wage earner	0.658	0.674	0.691
Married	0.548	0.581	0.000
Children (yes/no)	0.420	0.406	0.896
Ln(Population)	11.260	10.776	0.000

P value is from two-sided test of equal means.

3.1.1 Covariate Balance

The main assumption underlying Regression Discontinuity designs is that the individuals on the two sides of a border are comparable in all dimensions except for the "treatment". It is only possible to test the observable characteristics, and in this case, the ones that are included in our dataset. Covariate balance is is shown in Table 1.

For most variables, the covariates do not differ significantly on the two sides of the river. Since many of the variables are binned indicators rather than continuous, such as Age and Income, there are some bins at the extreme ends that are significantly different, likely due to the smaller number of observations in those bins. Other covariates that differ significantly are ethnic origin, higher education, and marriage. Given that the large cities in the Netherlands are predominantly in the North, it is not surprising that the more educated and ethnically diverse population is higher in the north, and that the marriage rates are higher in the south. To deal with the heterogeneity in these observable characteristics across the border, we include all of these variables in our regressions as controls.

3.2 Reduced Form OLS

$$Crime_i = \alpha + \tau_{FRD} \cdot D_i + \beta(x_i - x_0) + \gamma(x_i - x_0) \cdot 1\{x_0 \leq X_i\} + \xi B_i + \epsilon_i \tag{2}$$

Table 2: Reduced Form Regressions of Crime on Geography

	Property-Related Crime				
	Burglary	Burglary Attempt	Burglary + Attempt	Bicycle Theft	Theft from Car
South of Rivers	-0.003	-0.003	-0.004	-0.026***	-0.014**
	(0.005)	(0.005)	(0.009)	(0.008)	(0.006)
	[0.491]	[0.636]	[0.612]	[0.002]	[0.024]
N	33,671	33,671	33,671	33,671	33,671
R^2	0.006	0.007	0.011	0.073	0.028
	Personal Crime				
	Assault	Sexual Assault	Threat	Violent Theft	Pickpocket
South of Rivers	-0.006*	0.002	-0.010***	-0.001	-0.008**
	(0.003)	(0.003)	(0.004)	(0.001)	(0.003)
	[0.052]	[0.463]	[0.009]	[0.299]	[0.016]
N	33,671	33,671	33,671	33,671	33,671
R^2	0.034	0.015	0.034	0.007	0.012

Standard errors are clustered at the municipality level. All regressions also include individual controls, as described in section 2.

This specification follows the general RD specification outlined in Section 3.1 where we directly predict Crime outcomes using the distance from the river. We have two primary groups of crime outcomes, those pertaining to Property crime (such as burglary, bike theft, car theft) and those pertaining to Personal crime (such as assault or pickpocketing). The main results are shown below in Table 2.

Table 2 shows that being South of the River Waal does not significantly reduce incidences of burglary and burglary attempts, but it does lower the incidence of bicycle theft by 2.6% and theft from cars by 1.4%. There are also statistically significant lower rates of assault, threat, and pickpocketing in terms of personal crime, but the coefficients are much lower. These ambiguous results in the Reduced Form relative to those in the RD results also motivate the mechanisms that we explore in section 5.

3.3 First Stage

$$S_i = \alpha + \tau_{FRD} \cdot D_i + \beta(x_i - x_0) + \gamma(x_i - x_0) \cdot 1\{x_0 \leq X_i\} + \xi B_i + \epsilon_i \tag{3}$$

This specification uses the treatment of distance from the discontinuity to predict shutter rates. The River borders are highly predictive of the likelihood of adopting shutter rates. 3.

Table 3: First Stage Results

	South of Rivers
First-stage coefficient	12.452**
	(5.544)
	[0.026]
N	33,671
R^2	0.064

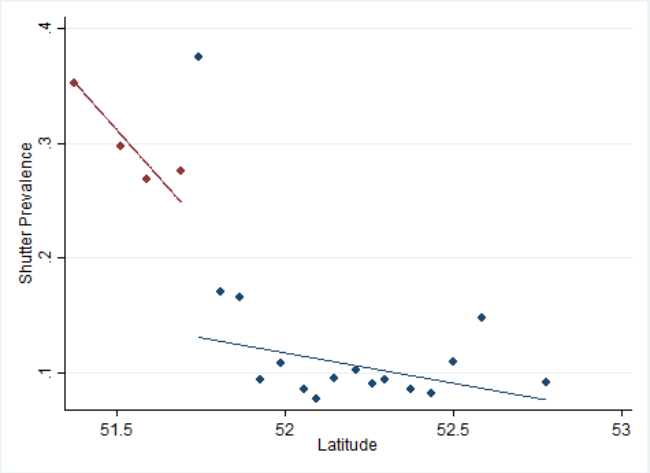


Figure 2: Discontinuity in Shutter Adoption Rates across River Borders

Visually, these are shown in Figure 2. The red dots signify the individuals in lower latitudes and show that there is a clear positive jump in the rate of adoption. Based on these figures, in our regressions we allow we allow for the slopes of the adoption prevalence to vary on both sides as well.

4 Fuzzy RD Results

The results from the Fuzzy RD specification are shown in Table 4. This shows the causal impact of shutter adoption on crime incidence across a variety of crimes, broadly categorized as "property" and "personal" crimes. The coefficients are much larger in magnitude and statistically significant relative to the Reduced Form results. These results indicate that there is a large amount of unobserved heterogeneity between the north and south which affect crime rates.

The coefficients indicate that adopting shutters lowers the incidence of burglary by roughly 36%, burglary attempts by 38%, and the total of the two by 69%. Bicycle theft is not impacted, which is understandable given the large prevalence of bicycle thefts in the Netherlands and the fact that these are less likely to occur near an individual's house. Thefts from cars are also reduced by 57%, which accords with the reduction in other forms of property crime given that cars are often parked close to one's house.

Table 4: Regression Discontinuity Results of Crime on Shutter Use (Discontinuity=South of Rivers)

	Property-Related Crime				
	Burglary	Burglary Attempt	Burglary + Attempt	Bicycle Theft	Theft from Car
Shutters	-0.361*	-0.382*	-0.669*	-0.215	-0.572**
	(0.209)	(0.217)	(0.376)	(0.171)	(0.288)
	[0.084]	[0.078]	[0.075]	[0.209]	[0.047]
N	33,671	33,671	33,671	33,671	33,671
	Personal Crime				
	Assault	Sexual Assault	Threat	Violent Theft	Pickpocket
Shutters	0.055	0.083	0.024	-0.023	0.072
	(0.088)	(0.091)	(0.082)	(0.039)	(0.115)
	[0.531]	[0.361]	[0.773]	[0.556]	[0.530]
N	33,671	33,671	33,671	33,671	33,671

Standard errors are clustered at the municipality level. All regressions also include individual controls, as described in section 2.

4.1 Falsification Tests

Adopting observable crime precaution technologies such as roll-down shutters should reduce incidences of property crime, such as burglaries and potentially thefts from cars. This follows from a simple model in which thieves must choose a specific neighborhood to target, and their expected payout from each neighborhood is a function of the available targets within that neighborhood. Any precautionary measures that reduce the expected benefit of a given neighborhood will serve to deter thieves. However, we do not expect criminals contemplating more personal crimes to be motivated by the same targets. As a falsification test, we present in all our results tables the impact on "personal" crime such as assault, sexual assault, and pickpocketing. We argue that these serve as the relevant group of outcomes to provide evidence that shutter adoption is not merely correlated with lower incidences of crime, but rather that shutters *deter* crime. Personal crime can occur anywhere, including outside of the individual's home, and it is unlikely to be deterred by the presence of shutters at the home. We take the lack of statistically significant results in the incidence of personal crime as further confirmation of our hypothesis.

4.2 Heterogeneous Effects

There are a variety of potential reasons for heterogeneous effects on how shutter adoption lowers crime incidence. The main reason for this heterogeneity is that households live in neighborhoods, and therefore the average level of crime in the neighborhood affects the likelihood that an individual household is affected. For instance, a high-security household living in an area with high crime levels might still experience, on average, higher crime incidence than a low-security household living in an area with low crime levels. If shutter adoption rates in a neighborhood affects the likelihood that it is targeted by criminals, then the relative benefit of individual households having shutters would vary. In this case, the underlying data generating process would be captured by the following equation:

$$Crime_i = \alpha + \beta(S_a)S_i + \gamma X_i + \epsilon_i \tag{4}$$

That is, the effectiveness of installing shutters on reducing the probability of a crime is a function of shutter prevalence in your area. This follows from the theoretical model described in Section 2 of our first report. To assess heterogeneous effects, we discretize the function $\beta(S_a)$ by estimating the average value of β for different ranges of S_a. That is, we estimate the following regression:

$$Crime_i = \alpha + \beta_- \mathbb{1}(S_a < \text{median})\hat{S}_i + \beta_+ \mathbb{1}(S_a > \text{median})\hat{S}_i + \gamma X_i \tag{5}$$

Differences between the estimates β_- and β_+ indicate differential effects of shutter installation depending on whether the overall prevalence of shutters in your area is below or above the median prevalence rate. This regression uses your predicted probability of installing shutters, $\hat{S}_i$, from the first stage of the fuzzy regression discontinuity estimation to control for endogeneity.

The main results are shown in Table 5 for property crime and Table 6 for personal crime. While the results are insignificant at conventional levels, they consistently demonstrate that installing shutters is more effective in a high prevalence area than in a low prevalence area. This suggests that living in areas with higher shutter prevalence increases your likelihood of being the victim of a crime if you do not have shutters, consistent with the deterrence mechanism: theives will target the most visibly weak houses in an area.

Table 5: Heterogeneous Effects: Adoption relative to Median, Property Crime

	Burglary	Burglary Attempt	Burglary + Attempt	Bike Theft	Theft from Car
	(1)	(2)	(3)	(4)	(5)
Below median	-0.00188	-0.00867	-0.00813	0.00595	-0.0133
	(0.0115)	(0.0120)	(0.0152)	(0.0192)	(0.0138)
Above median	-0.00682	-0.00313	-0.0116	-0.0280	-0.00169
	(0.00915)	(0.0101)	(0.0134)	(0.0176)	(0.0117)
N	33671	33671	33671	33671	33671
R^2	0.00618	0.00682	0.0112	0.0737	0.0286

Table 6: Heterogeneous Effects: Adoption relative to Median, Personal Crime

	Assault	Sexual Assault	Threat	Violent Theft	Pickpocket
	(1)	(2)	(3)	(4)	(5)
Below median	-0.00692	0.0113*	-0.0194	0.0000689	0.00598
	(0.0119)	(0.00646)	(0.0147)	(0.00511)	(0.0151)
Above median	-0.00732	0.00172	-0.00265	0.0000369	-0.0223***
	(0.00750)	(0.00674)	(0.0116)	(0.00395)	(0.00698)
N	33671	33671	33671	33671	33671
R^2	0.0338	0.0154	0.0339	0.00727	0.0122

5 Mechanisms of Shutter Adoption: Testing the Religion Hypothesis

As we showed above that increases in shutter rates seem to cause lower crime along the geographic discontinuity of the rivers Waal and Maas, the question remains whether the contagion hypothesis - that visible precautions spread secularly originating from Belgium - is the most plausible explanation of this phenomenon. we wanted to explore an alternative hypothesis. An important demographic difference between Northern and Southern municipalities in the Netherlands is the difference in religious affiliation: while in the Souther diocese of Roermond 68.1% of the population are Catholic, in the Northern dioceses of Utrecht and Rotterdam, for instance, less than 20% of the population are Catholic. In this section, we will test whether a regression discontinuity design based on historical divisions that strongly predict Catholic affiliation can equally well explain the effect of shutter rates on crime as a models that sees the rivers as a natural boundary for contagion. First, we will provide a short background on the historical mechanism for identifying the territory affected by this religious division. Then, we will substantiate a particular mechanism for why religion would be expected to affect trust and social cohesion, which, in turn, are expected to affect shutter prevalence. We then provide a translation of this historical discontinuity into our data, and show empirical estimates of the effects on shutter rates on crime. Ultimately, we reject the hypothesis that the effect of shutter rates on crime is mediated by cultural differences, which provides additional support to the contagion hypothesis.

5.1 Historical Origins of Dutch Religious Boundaries

There is much empirical evidence that historical institutions impact modern economic outcomes (Manz et al., 2006; Nunn, 2008; Dell, 2010) and that this may operate through the channels of social cohesion and trust (Nunn and Wantchekon, 2011; Lowes et al., Forthcoming). In addition, in modern organizations, there are significant differences in trust and attitudes towards others that correlate with the type of Christianity that individuals practice (Arruñada, 2010; Porta et al., 1996). In conjunction, these two literatures lead to a historically-motivated empirical design using the channels of trust and social cohesion to test whether modern shutter adoption leads to more effective crime deterrence.

The origins of the conflict lay in the Spanish King Philip II's insistence on imposing Catholicism across his kingdom, which at the time included the Netherlands. The northern regions of the Netherlands had become increasingly Protestant, and moreover religious tolerance was valued as it facilitated commercial prosperity. Under William of Orange, the northern provinces revolted against the Spanish king and Catholic institutions beginning in the year 1566. Although the conflict was not resolved for almost a century, the treaties established borders that were reflective of the original conflict. This helps to reinforce the importance of the Catholic-Protestant border as a relevant division between two social groups who practice and develop distinct social and economic values.

The historical border that we use for our regression-discontinuity is the one established in 1648 in the Treaty of Münster, which was part of the broader European Treaty of Westphalia, and separated the northern primarily Protestant Dutch Republic provinces from the southern primarily Catholic Flanders (modern-day Belgium). These treaties officially ended the Eighty Years' War (also known as the Dutch Revolt) and the Thirty Years' War respectively, and they established borders for free religious practice between Protestants and Catholics across Europe.

In particular, we consider the administrative and cultural separation of the "Generality Lands" (*Generaliteitslanden*), in the south of the territory of the modern Netherlands. These lands, originally under Spanish rule, came under control of the Dutch Republic as a result of the Eighty Years' War, but did not enjoy the same rights and powers as the other provinces in the Dutch Republic. Instead of being able to control their own affairs through a provincial legislative assembly and executive, they were under direct control of the States-General - the legislature of the Northern Dutch States. This state of limited sovereignty persisted until about the creation of the Batavian Republic in 1795, which absorbed the parts of the Generality Lands that are now part of The Netherlands. The latter territories correspond roughly to the provinces of North Brabant, Limburg, and southern Zeeland.

Aside from having being subjected to limited sovereignty for ca. 150 years, these areas are also culturally different from the rest of the Netherlands. As a result of having been under Spanish control, the population in these areas became, and remained, predominantly catholic - a distinction, which persist until today in The Netherlands. We will use these differences in religion and political history of the former Generality States to argue that we should expect a plausible difference in trust and precautions in these areas, relative to the more Protestant parts of The Netherlands.

5.2 The Impact of Cultural Divisions on Shutters

The literature on religiosity and economic and social behavior highlight differences between Protestants and Catholics that plausibly translate into investment in crime-precaution and criminality: In this literature, religious organizations are one type of institution that cultivate and incentivize certain types of behavior which develop into "cultural norms" (Weber, 1976; Foucault, 1977). Individuals in more hierarchical religions, like Catholicism have been found to have lower levels of trust in cross-country and micro-level studies (Porta et al., 1996) and to be associated with lower government performance (La Porta et al., 1999). We do not explore the multiple hypotheses for these correlations, but we posit that in our historical context, the legacies of prosecution during the Spanish and Dutch Inquisitions may have led to lower levels of social cohesion and trust among neighbors. Moreover, the experience of limited sovereignty for ca. 150 years would additionally be expected to lower the populace's social capital. Therefore, those individuals residing in the historically Catholic Generality States of the country are subject to a cultural "treatment" that is not experienced by the Protestant provinces. This channel is similar to that proposed by Nunn and Wantchekon (2011) as the mechanism for lower economic growth in Africa as a result of the historical slave trade.

We posit that these social and cultural variables influence individual decisions to adopt shutter rates and therefore serve as a plausible instrument for assessing whether shutter adoption impedes crime.

5.3 Mapping history to the Data: Distance to historical discontinuity

Based on an analysis of historical maps of The Netherlands and historical descriptions, we map the former Generality Lands of Brabant of the States, Flanders of the States, Overmaas of the States, and Upper Guelders of the States to the corresponding Dutch municipalities as of 2008.[3] The resulting mapping flags 110 Dutch municipalities (out of 443 total) located in North Brabant, Limburg, and the south of Zeeland as having been subject to this historical quasi-experimental treatment. The location of this territorial boundary in the Netherlands is shown in panel (a) of Figure 3. We can see that it corresponds to the southernmost municipalities of the country. Moreover, it is important to note that this discontinuity does *not* align fully with the river discontinuity analyzed above.

Based on this assignment of municipalities to being former Generality States, we can determine which of the municipalities are located along the border of this territory, Moreover, we can determine how many municipal boundaries they are removed from this historical border. Using this intuition, we define an index of distance to the Protestant border by determining the shortest neighbor-to-neighbor path between municipalities before they can cross from a Catholic into a Protestant municipality and vice versa. The number of steps needed is the "historic catholic" index number C_i for municipality i. For instance, all catholic border municipalities have $C_i = 1$. For the Protestant states, we use the negative of this number for their catholicism index.[4] That is, this index becomes more negative, the farther these municipalities are away from the border

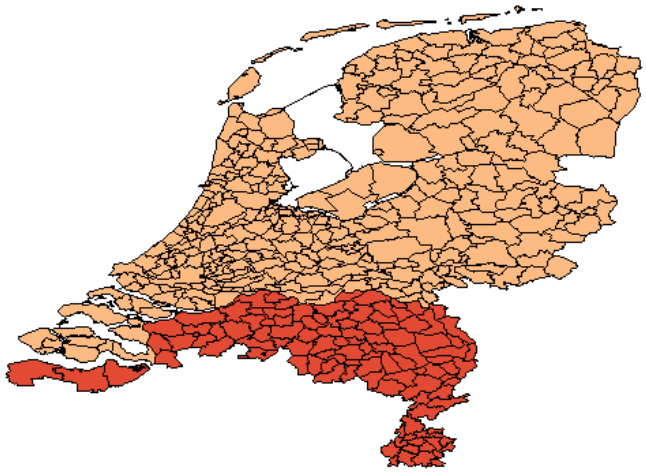
[3] We do not include the former Generality land of Westerwolde in this mapping, as it did not endure separate status for the same duration as the other territories: it became part of the province of Groningen in 1619 after only 25 years of limited sovereignty.

[4] We assign the highest observed distance score of 17 (-17) to Catholic (Protestant) Dutch islands, for which there are no neighboring municipalities via a land path.

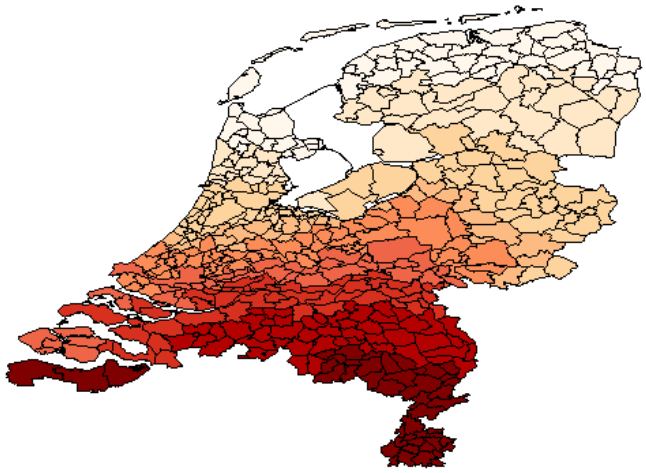
with the former Generality States. The result is a continuous variable for each municipality, running across a plausibly exogenous discontinuity - the historical border of the Generality States - which we use for the Fuzzy RD estimation below.

The distribution of this continuous municipal-distance index relative to the Generality States boundary can be seen in panel (b) of Figure 3. We can see that there is a continuous decline in this measure as we go from South to North in The Netherlands.

Figure 3: Index of municipal distance to historical Generality States boundary



(a) Distance index



(b) Historical border

5.4 Effect of Catholicism on Shutter-Crime Relationship

First, we need to establish that there is in fact an effect of the discontinuity at the historical boundary of the Generality States on shutter rates. Table 7 shows the result of regressing individual shutter ownership on being domiciled in a historical Generality States municipality, and a number of demographic covariates, including age, income, and marriage status. We can see that the historical boundary significantly affects shutter rates: households in the more Catholic territories are more likely to have shutters by an estimated rate of $\sim$6%, which is large, given

Table 7: First Stage Results

	Shutter rates
Historically Catholic	0.061***
	(0.020)
	[0.003]
N	64,823
R^2	0.089

Regressions include the demographic ontrol variables described in Section 2.1

* $p < .1$, **$p < .05$, *** $p < .01$

that the overall prevalence of shutters in the Netherlands is only 18.5% overall. This shows that if the previously observed negative relationship between shutters and crime were indeed due to cultural differences stemming from historical exposure to Catholicism, then we should observe a negative reduced form effect of catholicism on property-related crime. This also confirms the assumption that there is in fact a discontinuty in shutter rates at the

In Table 8, we run this reduced form regression, by regressing the reported prevalence of different forms of crime on being within the historic Generality States boundaries and controls. The table shows that the latter effect on crime is significant for property crimes but *positive*. That is, the catholic territories are shown to have a higher prevalence of burglary and theft from cars than the historically Protestant territories. This means that the "Second Stage" has the wrong sign from what we observed above.

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In Table 9, we confirm what we can already predict: the fuzzy RD result for the effect of variation in shutter rates on crime that is caused by the historical Catholic boundary is not significant. We do find some significant effects from the shutter rate variation caused by Catholicism on the prevalence of threats and violent theft, but not on property crime. This means that we did not find any evidence that social and cultural difference caused by the historical association with the Generality States is the reason for the observed causal relationship of shutter rates on crime associated with the river boundary. This strengthens the contagion hypothesis discussed earlier as the most likely explanation for the river boundary result.

6 Conclusion

This paper tests the hypothesis that shutter adoption has a causal impact on reducing burglary rates in the Netherlands. We focus primarily on a fuzzy regression discontinuity design, taking advantage of natural barriers to the spread of rolldown shutters. Because large rivers such as the Maas and Waal slow the contagion-like spread of visible precautionary measures (as discussed in

Table 8: Reduced Form Regressions of Crime on Historical Religion

	Property-Related Crime				
	Burglary	Burglary Attempt	Burglary + Attempt	Bicycle Theft	Theft from Car
Historically Catholic	0.009***	0.014***	0.023***	-0.009	0.009**
	(0.003)	(0.003)	(0.005)	(0.006)	(0.004)
	[0.005]	[0.000]	[0.000]	[0.119]	[0.015]
N	64,823	64,823	64,823	64,823	64,823
R^2	0.007	0.006	0.012	0.079	0.028
	Personal Crime				
	Assault	Sexual Assault	Threat	Violent Theft	Pickpocket
Historically Catholic	-0.001	0.002	0.000	-0.000	0.002
	(0.003)	(0.002)	(0.004)	(0.001)	(0.002)
	[0.778]	[0.339]	[0.966]	[0.636]	[0.398]
N	64,823	64,823	64,823	64,823	64,823
R^2	0.036	0.014	0.035	0.006	0.012

Standard errors are clustered at the municipality level. All regressions also include individual controls, as described in section 2.

Table 9: Regression Discontinuity Results of Crime on Shutter Use (Discontinuity=Historically Catholic Region)

	Property-Related Crime				
	Burglary	Burglary Attempt	Burglary + Attempt	Bicycle Theft	Theft from Car
Shutters	0.012	0.005	0.052	0.082	-0.111
	(0.103)	(0.105)	(0.185)	(0.286)	(0.101)
	[0.908]	[0.966]	[0.779]	[0.775]	[0.268]
N	65,033	65,033	65,033	65,033	65,033
	Personal Crime				
	Assault	Sexual Assault	Threat	Violent Theft	Pickpocket
Shutters	-0.053	0.018	-0.176*	-0.061**	-0.094
	(0.062)	(0.053)	(0.101)	(0.028)	(0.075)
	[0.396]	[0.733]	[0.080]	[0.030]	[0.211]
N	65,033	65,033	65,033	65,033	65,033

Standard errors are clustered at the municipality level. All regressions also include individual controls, as described in section 2.1.

our previous paper), they represent an exogenous shock to the prevalence of rolldown shutters.

We find that installing rolldown shutters reduces the probability of being the victim of a burglary (or attempted burglary) by more than sixty percent. Furthermore, we show that they are more effective in areas with higher average shutter prevalence because they act as a deterrent, shifting theives to visibly weaker targets. Finally, we investigate the effects of social, rather than geographic, boundaries by looking at municipalities near the boundary of a historically Catholic region established in 1648 by the Treaty of Münster. While we find strong first-stage results, we do not find any significant effects on crime rates. The lack of significance in the regression discontinuity design may be due to the fact that Catholic communities affect both crime rates and shutter adoption, thereby negating the overall effect.

Our analysis is subject to several limitations. In particular, the lack of geographic precision in the surveys gives us limited ability to look at narrow bands around our various discontinuities, which would increase the precision with which we could measure the effects of interest. Furthermore, a general limitation of regression discontinuity design is that it only estimates a local average treatment effect. To the extent that we are estimating this LATE on a particularly responsive (or unresponsive) margin, any effects that we find will not be generalizable to the entire country. This is of particular concern to any policy makers interested in the effects of precautionary mechanisms on crime. In addition, having a significant time dimension in the data would allow us to use panel estimation techniques that exploit the timing of shutter adoption and crime incidence.

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