ECgames 2017 – Case B

Team #8

April 7, 2017

1 Summary

We use a regression continuity design based on a data driven approach to choose optimal control groups to estimate the effect of installing window shutters on the probability of being the victim of burglary. In particular, we answer the following questions:

1. *What is the causal impact of shutter usage on victimization of burglary?* (Section 3)
    - In order to claim causality of the use of shutters on the probability of being victim of burglary (and attempted burglary), OLS regression is not sufficient: As we might install more shutters if the burglary rate is higher, we have to deal with reverse causality.
    - We make use of a regression discontinuity design based on differences in shutterization between geographically close regions.
    - We create an algorithm to automatically choose pairs of municipalities in an optimal way: a large difference in shutterization and a small geographical distance. This procedure is much more efficient than using a single boundary and is described in Section 2.
    - We implement our regression discontinuity design as a local IV specification. In some specifications, we use shutterization in the 90's as an additional instrument for current shutterization. In both equations, we include pair fixed effects.
    - Overall, our results show that the use of shutters does have a causal impact on the probability of being a victim of burglary. A falsification test shows that the use of shutters has no impact on the probability of being victim of theft from car.
2. *How does the causal impact of shutters vary by the share of other residents within the same municipality who also have shutters?* (Section 4)
    - In municipalities with high average shutter use, installing shutters decreases the probability of being victimized much more than in municipalities with low average use. This is consistent with the idea that households cannot be 'left out' if they don't want to get victimized.

2 Methodology

2.1 Drawing the line – a class of regression discontinuity designs

In order to assess the causal impact of shutter usage on burglary victimization (henceforth BV) we employ a regression discontinuity design based on differences in shutterization between geographically close regions.

Any regression discontinuity design requires the choice of two subsamples: One subsample just off the left of the cutoff ('low') and one just off the right of the cutoff ('high'). The simplest approach would be to draw a line on the map and use observations around that line. However, this will not necessarily be an optimal choice of regions, as locally there are many small discontinuities that would go unused. Moreover, there is no reason whatsoever to consider only connected sets as the two subsamples. Therefore, we consider many 'low' and 'high' subsamples at the aggregation level of municipalities, i.e., we choose a number of pairs of municipalities. Each pair consisting of a 'high' and a 'low' municipality will be geographically close but the 'high' municipality will have a significantly higher level of shutterization.

Formally, we choose K pairs of municipalities $(m_{\mathrm{l}}^k, m_{\mathrm{h}}^k)_{k=1}^K$ which minimize our loss function

$$L(\mathrm{l}, \mathrm{h}) := \omega\Big((\mathrm{lon}_\mathrm{l} - \mathrm{lon}_\mathrm{h})^2 + (\mathrm{lat}_\mathrm{l} - \mathrm{lat}_\mathrm{h})^2\Big)^{1/2} - \Big(\mathrm{shut}_\mathrm{l} - \mathrm{shut}_\mathrm{h}\Big)^2, \tag{2.1}$$

where, for example, lon_l denotes the longitude, lat_l the latitude and shut_l the shutter usage of the low municipality. This loss function induces a class of regression discontinuity designs indexed by K – the number of pairs – and ω – a weight to tune the distance-similarity trade-off. Higher values of ω ensure that the municipalities are very close to each other (including that they are smaller), so that we can be sure that the BV patterns would have been similar without window shutters. The higher this number, the lower the bias of our discontinuity design. However, we also need to ensure that we have a significant difference in the shutterization between the high and low members of each pair, so that we can identify the impact of shutterization on crime. Similarly, having a higher number of pairs will lead to a larger sample size and thus potentially more efficient estimation. Moreover, using a very low number of pairs might estimate local effects that are not necessarily applicable to the country as a whole, creating problems of external validity. On the other hand, a small number of pairs ensures that only the best are chosen. These necessary trade-offs can be seen as a limitation of our approach, however, we believe that the robustness of our results in the following Sections across specifications are encouraging.

2.2 Dutch Pairs

We now present the results of the pairing procedure described in Section 2.1. These are summarized in Figures 1, 2 and 3. In short, the lightest shaded municipalities are those which were not paired. The orange-shaded ones are the ones with high degree of shutterization and the red-shaded ones correspond to their pairs who have a low degree of shutterization.

Figures 1, 2 and 3 confirm the strength of our matching procedure in the sense that paired municipalities are near each other and therefore unlikely to greatly differ in terms of cultural and socio-economic aspects. That is, the shutter usage differences do not dominate the geographic distance. In addition, we

2.3 Regression Specification

Given our pairs $(m_{\mathrm{l}}^k, m_{\mathrm{h}}^k)_{k=1}^K$, we implement our regression discontinuity design as a endogenous treatment effect model, where the treatment is shutter, which is instrumented by being in the high municipality of the pair. The exogeneity assumption on this instrument thus is equivalent to the sufficient closeness of the two areas.

At this point, it is worth discussing the endogeneity that is present when one attempts at explaining BV using shutters. On the one hand, having shutters is expected to lower the probability of being victim of burglary. On the other hand, people who were victims of burglary (or attmempted burglary) are more likely

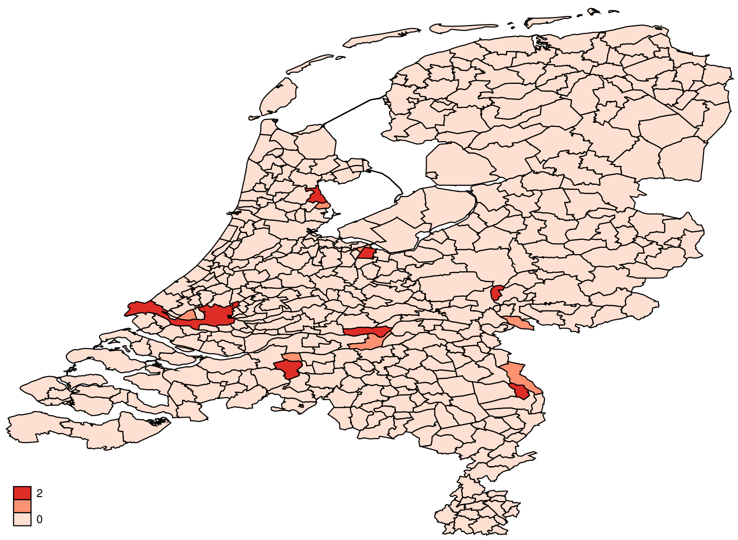


Figure 1: Map of paired municipalities, 10 pairs

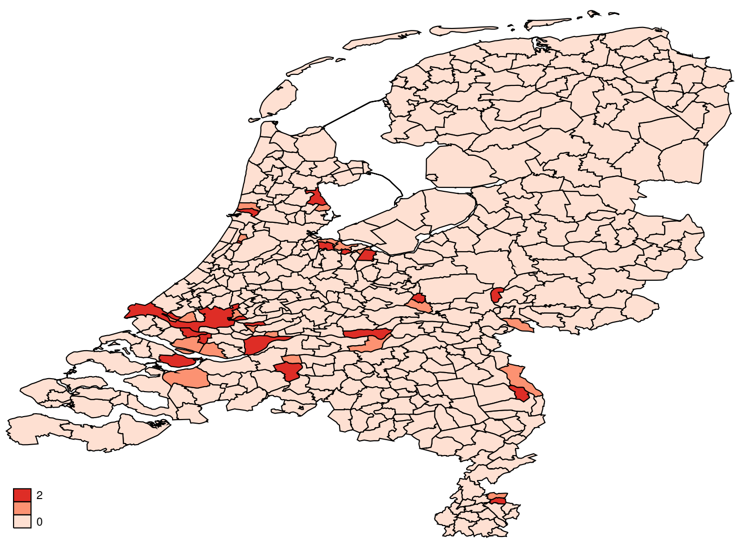


Figure 2: Map of paired municipalities, 25 pairs

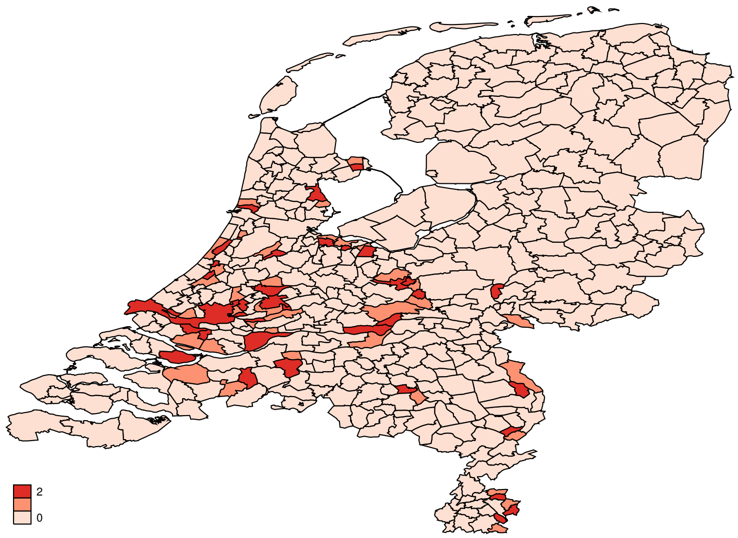


Figure 3: Map of paired municipalities, 50 pairs

to install shutters and other security measures.
Using this formulation for the discontinuity design has two benefits. Firstly, it allows us to combine the various pairs in one specification while giving us accurate control over the amount of inter-pair heterogeneity allowed. Secondly, it will allow us to combine the discontinuity design with other instrumental variables, both to increase our estimation accuracy as well and to be able to have further endogenous variables, like the average shutterization in the municipality. With one individual being the unit of analysis, we estimate the following instrumental variables equation:

$$\text{burgs}_i = \beta_0 + \beta_1 \text{shuts}_i + \beta_3 \text{pair}_i + \beta_4 \text{SES}_i + \epsilon_i \tag{2.2}$$

$$\text{shuts}_i = \pi_0 + \pi_2 \text{high}_i + u_i \tag{2.3}$$

where burgs denotes burglaries, shuts the current status of shutter usage, pair are pair-fixed effects, and SES socio-economic factors as controls. In the first stage (2.3), high is a dummy indicating whether individual i lives in the high shutter usage municipality of its pair.

Essentially, we instrument shutter use with being in the high one of the pair. This is exogenous, because, given that within-pair differences are very small being in the high pair does not change the burglary patterns. By using pair fixed effects, we can estimate this equation for all pairs jointly.

As an alternative specification, we add shutterization in the 90s as an additional instrument. This greatly improves the significance of our first stage. However, one might argue that burglaries now depend on burglaries in the past, which in turn depend on early shutterization. To alleviate this concern, we also control for past levels of crime, so that we essentially estimate the increase in crime, which cannot depend directly on past shutterization. Specifically, we estimate

$$\text{burg00s}_i = \beta_0 + \beta_1 \text{shut00s}_i + \beta_2 \text{burg90s}_i + \beta_3 \text{pairs}_i + \beta_4 \text{SES}_i + \epsilon_i \tag{2.4}$$

$$\text{shut00s}_i = \pi_0 + \pi_1 \text{shut90s}_i + \pi_2 \text{high}_i + u_i \tag{2.5}$$

where burg00s denotes burglaries (incl attempts) in the 2000s, shut00s the current status of shutter usage, burg90s the burglaries (incl attempts) in the 1990s, pairs is a dummy variable indicating different levels of burglaries in the municipality pair of individual i, and SES socio-economic factors as controls. In the first stage (2.5), shut90s denotes the shutter status in the 90s and high a dummy indicating whether individual i lives in the high shutter usage municipality of its pair.

2.4 Limitations

Before continuing with the results, we briefly want to discuss the biggest limitations of our approach. We believe, that the biggest drawback in this challenge is the data availability. First, we wished for a decent household panel. This would facilitate the analysis with respect to the fact that individuals could have been tracked over time.

Moreover, a richer or better selected data set would allow us to construct more IVs for the first stage given in Equation (2.3) and, thereby, improve the results in terms of accuracy and reliability. However, overall we believe that this is not too big of a concern given the strength of the used IVs.

Finally, if household addresses/geographic data would have been available we would have been able to incorporate that in our analysis such that households further away from the border of the municipality pairs could have been down-weighted. This is meaningful since one can expect that the further the household is away from the border (or discontinuity) the lower the treatment influence would be.

3 Results for Question a: Causal Impact

In this section we report our findings on the causal impact of the use of shutters on the victimization of burglary (and attempted burglary). In order to derive causal impacts, we make use of the pairs of municipalities, according to the methodology described above. Table 1 shows our results for 10 and 25 pairs of municipalities, corresponding to about 2200 and 5600 individual observations.
Overall, we conclude that the use of shutters has a negative impact on the probability of being a victim of burglary or attempted burglary. The magnitude of this effect varies across model specifications, as well as with the number of municipality pairs included in the estimation. Interestingly, even a low number of municipality pairs yields a strong magnitude of the effect. As these are the closest pairs these results are very convincing. Moreover, as the effect gets smaller as we include more pairs, it suggests that any bias due to non-perfect proximity runs against our effect, so that we actually estimate a lower bound on the magnitude of the effect. Anyways, even when enlarging the number of pairs included in the estimation (thus including less good pairs), the negative effect of shutters on burglary victimization remains statistically significant.

As an additional robustness check we have included other measures of preventing crime, like door locks, and risk perceptions directly. This could reduce potential problems of reverse causalities. However, although these measures are significant, our coefficients of interest do not change much.

In order to assess the plausibility of our procedure, we perform a placebo test using theft from car as dependent variable. The results are reported in Table 2 and corroborate our empirical approach. Indeed, having shutters has no statistically significant impact on the probability being a victim of theft from car. This gives additional streght to our pairing procedure and empirical approach.

Variables	(1)	(2)	(3)	(4)
shutters	-0.121**	-0.399*	-0.264***	-0.0722
Pair FE	YES	YES	YES	YES
SES	YES	YES	YES	YES
RISK	YES	YES	YES	YES
MEASURES	YES	YES	YES	YES
OLD CRIME (90'S)	YES	NO	YES	NO
PAIRS	10	10	66	66
Instruments	2	1	2	1
N	2233	2243	5640	5650

Table 1: Results: independent variable burglary

Variables	(1)	(2)	(3)	(4)
shutters	0.0955	0.109	0.0728	0.0811
Pair FE	YES	YES	YES	YES
SES	YES	YES	YES	YES
RISK	YES	YES	YES	YES
MEASURES	YES	YES	YES	YES
OLD CRIME (90'S)	YES	NO	YES	NO
# PAIRS	10	10	66	66
Instruments	2	1	2	1
N	2233	2243	5640	5650

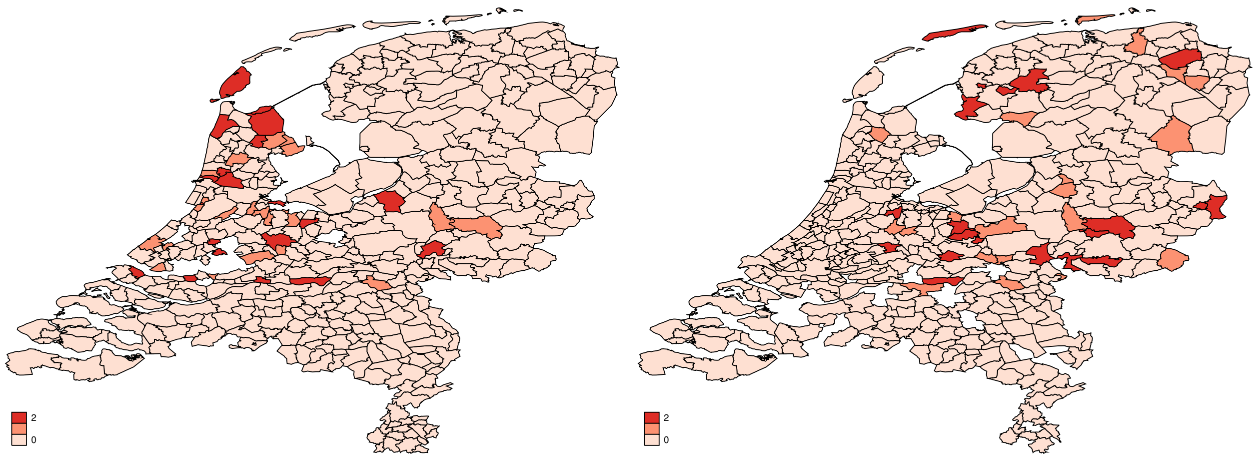
Table 2: Results: independent variable theftfromcar (falsification)

4 Results for Question b: Heterogeneity

The easiest way to see how the causal effect varies with the average would be to include an interaction between shutter and average in the regression. However, the average shutter is, of course, also endogenous, as on average people might get shutters if there is too much crime, therefore, we'd need to also instrument the interaction as well as the average. As we have a discontinuity *and* IV approach this would be possible, however, the results are incredibly inaccurate given that shutterization and average shutterization are highly correlated. Therefore, we take an entirely different approach.

Thanks to our data-driven approach to matching, we can easily create good pairs among both the subpopulation of low-shutter municipalities and high-shutter municipalities, see Figures 4a and 4b. This means that we pair up relatively high shutterization with very high shutterization for one subpopulation and relatively low with very low for the other. Thereby, we can still have a discontinuity design. Due to the slightly lower quality of the pairing, we rely on our specification with an additional instrument (1990s shutterization) to have decent power in the first stage. Our results suggest that in municipalities with high average shutter usage the causal effect of installing shutters is much more negative than in those with low average amount of shutter usage. This is consistent with the theory that thieves might pick the houses without shutters, so I will get victimized if everyone around me has shutters and I don't. Specifically, we estimate that for municipalities with above-average shutterization the causal effect is between -.89 and -.49, i.e., economically and statistically highly significant. For municipalities with below-average shutterization is statistically insignificant, but we can say that it is between -.21 and .14.

Figure 4: Municipality pairs, many and few shutters



(a) Few shutters

(b) Many shutters

5 Conclusion

All in all, we could conclude that the use of shutters does have a negative impact on the probability of being a victim of burglary or attempted burglary. Given our geographic discontinuity design, together with the use of instrumental variables we are able to claim causality for this effect.

We run a placebo test in order to confirm the plausibility of our empirical approach. Its results confirm no effect of the use of shutters on the probability of suffering from car theft.

Finally, we assess the heterogeneity of this causal effect. On that matter, we conclude that in municipalities with high average shutter usage the causal effect of installing shutters is much more negative than in those with low average amount of shutter usage.