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DOES REGULATION OF BUILT-IN SECURITY REDUCE CRIME? EVIDENCE FROM A NATURAL EXPERIMENT*

Ben Vollaard and Jan C. van Ours

We provide evidence that large-scale government intervention in the use of self-protective measures lowers crime. Since 1999, all new-built homes in the Netherlands have to have burglary-proof windows and doors. We find the regulatory change to have reduced burglary in new-built homes from 1.1 to 0.8% annually, a reduction of 26%. Even though the regulation of built-in security does not target preventative measures at homes that are most at risk, the social benefits of the regulation are likely to exceed the social costs.

Citizens exercise a demand for crime by exposing themselves to the risk of theft and violence (Ehrlich, 1981). Exposure can be limited by self-protective measures, such as keeping valuables out of sight, avoiding streets at certain times and installing devices such as burglar alarms. The supply of crime by offenders has been extensively studied, including studies into the effect of the threat of punishment on the decision to commit crime. How potential victims protect themselves against crime has received much less attention. In most empirical studies, the level of victim precaution is taken as a given.

From an economic perspective, victim responses to crime are important as they add greatly to the costs of crime to society, with virtually everybody taking some precautionary measures. In addition, victim precaution may either substitute or enhance public expenditures on crime control. A hidden radio transmitter in private vehicles could make retrieval of stolen vehicles by the police more effective (Ayres and Levitt, 1998). Alternatively, a higher level of police protection may reduce avoidance behaviour of potential victims (Vollaard and Koning, 2009), which in turn could drive up victimisation of crime, as argued by Philipson and Posner (1996).

From a social welfare perspective, potential victims may under-invest in self-protective measures, since some of the costs of crime are borne by society, including the use of police and justice resources. Perhaps more importantly, under-investment may result from behavioural traits such as an inability to commit to a strategy of precautionary behaviour and being overly optimistic about the chance of getting victimised by a burglary (as with health preventive behaviour, Thaler and Sunstein, 2009). The case for under-investment is not clear-cut, however, as victim precaution itself may have negative external effects on the risk of victimisation of other potential victims. If victim precaution merely displaces crime from protected to unprotected targets, individual

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precautionary measures may actually be wasteful from a social welfare perspective (Clotfelter, 1978; Shavell, 1991).

In line with experiences with similar policies aimed at changing health preventive behaviour and pension saving decisions, burglary prevention advice, publicity campaigns and subsidies covering all or part of the costs of installing protective devices have been found to have little to no effect on levels of victim precaution (Barthe, 2006). Policies aimed at integrating self-protective features into products may be more promising, warranting further analysis of their effectiveness. Given the aforementioned potential for redistribution rather than prevention of crime, such policies may only provide welfare gains when displacement effects are limited.

In this article, we study the effect of large-scale government intervention in precautionary measures against acquisitive crime. Since 1999, all new-built homes in the Netherlands have to have high-quality locks and burglary-proof windows and doors. The Building Code was changed accordingly. Since most homes are built as part of large-scale residential construction projects, application of the protective measures was uniformly applied to large numbers of newly built co-located homes, limiting displacement of burglary to directly neighbouring homes.[1]

The change in the Building Code provides a natural experiment in the regulation of self-protective measures. The regulation makes application of home security conditional on the year in which the house is built. The resulting exogenous shock in built-in security allows us to estimate its effect by comparing victimisation of burglary in homes that were built just before and just after the change in regulation. By using a rich sample of nation-wide micro-data on victimisation of crime and adopting a quasi-experimental approach, we avoid methodological discussions related to the results of aggregate crime regressions that are typical of most of the empirical literature on the use of protective measures (including debates about the benefits of guns as protective device, for a discussion see Durlauf *et al.*, 2008). We find the change in the Building Code to have reduced the burglary risk in newly built homes by 26%. We find no evidence for displacement of burglary to older homes or to other property crimes including theft from car and bicycle theft.

Our main contribution to the literature is the finding that large-scale government intervention in victim precaution lowers crime. The existing literature on the regulation of built-in security is either descriptive in nature – as in studies on the effect of regulation of motor vehicle security, including Webb (1994) on the steering lock and Brown (2004) on the electronic engine immobiliser – or limited to small-scale local interventions, such as Bowers *et al.* (2004). In addition, the broader literature on the effect of self-protective measures on victimisation tends to ignore simultaneity in the relation between security measures and crime: subjects that are most at risk are also more likely to take security measures. In some cases, the resulting estimation bias is so strong that a positive relation between levels of crime and precautionary measures is found (Tseloni *et al.*, 2004). For instance, to the best of our knowledge, no study has shown burglar alarms to have an independent, negative effect on victimisation of burglary, with most studies showing a positive correlation between the burglary risk and

[1] In the Netherlands, some 95% of homes are built in batches of 20 or more, with building projects encompassing some 70 homes on average (CBS, 2009).

the presence of a burglar alarm (Weisel, 2004). Notable exceptions to the lack of attention to simultaneity in this literature are Ayres and Levitt (1998) and the follow-up study Gonzalez-Navarro (2008) who study the effect of exogenous variation in the use of a car-tracking device.

The remainder of the article is organised as follows. In Section 1, we discuss the 1999 regulation of built-in home security arguing that its introduction can be considered as a natural experiment. In Section 2, we describe our data. Section 3 presents the set-up of our analysis and Section 4 presents our parameter estimates, including a wide variety of sensitivity tests. In Section 5, we conduct an analysis of costs and benefits of the regulation of built-in security. Section 6 concludes.

1. The Regulation of Built-in Security: A Natural Experiment

The regulation of built-in home security came into force on 1 January 1999. From that date, home builders could only obtain a building permit if they met the legal requirements for built-in security. The criteria are spelled out in the law in great detail. Home builders are obliged to use certified burglary-proof locks and window and door frames. Building contractors can easily identify certified materials by checking the presence of a punched hallmark showing two stars. The law prescribes which parts of the home need to be fitted with secured doors and windows, excluding those that cannot easily be reached by burglars.

We do not directly observe the presence of built-in security in homes. Rather, we infer from the year of construction of the home which homes have or do not have burglary-proof doors and windows. Anecdotal evidence from interviews with practitioners suggests that application of similar security measures prior to the change in regulation was very limited and that building practices changed in line with the change in regulation. In practice, manufacturers of window and door locks and frames determine the quality of the materials used, as almost all building contractors use prefabricated elements. The majority of residential housing development in the Netherlands consists of large-scale housing projects in which standardised materials are used that meet the legal requirements.[2]

Around the time of the regulatory change, a package of built-in security measures for new homes named Secured by Design (PKVW) became increasingly popular. Some municipalities urged project developers to adopt the measures – although they did not have the legal means to enforce their application. Secured by Design exceeds the requirements of the Building Code 1999, by also encompassing burglary-proof garage doors, unobstructed views on parking lots and no free access to back alleys. We have been provided with address-level data on the homes with the Secured by Design-certificate, which allows us to disentangle the effect of the change in the Building Code and this voluntary scheme.

We observe the year of completion of the home rather than the year the building permit was granted. There is a time lag between the two. Data on time-to-completion of residential construction projects collected by Statistics Netherlands show that on

[2] Small-shop contractors using non-standard materials may not always be in compliance with the law, but they constitute only a small part of the market.

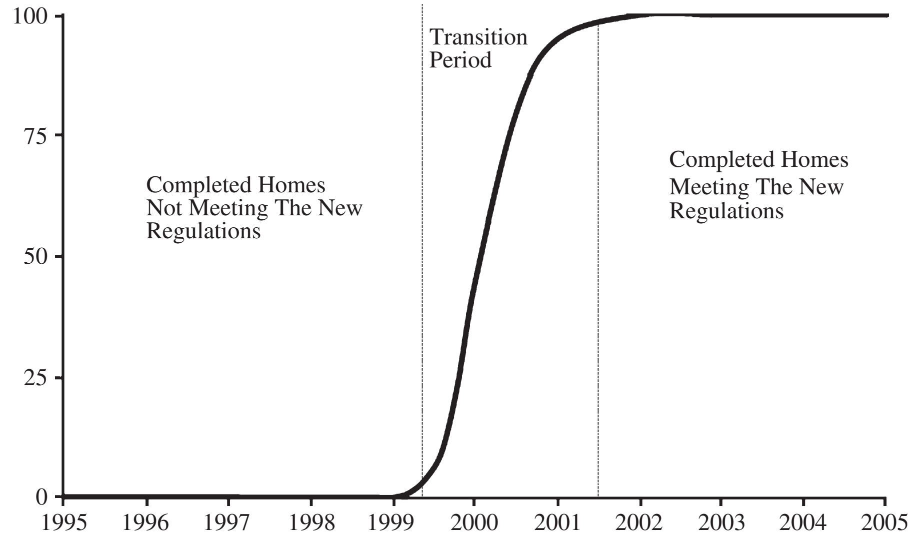

Fig. 1. *Share of New-Built Homes Meeting the* 1999 *Building Code* (%)
Note. Based on time-to-completion statistics for residential construction.
Source: CBS (2009).

average it takes two years to complete a home (CBS, 2009). Assuming full compliance with the law and no application of similar built-in security prior to the change of the law, Figure 1 shows the trend over time in the share of completed homes with the built-in security prescribed in the new building regulations. Non-compliance was guaranteed up to construction year 1999, with only a small minority of the homes completed within one year after receiving the building permit. For instance, the building permit for a home completed in March 1999 was most likely granted in 1997, that is long before the new regulations were in place. Homes completed in 2000 could either meet the old or the new regulations. In 2001, most completed homes were built according to the new regulation. We assume construction year 2001 to be the first year in which the new building code was in force. In the sensitivity analysis, we test how robust our results are to excluding homes completed in 2000 from the sample.

Households are assigned to treatment on the basis of the year of construction of the home they are living in. Assignment occurs through a known and measured deterministic decision rule. Assuming that households living in homes built shortly before the change in the Building Code are similar to households living in homes built shortly after the change in the Building code, the regulation of built-in security is a natural experiment (Imbens and Lemieux, 2008). Therefore, we can evaluate its causal impact by comparing the rate of victimisation of burglary for homes that have been built before and after the regulatory change.

2. Data

We combine data from four different sources. Our source of crime data is the annual National Victimisation Survey (VMR). Using victimisation data rather than policerecorded crime data prevents measurement error in the outcome variable through incomplete reporting and recording of crime incidents. In addition, the survey includes a host of background characteristics of respondents both affected and unaffected by crime during the period of the analysis. The VMR is a repeated cross-section telephone survey among the Dutch population aged 15 or over. We use all four waves of the VMR, from 2005 to 2008. In the interviews, respondents are asked about crime incidents experienced in the five years prior to the interview. Once victimisation over this five-year period is established, the survey includes more detailed questions about incidents experienced during the last 12 months, including the exact location at which the crime took place.

To establish the rate of burglary, we select survey responses relating to completed burglary with loss of property. Burglary is a relatively rare offence, with the share of households victimised over the last 12 months ranging from 1 to 1.5%. To have sufficient variation in victimisation of burglary in our sample, we include experience of victimisation over the last 24 months rather than the last 12 months.[3] As the survey does not include information on the location of the crime for incidents experienced more than 12 months prior to the interview, some burglaries may have been committed at the previous rather than the current address. The yearly rate of households moving does not exceed 7%, however, greatly limiting the number of possibly mismeasured burglaries. In the sensitivity analysis, we show the use of the 24-month rather than the 12-month time window to only affect the precision and not the size of the estimated effect.

The second dataset we use is the National Building Register (Woningregister) which contains information on the characteristics of the home. Information about the year of completion of the home is available from 1 January 1993 onwards. Our analysis is based on the sample of 9,784 respondents who live in a home completed in 1993 or later.

The third dataset we use are administrative data on all addresses of homes that are certified Secured by Design (PKVW), the aforementioned voluntary security package for new homes. These data are provided by the CCV, the non-profit organisation administering the certification scheme. Finally, we use information on the type of neighbourhood, provided by the Dutch research institute ABF Research. Neighbourhood types are measured at four-digit postcode level distinguishing between city centre, just outside city centre, suburb and outside city limits.

The National Victimization Survey also provides information on victimisation of bicycle theft, theft from cars and acts of vandalism (excluding car vandalism). As these crimes often do not take place around the home, we use victimisation in the last 12 months rather than the last 24 months as the place of the incident is only known for incidents that occurred within this smaller time window. Figure 2 shows the evolution of the crime rates in the calendar time period 2005–8. All types of victimisation of crime have declined during this period, with the strongest drops in bicycle theft and vandalism. Clearly, as the change in the building regulations had a slow and gradual effect on residential construction, its impact cannot be inferred from the evolution of the burglary rate by calender year in Figure 2.

[3] As we use victimisation over the last 24 months, we exclude from the sample households living in a home that was completed less than two years ago. Thus for the 2005 survey, we exclude construction years 2003 and later; for the 2006 survey, we exclude construction years 2004 and later, and so on.

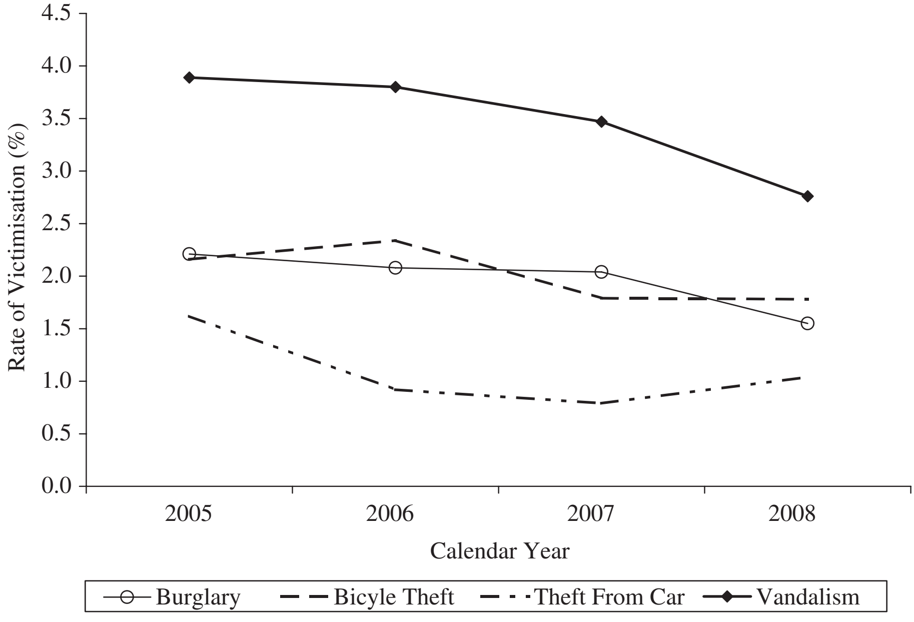

Fig. 2. *Various Crime Rates by Survey Year* (%)
Note. Burglary in past 24 months; bicycle theft, theft from car and vandalism in past 12 months.

Table 1 provides summary statistics for all homes in the sample that are built in the years before and after the change in the regulation. As shown, the average burglary rate for homes built in the period 1993–2000 was 2.15%, whereas for houses built in the period 2001–5 this was 1.61%. Furthermore, Table 1 shows that most of the characteristics of the household, the home and the neighbourhood before and after the change in the Building Code are very similar. The major exception is the share of Secured by Design homes, which is 7% before and 29% after the change in the Building Code. As we will show in the sensitivity analysis, the smooth change in the use of this voluntary scheme does not bias the estimated effect of the regulatory change.

3. Set-up of the Analysis

As the change in the Building Code has the characteristics of a natural experiment, its effects can be established by comparing burglary rates before and after the change. Figure 3 shows the evolution of the average burglary rates by year of construction of the home. Clearly, the burglary rate for homes built according to the new Building Code is lower than the burglary rate for older homes.

Although Figure 3 suggests that only the change in the building regulations resulted in a structural break in the rate of burglary by year of construction, other factors may have had an impact on burglary victimisation as well. Other factors may include changes in characteristics of households, homes and neighbourhoods during the period of the analysis.

Table 1

Means of Variables by Construction Years; 1993–2000, 2001–5

	1993–2000	2001–5	Difference (% point)
Victimisation of crime (%)			
Burglary (last 24 months)	2.15	1.61	−0.54*
Burglary and attempted burglary (last 24 months)	4.32	4.12	−0.20
Bicycle theft in own neighbourhood (last 12 months)	1.83	2.16	0.33
Theft from car in own neighbourhood (last 12 months)	0.87	1.24	0.37*
Vandalism in own neighbourhood (last 12 months)	3.49	3.43	−0.06
Household characteristics (0/1)			
One-person household	0.13	0.11	−0.02***
No children aged 14 or below	0.62	0.61	−0.01
Non-western immigrant	0.04	0.06	0.02***
Low educational attainment	0.26	0.24	−0.02*
Separated	0.05	0.05	0.00
Not married	0.28	0.30	0.02**
Bicycle insurance	0.47	0.46	−0.01
Car alarm	0.43	0.47	0.04***
Home characteristics (0/1)			
Secured by Design	0.07	0.29	0.22***
Burglar alarm	0.17	0.17	−0.00
Shutters	0.16	0.13	−0.03***
Outside light	0.91	0.91	0.00
Extra locks	0.91	0.92	0.01**
Rental property	0.22	0.21	−0.01
Expensive owner-occupied home	0.14	0.15	0.01
Single-family home with garden	0.77	0.72	−0.05***
Neighbourhood characteristics (0/1)			
City centre	0.05	0.06	0.01
Just outside city centre	0.31	0.28	−0.03***
Suburb	0.17	0.23	0.06***
Outside city limits	0.46	0.43	−0.03***
Lots of contacts with neighbours	0.68	0.71	0.03**
See police at least once a week	0.24	0.27	0.03***
Number of observations	6,873	2,911	

Note. ***, **, *, indicates significance at a 1%, 5%, 10% level.

First of all, a change in household characteristics may have affected burglary rates. If households that are relatively security-conscious have a preference for homes built after the change in the Building Code, then the assignment rule is no longer truly orthogonal to the burglary risk of the home. Security-conscious households may take more self-protective measures than other households after all. As a result, part of the decline in the burglary risk for homes built under the new Building Code may be the result of selection effects rather than improved built-in security. Selection effects are not likely since the change in the building regulations is not widely known and the average citizen is limited in his capacity to assess the quality and benefits of built-in security in the home they are interested to buy. It has been found that real estate agents are often not aware of whether a home features the Secured by Design certificate, which suggests that potential home buyers do not attach great importance to the presence of burglary-proof windows and doors (Bijsterveld, 2005). Moreover, the

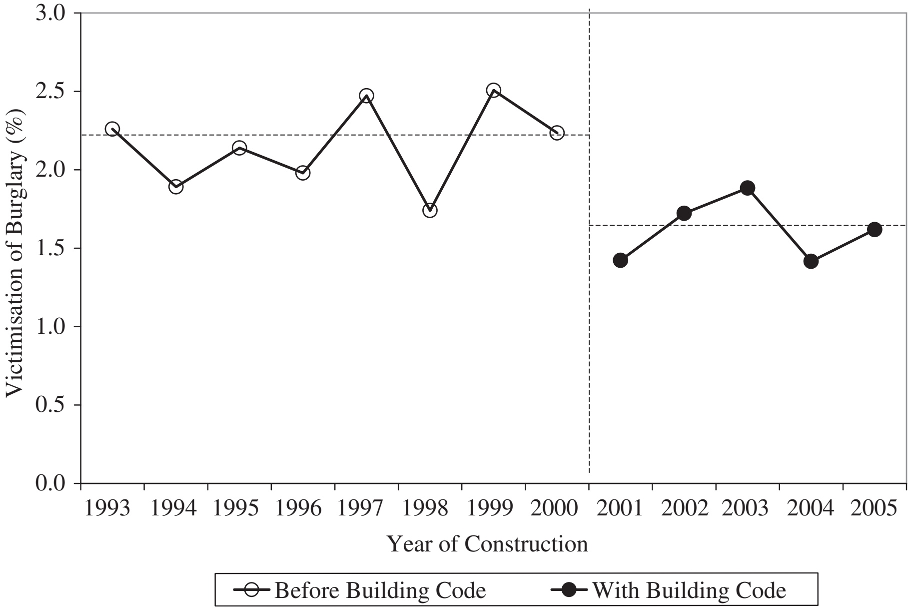

Fig. 3. *Victimisation of Burglary by Year of Construction of the Home* (% *in Past* 24 *Months*)

preference for security of the home may be dominated by other preferences, such as the location of the home and attractiveness of the neighbourhood. During the period of analysis, residential construction was highly restricted, which resulted in a relatively strong increase in prices of homes in the most desirable regions (mostly in and around major cities such as Amsterdam, The Hague and Utrecht). Clearly, in a tight housing market where home buyers have difficulty in finding a home in a location that suits their preferences, the quality of built-in security is less likely to be of major importance. To address possible selection effects, we include a number of individual household characteristics that may be related to the preference for security, including the level of education and household composition. In addition, in the sensitivity analysis, we show our estimates to be robust to the presence of a range of additional home security measures that may be more likely to be taken by security-conscious households.

The age of the home may have an independent effect on the burglary rate. Newly built homes tend to be occupied by households with very young children and both parents working. The resulting lack of natural surveillance by occupants may increase the risk of burglary in new neighbourhoods. To prevent an upward estimation bias, we include presence of children aged 14 or below in the household and a number of other household composition characteristics as control variables. Naturally, the age of the home is strongly related to the binary variable representing the regulatory change, making it difficult to separately identify the effect of both variables. In the sensitivity analysis, we provide additional results suggesting that excluding the age of the home from the estimation equation does not bias our main parameter estimates.

Changes in characteristics of the home may also have affected rates of burglary. Cohorts of homes from different construction years may differ in ways that affect their risk of burglary. The share of homes built as part of greenfield developments outside cities gradually increased during the period of the analysis (see the summary statistics on homes built in suburbs in Table 1). As homes in suburbs are less likely to be burgled, this trend could lead us to overestimate the effect of the change in the Building Code. As discussed earlier, the number of certified Secured by Design homes has increased during the period of the analysis, which may have reduced the risk of burglary in a similar fashion (see Table 1). To address such cohort effects, we include a number of observable characteristics of the home, its occupants and the neighbourhood at the cohort level as explanatory variables.

Finally, characteristics of the neighbourhood may have affected burglary rates as well. Public law enforcement may react to the change in the building regulations. Greater levels of protective measures in new-built neighbourhoods may induce the police to shift their attention to older neighbourhoods. To prevent estimation bias through this type of offsetting behaviour, we include a control variable for the visible presence of police in the neighbourhood.

The equation to be estimated is specified as follows:

$$B_{i,p,t,\tau} = \alpha_t + \alpha_p + \boldsymbol{\beta}\mathbf{X}_{i,p,t,\tau} + \delta I(\tau \geq 2001) + \varepsilon_{i,p,t,\tau} \tag{1}$$

where B is a dummy variable which denotes whether or not household i living in province p, surveyed in year t and living in a home built in year τ was a victim of burglary in the 24 months preceding survey year t. Furthermore, to account for influence of calender time changes in the national burglary rate we include survey year fixed effects, α_t. To account for regional differences, we include province fixed effects α_p. The $\mathbf{X}$ variables represent characteristics of household, home and neighbourhood. The introduction of the new Building Code is represented by the indicator function $I(\tau \geq 2001)$, hence the parameter δ measures the effect of the code on the burglary rate. Finally, $\boldsymbol{\beta}$ is a vector of parameters and ε is an error term. We estimate the parameters of our linear probability model accounting for clustering of observations by province.[4]

4. Parameter Estimates

4.1. *Baseline Model*

The first column of Table 2 shows the parameter estimates for our baseline model. The signs of the estimated effects of the control variables are as expected. At the household level, we find burglary victimisation to be positively related to living alone, having children above 14 years of age, being separated, not being married, living in an expensive owner-occupied home, living in a single-family home with garden (compared with living in an apartment), living just outside the city centre (compared with living outside city limits), not having lots of contact with the neighbours and seeing the police at least once a week in the neighbourhood. The variable of interest, the Building Code,

[4] Plans for residential construction are made at the level of the province, which results in correlation of characteristics across homes built in the same province.

Table 2

Parameter Estimates Linear Probability Models – Burglary, Burglary and Attempted Burglary

	Burglary baseline	Burglary – excluding Secured by Design	Burglary and attempted burglary
Building code	−0.56	−0.53	−0.29
	(0.20)**	(0.22)**	(0.40)
Household characteristics			
One-person household	1.02	0.94	0.58
	(0.39)**	(0.48)*	(0.62)
No children aged 14 or below	−0.48	−0.38	−0.83
	(0.24)*	(0.23)	(0.30)**
Non-western immigrant	−0.53	−0.71	1.82
	(1.40)	(1.33)	(2.22)
Low educational attainment	−0.11	−0.17	0.10
	(0.29)	(0.36)	(0.51)
Separated	1.42	1.50	1.31
	(0.65)**	(0.76)*	(0.58)**
Not married	0.77	0.90	1.67
	(0.29)**	(0.35)**	(0.46)***
Home characteristics			
Secured by Design	0.37	–	0.17
	(0.25)		(0.46)
Rental property	0.32	0.29	−0.01
	(0.44)	(0.54)	(0.52)
Expensive owner-occupied home	1.49	1.39	2.81
	(0.51)**	(0.60)**	(0.63)***
Single-family home with garden	0.97	1.03	0.46
	(0.40)**	(0.51)*	(0.49)
Neighbourhood characteristics			
City centre	1.00	1.49	1.82
	(0.73)	(0.95)	(1.14)
Just outside city centre	1.09	1.25	2.34
	(0.35)***	(0.42)**	(0.56)***
Suburb	0.29	0.16	0.68
	(0.45)	(0.44)	(0.53)
Lots of contacts with neighbours	−0.33	−0.26	−1.04
	(0.16)*	(0.21)	(0.38)**
See police at least once a week	0.92	0.67	1.88
	(0.35)**	(0.46)	(0.48)***
Number of observations	9,784	8,480	9,784

Notes. Coefficients × 100. All estimates contain fixed effects for province (11) and year of survey (3). Standard errors between parentheses are clustered by province. ***, **, *, indicates significance at a 1%. 5%, 10% level.

has a significant negative effect on the burglary rate. Taking the burglary rate prior to construction year 2001, the estimate of −0.56% point suggests that the regulatory change reduced victimisation of burglary by 26%. Finding an effect of built-in security is in line with anecdotal evidence about the change in building practices in response to the new Building Code, which we discussed in Section 2. Apparently, the built-in security measures were effective in preventing successful burglaries with loss of property. Since the regulatory change until the beginning of 2010 about 650,000 new homes have been built in the Netherlands. On the basis of our parameter estimates, we conclude that during 2001–9 almost 10,000 burglaries in these homes were prevented through application of built-in security.[5]

The estimated effect of the government regulation of 0.56% point is almost identical to the unconditional difference in burglary rates of 0.54%, presented in the first row of Table 1. The similarity of the conditional and the unconditional estimate supports the assumption that the government regulation can be considered as a natural experiment. Other potential determinants of the burglary rate by year of construction of the home change smoothly, which prevents them from biasing the estimated effect of the regulatory change (cf. Van der Klaauw, 2008). Indeed, when including only household characteristics, only home characteristics or only neighbourhood characteristics, the estimated effect of the Building Code is found to be highly similar. To establish the robustness of our findings further, we present a wide variety of sensitivity tests in the next Section.

4.2. *Sensitivity Analysis*

As discussed earlier, the percentage of homes that are certified Secured by Design gradually increased during the period of the analysis, affecting the presence of built-in security in homes within the sample. Figure 4 shows the evolution by year of construction

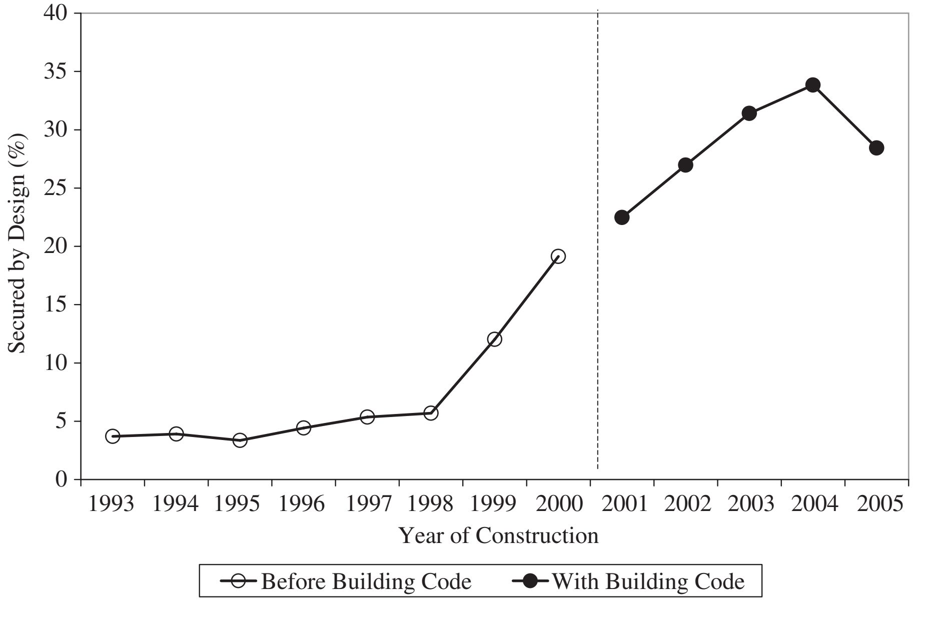

Fig. 4. *Percentage of Secured by Design-homes by Year of Construction of the Home*

[5] Note that homes differ in the number of years that they have been exposed to the risk of burglary. When computing the number of prevented burglaries by 2009, we take into account the number of years that have elapsed since the year of completion of the home. We discuss displacement of burglary to older homes and other types of property crime in response to the regulatory change later in the article.

of the share of homes built under this voluntary scheme. To investigate this source of potential estimation bias, we exclude all certified Secured by Design homes from the sample. The second column of Table 2 shows that the parameter estimates remain largely unchanged, supporting the argument that we are able to distinguish the effect of the change in the Building Code from the increased application of Secured by Design.

As discussed in Section 2, construction year 2000 falls within a transition period. The average time-to-completion is two years, which means that only some homes completed in 2000 may have been built in accordance to Building Code 1999. So far, we have assumed construction year 2000 to fall before the regulatory change. To investigate how sensitive our results are to this assumption, we exclude homes made in 2000 from the sample. The second row of Table 3 shows that the estimated effect of the Building Code on burglary rates is robust to restricting the sample to construction years outside the transition period.

We use a 13-year time window around the structural break, with eight construction years before 2001 and five construction years since 2001. A wider time window allows us to be more confident about the size of the effect of the regulatory change but may also introduce an estimation bias through the presence of heterogeneity. Homes built several years earlier or later than the structural break of 2001 are more likely to be different than homes built just before and after 2001. If these other characteristics affect the treatment and experimental group differently, then the estimated effect is likely to be biased. To investigate whether reducing the sample only affects the

Table 3

Various Model Specifications – Effect Building Code on Burglary

Model specification	Effect Building Code	Observations
1. Baseline (construction years 1993–2005)	−0.56 (0.20)**	9,784
2. Excluding construction year 2000	−0.58 (0.21)**	9,068
3. Construction years 1996–2005	−0.55 (0.26)*	7,117
4. Construction years 1997–2004	−0.62 (0.36)	5,949
5. Construction years 1998–2003	−0.47 (0.52)	4,413
6. Construction years 1999–2002	−0.85 (0.50)	2,914
7. Including burglar alarm/shutters/outside light/extra locks	−0.55 (0.20)**	9,784
8. Burglary rate last 12 months	−0.23 (0.12)*	9,994
9. Excluding suburban areas	−0.70 (0.25)**	7,926
10. Including age of the home	−0.70 (0.60)	9,784

Notes. Coefficients × 100. The parameter estimates of household, home and neighbourhood characteristics are not shown; the first estimate in this Table is identical to the estimate shown in the first column of Table 2. All estimates contain fixed effects for province (11) and year of survey (3). Standard errors between parentheses are clustered by province. **, *, indicates significance at a 5%, 10% level.

precision of the estimated effect rather than the size of the effect, we vary the size of the sample around the threshold. The third to sixth rows of Table 3 show how the estimated effect varies when we reduce the range of construction years within the sample. Clearly, the imprecision of the parameter estimate increases but the point estimate is robust to the reduction of the sample size.

Occupants of homes with high levels of built-in security could expose themselves to higher risks than occupants of homes lacking these security measures (similar to car drivers offsetting the safety provided by air bags by driving more aggressively, as shown in Peterson *et al.*, 1995). For instance, occupants could leave valuables in sight when away from home or put off investment in additional security devices, such as burglar alarms. When we include the presence of additional security measures (shutters, outside light, burglar alarm, extra locks) as potential channels of offsetting behaviour in (1), the estimated effect of government regulation hardly changes (the seventh row of Table 3). If offsetting behaviour would have been strong, then including these additional security measures would have resulted in a much bigger estimated effect of government regulation. Thus, we find no evidence that the impact of the regulatory change is affected by a behavioural response from occupants.

To obtain sufficient variation in the rate of burglary by year of construction, we used victimisation over the last 24 months rather than the last 12 months. As discussed before, by extending the time window to 24 months, we may include some burglaries in the sample that were committed at the previous address. The eighth row of Table 3 shows that the size of the effect is half as large when using the 12 months-burglary rate, which means that it is similar to the baseline estimate. In line with our assumption, using the larger time window only affects the precision and not the size of the estimated effect of the regulatory change.

The effect of the regulatory change may depend on the type of neighbourhood. For instance, the type of offender may differ between localities, with prolific offenders addicted to drugs concentrated in the city centre. Table 4 shows differences in victimisation of burglary before and after the regulatory change across neighbourhood types. Burglaries occur most often in the city, with the drop in the burglary rate

Table 4

Victimisation of Burglary and Attempted Burglary by Area and by Year of Construction of the Home (%)

	1993–2000	2001–5	Difference (% point)
(a) Burglary			
City centre	2.4	2.3	−0.1
Just outside city centre	2.9	1.9	−1.0
Suburbs	1.9	2.0	0.0
Outside city limits	1.7	1.1	−0.6
Average	2.2	1.6	−0.5
(b) Burglary and attempted burglary			
City centre	5.1	5.7	0.6
Just outside city centre	6.0	4.9	−1.1
Suburbs	3.7	4.7	1.0
Outside city limits	3.3	3.0	−0.3
Average	4.3	4.1	−0.2

concentrated in neighbourhoods just outside the city centre. A similar sized drop can be seen in homes located outside city limits. The absence of a comparable drop in the burglary rate for homes in the city centre and suburbs in these areas can be explained by a higher rate of attempted burglary for homes built after the regulatory change compared with homes built before the regulatory change, as also shown in Table 4. Whereas the rate of burglary and attempted burglary combined declines for homes just outside the city centre and outside city limits, this rate goes up for homes in the city centre and in suburbs. Young homes in these areas seem to be relatively attractive to burglars. The higher level of built-in home security does not prevent all burglars from attempting a burglary in these homes, as shown in the third column of Table 2, but it is successful in preventing them from entering the home. Apparently, the presence or the effectiveness of the built-in security is not immediately evident to all burglars. Given the higher rate of attempted burglary in some areas, the impact of the regulatory change may be larger than can be inferred from looking at completed burglary with loss of property alone. When we exclude suburbs – areas with a relatively strong increase in attempted burglary – the estimated reduction in victimisation of burglary increases from 26 to 32%, as can be inferred from row 9 of Table 3.

As discussed in Section 4, it is difficult to simultaneously assess the impact of age of the home and the regulatory change as the two are strongly correlated. Row 10 of Table 3 shows that when we directly include age of the home in the estimation equation the estimated effect becomes imprecise and the point estimate increases from -0.56 to -0.70 (the impact of age cannot be estimated precisely either). As discussed before, new homes may be more attractive to burglars, which may explain why including age in the estimation equation slightly increases the estimated effect of the regulatory change. We conclude that an evaluation based on the rate of burglary may present a lower-bound estimate of the overall effect of the regulatory change.

As a further test of the robustness of our findings, we investigate whether vandalism in the own neighbourhood (excluding car vandalism) is affected by the introduction of the Building Code. Clearly, we should not see any effect of the regulatory change on a crime type that is unrelated to burglary. Figure 5 shows the unconditional means of vandalism by year of construction of the home. Unlike burglary, vandalism does not show a structural break around construction year 2001.[6] The impact of the regulatory change works through the increased application of built-in home security, only affecting burglary, and not other crimes. Later in this Section, we discuss displacement of burglary to related property crimes such as theft from car.

4.3. *Displacement of Burglary to Older Homes*

During the time that not all homes feature burglary-proof windows and doors, a period that is likely to span decades, offenders may shift their activities to older, less-protected homes, a tactic known as target displacement. Depending on spillover effects to other homes, the nation-wide effect of the regulatory change on the number of burglaries may be larger or smaller than the direct effect on the number of burglaries in newly

[6] In Table 6, the absence of a structural break around construction year 2001 is confirmed by conducting a test based on (1) with vandalism as dependent variable.

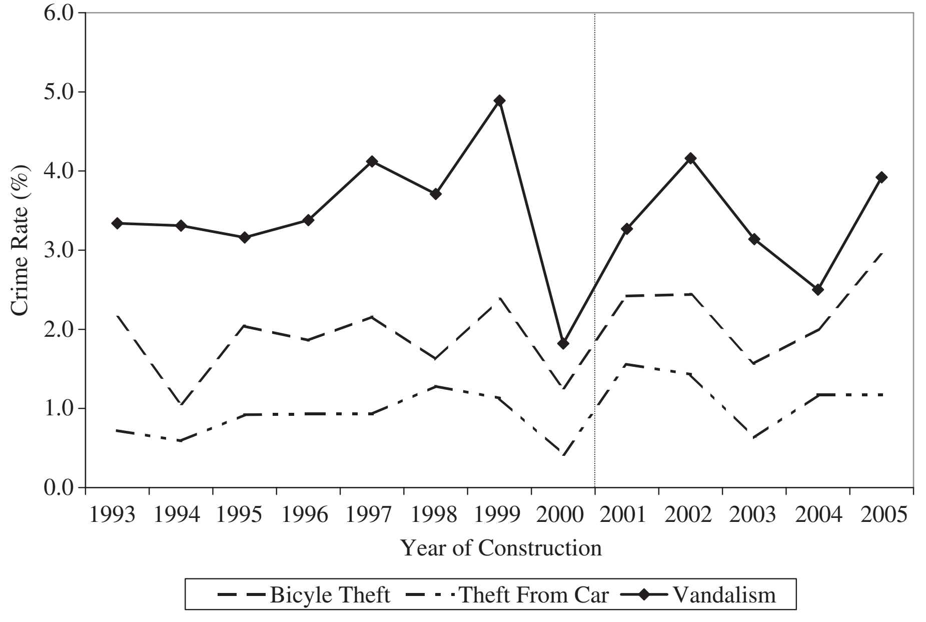

Fig. 5. *Various Crime Rates in Past* 12 *Months by Year of Construction of the Home* (%)

built homes. In the case of displacement, some crime is not prevented but redistributed. Evidence of displacement to less-protected targets has been found for several built-in security devices against car theft, including steering locks (Mayhew *et al.*, 1976), electronic engine immobilisers (Brown, 2004) and radio transmitters for retrieval of stolen cars (Gonzalez-Navarro, 2008). Alternatively, offenders may avoid older homes if it is not immediately evident which homes have and which homes do not have the built-in security, negatively affecting the overall returns to burglary.[7]

If there is displacement of burglary to homes built before 2001, then the burglary risk of these homes should be relatively high when they are located where there is a relatively large share of well-protected homes. To test for the presence of this displacement effect, we use information from all 57,422 respondents of the National Victimization Survey living in homes built before the regulatory change – rather than the 9,784 respondents living in homes completed in 1993–2005, the subsample we have used so far. We test whether the burglary risk for homes built before 2001 increases with a larger neighbourhood or municipality share of homes completed since 2001. Neighbourhoods are defined at the four-digit postcode level on average including close to 3,000 households; a municipality includes on average some 16,000 households.

[7] Ayres and Levitt (1998) have shown displacement of crime to be limited when protective devices are not visible to offenders. They find that both protected and unprotected cars benefit from the use of radio-transmitters for retrieval of stolen vehicles when it is not immediately obvious to car thieves which car has and which car does not have the device installed. Interestingly, Gonzalez-Navarro (2008) shows what happens when the same protective device is visible to car thieves. In Mexico Lojack was exclusively licensed to Ford. Ford heavily advertised which models had the device installed. Gonzalez-Navarro finds that the exclusive licensing scheme reduced theft of protected vehicles but imposed strong negative externalities on unprotected vehicles.

Table 5
Spillover Effects of Building Code 1999 *on Burglary Risk of Older Homes*; *Linear Probability Models*

	Same neighbourhood		Same municipality	
	(1)	(2)	(3)	(4)
Share of homes built since 2001	−1.16 (0.88)	–	0.85 (1.62)	–
Share of homes built since 2001× City	–	−0.79 (1.52)	–	4.01 (2.71)
Share of homes built since 2001× Suburb	–	1.05 (1.66)	–	1.90 (5.01)
Share of homes built since 2001×Outside city limits	–	−2.55 (0.90)**	–	−2.17 (2.69)
Number of neighbourhoods/municipalities	1,447	1,447	439	439

Notes. Coefficients × 100. Based on 57,422 observations; see also footnote Table 3.

In the estimation equation, we replace the policy variable by the share of homes built since 2001. Our sample includes 1,447 neighbourhoods and 439 municipalities. In this sample, the percentage of homes built since 2001 varies from 0% to almost 100% at the level of the neighbourhood and from 0 to 31% at the level of the municipality.

Table 5 displays the evidence for spillover effects on older homes. The results in columns (1) and (3) show that on average burglary rates are not affected by the share of homes built since 2001 in the same neighbourhood or municipality. The signs of the two coefficients in the second and third column suggest that the presence of newly built homes may reduce the burglary risk if they are located in the same neighbourhood and may increase the burglary risk if they are located elsewhere in the municipality, but neither of the two parameter estimates is different from zero at conventional levels of significance. In the second and fourth columns, we analyse whether the overall estimates hide heterogeneity between types of neighbourhoods. We find little evidence for the presence of externalities at this level of aggregation. Outside city limits, homes seem to benefit from being located in the direct vicinity of newly built homes (column 2). All other effects are not statistically significantly different from zero. We conclude that there is no clear evidence for a negative externality of the regulatory change on the burglary risk of older homes.

4.4. *Displacement of Burglary to Other Property Crime*

In response to better security in new-built homes offenders may also shift their attention to other, related property crimes. The National Victimization Survey provides data on victimisation of bicycle theft and theft from car in the own neighbourhood, allowing us to analyse whether these crimes are more likely to occur around homes that have been built according to the new building regulations. Anecdotal evidence from interviews with practitioners suggests that displacement to bicycle theft is most likely, as burglars may have shifted their attention from the home to the garage, in which often bicycles are parked. Securing garages against theft was not part of the 1999 Building Code, leaving them relatively unprotected.[8]

Figure 5 shows the unconditional means of bicycle theft and theft from car by year of construction of the home. We only include crime incidents in the own neighbourhood. In contrast to the clear drop in the rate of burglary after construction year 2000, we do not see a similar structural break for bicycle theft and theft from car. Similar evidence for the absence of an effect is reflected in the estimation results for bicycle theft and theft from car presented in Table 6. We estimate displacement effects of the change in the Building Code by substituting burglary for theft from car and bicycle theft as dependent variable in the estimation equation. To address heterogeneity in the quality of bicycles, we include the percentage of bicycles insured against theft. Only bicycles up to three years old tend to be insured against theft. Similarly, we include the percentage of cars with an alarm system installed as an indicator of quality of the car. The estimated coefficients for the change in the Building Code are positive but not statistically significant. To conclude, we find no evidence of displacement of burglary to other property crimes in the direct vicinity of better-protected homes.

5. Benefits and Costs of Regulation

The costs of regulation related to setting and maintaining building standards are mostly fixed. As some 70,000 homes are built annually, regulation costs per home are small. Municipalities tend to rely on industry standards for building materials rather than inspections of the home upon completion. The direct costs of installing burglary-proof windows and doors are relatively small. Practitioners estimate these costs to be about 430 euro per home, which is equal to less than 0.2% of the average house price of 240,000 euro. We assume the small increase in building costs to have had no distortionary effects on the housing market (for instance, building contractors lowering quality of the home on other dimensions than security) or on consumer behaviour (for instance, consumers adjusting their bundle of consumption goods).

Even with relatively minor costs of regulating built-in security, the benefits have to be substantial to justify the costs. Burglary is a relatively rare crime, with only 1.5% of homes victimised annually at the time of the introduction of the new Building Code. In other words, on average, a home is burgled every 66 years. The building regulations apply uniformly to all homes, whereas only some homes are likely to be burgled. Thus, reducing burglary by way of regulation of built-in security is a relatively crude measure. In contrast, uniform application increases the social benefits of security as it limits displacement of burglary to neighbouring homes.

To estimate the benefits of the decrease in burglary victimisation, we use a Home Office study into the private and social costs of burglary (Dubourg *et al.*, 2005).[9] In this study, the social costs of a burglary are estimated to be 4,700 euro per incident, a third

[8] The potentially offsetting effect of burglars aiming for the garage rather than the home may be incorporated in victimisation of burglary if survey respondents do not see the two types of incidents as different. In that case, the estimated effect of the regulatory change on burglary is the net effect of burglary in the home and burglary in the garage. Whether respondents see theft of their bicycle as part of a burglary does not affect our analysis of displacement of burglary to bicycle theft.

[9] Similar figures on the costs of crime are not available for the Netherlands.

Table 6

Parameter Estimates Linear Probability Model – Bicycle Theft, Theft From Car and Vandalism

	Bicycle theft	Theft from car	Vandalism
Building code	0.33	0.28	−0.19
	(0.44)	(0.24)	(0.24)
Characteristics household			
One-person household	0.44	−0.26	−0.30
	(0.41)	(0.18)	(0.88)
No children aged 14 or below	−0.67	0.24	−1.30
	(0.22)**	(0.16)	(0.30)**
Non-western immigrant	0.37	0.26	1.35
	(0.63)	(0.58)	(0.65)*
Low educational attainment	−0.39	−0.02	−1.21
	(0.35)	(0.28)	(0.43)**
Separated	0.17	0.29	0.36
	(0.45)	(0.34)	(0.68)
Not married	2.25	1.00	1.16
	(0.41)***	(0.14)***	(0.51)**
Characteristics home			
Secured by Design	−0.19	−0.18	0.07
	(0.30)	(0.20)	(0.41)
Rental property	−0.12	−0.01	−0.48
	(0.47)	(0.32)	(0.59)
Expensive owner-occupied home	0.48	−0.29	0.84
	(0.40)	(0.21)	(0.58)
Single-family home with garden	−0.44	−0.08	−0.23
	(0.46)	(0.22)	(0.49)
Characteristics neighbourhood			
City centre	2.35	0.00	0.73
	(1.48)	(0.32)	(0.60)
Just outside city centre	0.99	0.43	0.54
	(0.42)**	(0.30)	(0.48)
Suburb	0.11	−0.23	−0.68
	(0.35)	(0.17)	(0.42)
Lots of contacts with neighbours	−0.07	0.34	−0.68
	(0.51)	(0.16)**	(0.25)**
See police at least once a week	0.77	0.35	0.19
	(0.37)*	(0.40)	(0.51)
Bicycle insurance	−0.37	–	–
	(0.28)		
Car alarm	–	0.99	–
		(0.28)***	

Notes. Coefficients × 100. Based on 10,020 observations; see also footnote Table 2.

of which are related to the use of police and justice system resources.[10] Based on the estimated impact of the change of the Building Code, the benefits of the reduced burglary risk amount to some 14 euro per home in the first year. Over a 75-year period – the average lifespan of residential buildings – and using a discount rate of 2.5%, the total benefits amount to 460 euro per home. A somewhat longer or shorter lifespan of a

[10] Dubourg *et al.* (2005) reports costs of crime in British £ of 2003. We converted the costs into euro using the exchange rate of 2003 and correcting for inflation over the period 2003–9.

home hardly affects the total benefits, as benefits which are decades away are heavily discounted.

As discussed before, we do not find the new Building Code to have a negative effect on the burglary risk of older homes or on victimisation of other property crimes. Leaving these external effects aside, we find the regulation to be welfare increasing. The benefits of this one-size-fits-all measure exceed the costs, albeit not by a large margin.

6. Conclusions

In our empirical analysis, we find that regulation of built-in security in homes is highly effective in reducing victimisation from burglary. Through the application of better burglary-proof windows and doors, the burglary risk in new-built homes has been reduced by 26% compared with homes built in the years prior to the regulatory change. Our results are robust to various model specifications, including the time window around the structural break, the year the regulatory change went into effect, and changes in characteristics of households, homes and neighbourhoods that coincided with the change in regulation.

The introduction of the Building Code does not seem to have had a negative effect on burglary rates in homes built before the regulatory change. We do not find evidence for displacement of burglary to other property crimes either. Leaving these externalities aside, we find that the social benefits of the regulation exceed the social costs, even though application of the measures has not been targeted at homes that are most at risk and carelessness of occupants may have undermined some of the protective effect of the security measures. The built-in home security requires some effort on the side of potential victims after all, including closing and locking all doors and windows that are accessible to burglars.

Finding a large effect of the regulatory change implies that households living in homes built before the change in the regulation took few precautionary measures to compensate for their lack of built-in security. Apparently, homes with a low level of built-in security have a higher risk of burglary. The inability to commit to a strategy of precautionary behaviour and the tendency to be overly optimistic about the chance of being victimised are two explanations for low levels of private crime prevention. In line with the literature on health preventive behaviour, the effectiveness of regulation of built-in security compares favourably to measures aimed at changing victim behaviour, including burglary prevention advice, publicity campaigns and subsidies for expenditures on security.

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