# The Effect of Card Reader Locks on Theft on a University Campus

*Jacob Kaplan*

**Abstract:** Door locks are an ubiquitous form of security to control access to a building with the goal of reducing crime there. However, research on door locks is often limited by methodological issues and primarily focuses on residential or commercial locations. This paper assesses the impact of card reader door locks on school buildings on an urban university campus. Using a difference-in-differences approach, this paper estimates the effect of card reader locks on crime in buildings. The results indicate that the locks do not significantly affect crime within the buildings. Avenues for future research, including suggestions of specific universities at which to conduct further studies, are discussed.

## 1 Introduction

Controlling access to a location as a means to reduce deviancy is an ancient practice. The gates of medieval castles, for example, ensured that only those permitted to enter may do so (Poyner 1983). In modern times, castles are no longer used, but the lessons of access control endure. Door locks are a modern replacement of the castle gate, permitting the owner to limit access to only those with keys. The use of door locks is ubiquitous. An analysis of the British Crime Survey found that in 1998, 72% of households had a deadbolt lock, an 11-percentage point increase from 1992 (Budd 1999). Kesteren and colleagues (Kesteren, Mayhew, and Nieuwbeerta 2000) examined the International Crime Victimization Survey and found similar trends of increasing deadbolt lock ownership worldwide; in the United States, 53% of homes had deadbolt locks in 2000. While the usage of locks is widespread, evidence of their effectiveness is less thorough.

While research generally finds that locks are associated with lower crime, the cross-sectional nature of these studies limits claims of causation. Studies typically evaluate door locks' effect on crime but count the locks at the time the crime occurred. Additionally, nearly

all past research on this subject has evaluated traditional key-locks. While key-locks are still the predominant type of lock in use today, businesses and individuals are increasingly turning to technology as a security-supplement. For example, "smart locks" that open to individuals with specialized access permission (often through an identity card or key-fob) are increasingly available (Ho et al. 2016).

The current study evaluates the effect of using door locks on theft and crime in general on campus buildings at a large urban university. More specifically, the locks utilized are card readers (opened using student or staff identification cards) which can be activated in various buildings at different times. The card readers selectively permit students and staff to enter during specific times and into specific buildings - offering a more flexible approach than traditional key locks. There has been no published research on this technology's effect on crime to date.

Using monthly theft and total crime data, this study examines crime before and after card readers are installed in buildings with the card readers against a comparison group of similar buildings that could have card readers. The results show no evidence that card readers affect crime in buildings. The null findings may be the result of the already low level of crime in campus buildings as the average campus building experiences fewer than two crimes per year.

This paper is organized as follows: Section 2 provides details of past research on access control. Section 3 explains the data used. Section 4 describes the empirical model, Section 5 shows the results. Section 6 discusses these results and notes avenues for future research, including which universities are good candidates for conducting similar studies.

# 2 Previous Research

Crime Prevention Through Environmental Design (CPTED) is an approach that seeks to alter the physical environment to reduce opportunities for crime (P. M. Cozens, Saville, and Hillier 2005; Walsh 1999; Welsh and Farrington 2009; P. Cozens and Love 2015). By limiting the chances an offender has to commit a crime, the total number of crimes should drop. Much of CPTED incorporates minor changes in a given area, which may vary from a single building (Minnery and Lim 2005) to wide sections of a city. Often this is done through the implementation of technology or physical alterations.

A core tenet of CPTED is that alterations in the environment can act as subtle nudges to affect behavior. This can reduce an offender's propensity towards criminal behavior or reduce victim vulnerability. Crowe and Zahm assert that "the elements that make a neighborhood safe are the same elements that make a 'good' neighborhood" (1994, 22). This "good neighborhood" is made so when opportunities for lawful behavior are maximized, and opportunities for unlawful behavior are minimized. Specifically, they suggest using "physical design elements" (1994, 22) to control access to the home, improve community members' ability to see who is nearby, and demarcate exactly where community land ends and private land begins. These ideas are the basis of CPTED.

To reduce crime, CPTED alters the environment to increase "territoriality, surveillance, [and] access control" (P. M. Cozens, Saville, and Hillier 2005, 330). An example of a subtle technique is a home with well-trimmed hedges which provides a view both into and out of the house. This increases the potential for passers-by on the street to observe if anyone unwelcome is in the home, and for the home resident to monitor for wrongdoers in the street (Weisel 2002; P. Cozens and Love 2009). Additionally, the trimmed hedges indicate that the owner takes pride in their home and would not tolerate disorderly activity in the community. A neighborhood where all homes are well-maintained signals that there is a norm of caring for the neighborhood and that each resident adheres to this norm.

Weisel's (2002) analysis of burglaries supports this notion, as she found that single-family homes with limited ties to the neighborhood are at greatest risk of burglary. These include homes that are "vacant for extended periods" of time, have new owners, have limited visibility due to high fences or hedges, or without (or with inadequate) security devices (2002, 8). The lengthy periods of vacancy and new ownership limit the effectiveness of natural surveillance by community members. In both cases, neighbors have limited knowledge about who are legitimate members of the community and who are strangers - in essence, who belongs and who does not. This limits their ability to accurately identify a potential offender and alert the authorities. Tall hedges make it difficult for surveillance to occur even if the community knows who belongs there and may encourage offenders who wish avoid detection. That elements of the physical environment signal a community's concern for crime - and willingness to combat it - is a core component of the influential Broken Windows Theory.

Kelling and Wilson's (1982) Broken Windows Theory suggests that vandalism increases in locations "that seem to signal that 'no one cares'." A well-ordered home signals that someone does care, and that crime would not be tolerated there. A messier neighborhood, lacking the perceived personal pride and natural (informal) surveillance of an orderly neighborhood, would likely be an easier target for criminals. The signal that the community cares is more important than individual aspects of the environment. A well-kept hedge may offer minor visibility improvements compared to an unkempt one. But it can send a signal to offenders that the hedge's owner cares about their home - and may have made other investments (e.g. door locks) that increase the offender's risk of capture. However, for Broken Windows Theory to be accurate, offenders must be able to recognize these signals and respond accordingly.

There is evidence that offenders do in fact respond to visible security measures. A qualitative study by Carmel-Gilfilen (2011) conducted a walk-through of retail stores with self-admitted shoplifters and asked them to discuss store security and their willingness to shoplift there. Among the most cited store security measures were video cameras and security

tags on clothes. "Expert" shoplifters, those with either 25 lifetime shoplifts or 10 shoplifts in the past year, were more deterred by physical security measures such as cameras than were novice shoplifters (2011, 27). This indicates that CPTED may be more effective against experienced offenders who are aware of the security and its effect on their likelihood of detection.

There is good reason to believe that securing exterior doors and windows may reduce crime. In one third of burglaries, the offender "[enters] through unlocked or open windows or doors" (Weisel 2002, 14). Budd's analysis of burglaries in the United Kingdom came to a similar conclusion, finding that 22% of burglaries occurred through unlocked doors or windows (1999). Securing these entrances with locks would "greatly reduce the risk of being burgled" (1999, 22). Additional security devices provide additive protection from burglars.

Physical obstructions to crime are a part of CPTED's access control, sometimes referred to as "target hardening" (P. M. Cozens, Saville, and Hillier 2005). Physical security measures should be seen, not as an impregnable fortress, but as a deterrent for crime. The majority of burglars are "easily deterred by dogs, alarms or locks" (Weisel 2002, 16). For those clever- or determined-enough to bypass these security measures, they serve to increase the risk that the offender is caught. Target hardening measures involve both making the vulnerable location harder to enter and limiting the scope of possible offenses if entry occurs.

## 2.1 External Target Hardening

The primary method for preventing an offender's entry is through the use of locks on doors or windows. Using locks is more important than just owning them. Weisel (2002) in the United States, and Budd (1999) in the United Kingdom, found that about one in four burglaries occurred through an unlocked door or window. Budd's seminal paper on burglary in the United Kingdom, using crime victimization data, found that the presence of security devices was associated with fewer burglaries. Door and window locks were the most effective devices.

However, even for homes targeted by a burglar, these devices were protective. Burglaries against homes with door or window locks were more likely to be attempts rather than completed burglaries. The devices prevented the offender from entering the building.

Tseloni and colleagues also utilized national crime victimization surveys and attempted a cross-national analysis of burglary (2004). They used data from the United States, the United Kingdom (England and Wales), and the Netherlands to assess, among other factors, how target hardening affects burglary. In every country assessed, they found that hardened targets (those with locks, burglar alarms, and outdoor lighting) had increased odds of burglary. In the United Kingdom and the Netherlands, the odds more than doubled. In the United States the odds increased by 19% relative to homes without such devices. These analyses, however, are limited by the study design. As their study was cross-sectional, they were unable to assess if the security devices were acquired before or after the burglary. This is a common issue in target hardening research that will be discussed shortly.

One study that partially avoids this issue is Vollaard and van Ours' (2011) quasi-experimental study on the effect of burglary-resistant home doors and windows on residential burglary in the Netherlands. In 1999, the Netherlands changed its building codes to require all new homes to use these more secure features. The changes to the new homes were fairly inexpensive relative to the home cost (about $695 per home in 2018 dollars). Using victimization data, the authors compared burglaries in homes built before and after the changes, finding that new homes had a 26% lower burglary rate. They also found that the new homes had a protective effect on their neighbors. Older homes that were near the new homes had a lower rate of burglary compared to older homes without new neighbors. This indicates that burglars respond to changes in their opportunities. A neighborhood full of unsecured homes to burgle, after all, is a better target than a neighborhood with half as many opportunities.

## 2.2 Internal Target Hardening

Once an offender has entered a location, various methods are available to deter them from completing their crime. In locations that handle cash, drop safes are a commonly studied method to do this. A drop safe is essentially an armored United States Postal Service collection box; everyone has access to deposit money, but only managers can open it. This prevents store employees from being able to open the safe, greatly reducing the amount of money a robber can take. Often this tool is used in liaison with policies that limit the amount of cash in a register. An offender would not risk lengthy prison time, it is theorized, for a small amount of money (Crow and Bull 1975).

In the most robust study on target hardening to date, Crow and Bull (1975) conducted an experiment to see the effect of CPTED on convenience store robberies. Stores which received the treatment altered their store in minor, often cost-free, ways. Advertisements on windows were removed - to increase visibility in and out of the store - and signs were posted that said that cash handling policies were in effect (e.g. cash limits in registers and drop safe usage). A small minority of treated stores utilized more costly techniques such as moving the drop safe into a more visible location or adjusting store lighting. In an eight-month follow-up, the treatment group's robbery rate was nearly 18% lower than the control's rate. Unfortunately, the study's use of multiple CPTED techniques only lends support to CPTED in general and cannot determine for certain which aspect of the changes reduced robbery. More recent studies on drop safes offer some knowledge on this specific tool.

A review of studies by Amandus et al. (1995) and Casteel and Peek-Asa (2000) found that while most studies on drop safes concluded that they reduced robbery, several studies were limited by methodological issues They failed to control for confounding effects of local crime characteristics (e.g. crime rate) and other CPTED variables (e.g. location of cash register). Amandus et al.'s own analysis of robberies in Florida convenience stores found a significant lower odds of robbery for stores with "poor cash handling policy" (1995, 715).

These stores, which did not have drop safes or cash limits, had 90% lower odds of robbery than stores that had a stronger cash policy. S. A. Hendricks et al. (1999), in an analysis of 400 convenience store robberies in Virginia, came to an opposite conclusion. They found that stores with poor cash handling policies (ones that did not have a cash limit or a drop safe) had more than double the odds of robbery relative to stores with good policies. Stores that were robbed may have changed policy to reduce the chance of future robberies (e.g. by changing cash handling policy). As both Amandus et al. (1995) and S. A. Hendricks et al. (1999) measured store policy simultaneously with the robberies, their results may be due to reverse causality as policies may be a reaction to past robberies

Research has also been conducted as to the effect of CPTED on violence during convenience store robberies. Estimates find that between 5-12% of these robberies end in employee injury (Crow and Bull 1975; Faulkner, Landsittel, and Hendricks 2001; Amandus et al. 1997). The high rate of injury has spurred research into CPTED methods that reduce injury were a robbery to occur.

A study by Faulkner et al. (2001) found that having visible drop safes were associated with a 60% reduction in the odds of employee injury in convenience store robberies. The robbers for stores with a visible drop safe may have changed their behavior upon their inability to access the safe. The presence of the drop safe may have prevented, in many cases, the escalation of the situation into a violent encounter. They also found a significant drop in employee injury in stores that limited cash in the register to $100. These indicate that offenders may behave more cautiously (violence during a robbery can lead to a lengthier incarceration) in situations with lower perceived reward. However, as these studies were cross sectional, they cannot say whether the CPTED methods used caused the decline in employee injury.

## 2.3 Limitations of Prior Research

The use of target hardening to reduce crime is a technique far more widely utilized than adequately studied (Casteel and Peek-Asa 2000). Casteel and Peek-Asa's review of 26 studies on this topic contains only eight studies that used a control group or used experimental or quasi-experimental designs. Three of the studies with a control group used stores that declined to participate, allowing for selection bias. In fifteen of the reviewed studies, the research was "generated for an agency" and not subject to peer review; three studies were published in non-peer review journals (2000, 4). Amandus et al.'s (1995) review of 14 studies on CPTED and convenience store robberies contains only two experimental designs. Ten of these studies are cross-sectional, and thus unable to determine if the CPTED methods existed before the robbery took place. Their own study involved visiting stores 1-3 years *after* a robbery and assessing their CPTED factors at that later date. R. D. Hunter (1988) utilizes the same data as Amandus et al. and has similar results. Data on convenience store CPTED techniques in Virginia, which both Hendrix et al. (1999) and Faulkner et al. (2001) used for their studies, were collected only after that store reported a robbery. This lack of proper temporal ordering between procuring the security device and when the crime occurred makes determining the effect of target hardening devices, such as locks, on crime difficult.

This issue is exacerbated because while a crime victim would likely see security devices as a worthwhile investment, non-victims may see it as unnecessary. Therefore, it may be more likely that a crime victim had a security device than a non-victim, leading to the inaccurate belief that security devices cause crime. Budd (1999) offers evidence in support of this. Her analysis of security device ownership for burglary victims showed a substantial increase in ownership after victimization. For both burglary and attempted burglary victims, door deadbolt ownership increased by around 30% and window lock ownership increased by over 20% (1999, 40).

Research on repeat victimization has found that merely being the victim of a crime

"increases risk of further victimization" (Ashton et al. 1998, 271). These victims are often repeatedly targeted because some characteristic makes them more vulnerable. In cases of burglary, these characteristics involve building location, poor security, and occupation (Weisel 2005; Weisel 2002). The impact of a first victimization is substantial, with burglary victims being up to four times as likely to suffer another burglary in the weeks following the first incident than homes never victimized (Pease 1991). Ashton et al. (1998) interviewed convicted burglars and found that one-third of these burglars had in fact returned to past targets and burglarized them again.

These studies provide insight into the mechanisms of how lacking proper time-order on building security devices can affect research. A victim that suffers multiple burglaries may be highly motivated to acquire protective devices, even more so than a victim with a single burglary. Failing to control for other factors that motivate offending, these victims may appear to *increase* their risk of burglary by investing in protective devices. The burglars interviewed by Ashton et al. (1998) noted that the procurement of security devices was a major catalyst for stopping their repeat victimization.

Access control is ubiquitous, ranging from security guards at building entrances to turnstiles in subway systems (La Vigne 1997). Access control has also benefited from advances in technology which allows flexibility in who can enter a building and during which times. For example, the Cochran Homes, a public housing complex built in 1953 in St. Louis, Missouri, utilized card readers to control entrance to the building (William Brill Associates and America 1977). In lieu of guards, the Cochran Homes required residents to swipe an identification card for entrance to the lobby and access to the elevators. This strategy was meant to balance the need to prevent unauthorized non-residents from entering the building with a desire to ensure that their home's entrance "did not suggest a prison" (1977, 18). The conflict between reducing crime and avoiding the creation of a "fortress society" is a recurrent theme in CTPED (Welsh and Farrington 2009, 7). In the half century since the Cochran

Homes began using this access control technology, its adoption has been widespread. Yet little is known about its effect on crime. Unfortunately, implementation of card readers in the Cochran Homes was not accompanied by an analysis of their effect on crime.

## 2.4 The Current Study

This paper examines the effect of card reader locks in building entrances on crime in buildings on an urban university campus. The university began utilizing card readers to limit access to certain buildings to only authorized students and staff. This paper analyzes how theft and total crime in buildings changed after that building received card readers compared to buildings who have yet to adopt them.

The card reader buildings activated their access control at different times. This study uses a matched comparison design to assess the effect of the card readers. Each of the card reader buildings (N = 16) was matched with two buildings based on similar location, size, visibility, and building type to enhance the quality of the comparison group. Building size involves both the number of floors and the square footage of the building. Comparison buildings are often on the same block as the treated building and are visible from the same location. If comparison buildings are not physically near their card reader match, they were chosen based on similar locations on campus. A card reader building on the peripheral of campus was matched with a comparison building likewise on the peripheral. Their similar visibility means that a criminal deciding which building to target would be aware of each building's presence. The building type is the main purpose of the building. A building with classrooms, for example, was matched with other classroom buildings. In this way both the building interior and its potential victims (e.g. students, administrative offices) are similar for both groups.

This study improves the research on access control in a number of ways. First, the use of a difference-in-differences design avoids the endogeneity problem that has limited prior

research. A difference-in-differences design measures the effect of a treatment by comparing changes in the desired outcome over time in the treated group to a group similar to the one that was treated under the assumption that, but for the treatment, both groups would have parallel trends (Abadie 2005). This design ensures proper-time order and allows an evaluation of the lock's effect on crime. A benefit to this design is the two groups do not need identical crime counts, merely similar trends prior to treatment. Second, using theft rather than robbery or residential burglary offers a much larger sample of offenses than past research has used. Finally, whereas most previous studies assess access control on residential or commercial buildings, this study examines a university campus. University campus buildings often have higher foot traffic than either residential or commercial buildings, a factor that may affect the impact of access control devices.

# 3 Data

This study uses crime data from the university police for the period between June 2005 and November 2016. Each incident includes a record of which crime occurred, the date it happened, and in which building it occurred in. The university police also provided data on when card readers were installed in buildings. Non-card reader building security - guards and virtual concierge - data for each building also comes from the university police. Characteristics of the buildings come from the university's website.

## 3.1 Building Security

The focus of this study is to examine whether card readers reduce crime. For this, data available from the university police tells which buildings have card readers, when implementation began, and other security measures the building may have.

In addition to card readers, buildings may have security through guards or a virtual concierge. Though the data indicates whether what type of additional security a building

may have, it does not say when that security was implemented. Security guards are private security hired by the university. They may be posted at specific locations - generally near main entrances - or mobile through the building. However, buildings with security guards can still have unsecured entrances, particularly if there are fewer guards than perimeter doors.

A virtual concierge is a call box outside a building that people can use to gain access. Either a building administrator or a university police employee will answer the call and, using a security camera in the callbox to look at the person's identification card, verify that the person is allowed to enter the building and grant them access. This is a similar tool to card readers in limiting access to a building but is far more labor intensive.

## 3.2 Building Characteristics

The physical features of a building may have an effect on victimization. This study considers three measures of building characteristics when selecting comparison buildings: the number of perimeter doors, the number of floors, and the square footage of the building. A building with many doors may be seen as less secure, as some doors may be unguarded or infrequently used (Weisel 2002). Buildings with a large number of perimeter doors may weaken the impact of security guards. Larger buildings may also be more populated and allow criminals to blend in with the crowd. The literature on the effect of building size (generally measured through the number of floors) has been mixed between no effect (Newman and Franck 1982) and weak effects (Newman and Franck 1982; Holzman, Kudrick, and Voytek 1996). Greenberg and Rohe's (1984) study found that most burglaries occurred on the first floor, indicating that ease of access, rather than building size, is an important predictor of burglary targets.

Table 1 shows summary statistics of these building features and average monthly and total crime experienced for each group. Row 1 shows the characteristics for the card reader buildings, while row 2 shows the characteristics for the comparison group. Row 3 includes all other buildings on campus.

The card reader and comparison buildings are relatively similar in terms of crime and building characteristics. Card reader buildings often have greater security than the comparison group. The card reader and comparison groups have similar monthly crime rates prior to installation of card readers. The average building experiences fewer than 2 crimes per year. The card reader buildings experienced a combined 357 crimes during the period studied while the comparison group had 644 total crimes. Comparison buildings are larger than card reader buildings. They have about 1.5 more perimeter doors and are 15,000 square feet larger than card reader buildings, but these differences are within one standard deviation. Among security features, card reader buildings are more likely to have guards or virtual concierges. This is most clear with virtual concierges, as card reader buildings are more than twice as likely to have them than the comparison group. This may be because buildings that are already concerned about security are more likely to request virtual concierges and card reader locks than other buildings.

Buildings with guards or virtual concierges are also more likely to have an entrance facing a major street. Studies on burglary targets found that buildings that are easier to quickly enter - those on the corner, on through streets, or near major streets - are more likely to be targeted (Weisel 2002; Johnson and Bowers 2010; P. Cozens and Love 2009). These types of buildings are easier for offenders to evaluate and then quickly enter and exit during the crime. Buildings with guards or virtual concierges are also more likely to contain well-funded departments (e.g. the business and law schools) that are able to pay for the security. However, average monthly crimes and security differences appear small and not statistically different.

The card readers are a supplement rather than a replacement to the other security. In most cases the card reader is only active during the night, so its effect is limited to only the night hours. Other building security, such as guards, are not replaced by the card readers but its presence may improve the guard's effectiveness. For example, a building with multiple

doors and a single guard has many doors unguarded at any given time. With the addition of the card reader, all entrances are secured, and the guard can monitor the entry of persons through a single door of their choosing.

## 3.3 Crime

The university police respond to crime on campus and in the immediate surrounding area. A majority of crimes occur outside of buildings, generally in the streets around the campus. This study only considers the crimes that occur within campus buildings. Theft is by far the most common crime in buildings. This category captures 90% of all crimes and contains offenses such as "theft from building" and "theft of a bicycle." The other 10% of crimes are made up of 5% burglary, 2.5% assault, and 2.5% other crimes. This study examines theft and all reported crimes as the two main outcomes.

Figure 1 shows the total number of total crimes for card reader and comparison buildings in the 10 months prior to and after the card readers were installed. Trends are similar before card readers were installed indicating that the comparison pairs were properly selected. The number of crimes each month was low; with both groups experiencing fewer than five total crimes in the majority of months. As crime is so uncommon in these buildings, a single building experiencing a higher than average month of crime can cause significant fluctuation in the number of crimes that group had in that month.

Table 1 also provides context of the frequency of crimes occurring in buildings by showing the average monthly thefts in both card reader and comparison buildings before and after the card reader was activated. In both groups, the average number of monthly crimes decreased after card readers, reflecting a campus-wide trend of decreasing crime.

Figure 2 shows this downward trend in crime by showing the aggregate monthly sum of crimes in campus buildings for the entire period studied. The trend over time is downward, indicating that the campus is getting safer.

# 4 Methods

This study estimates the effect of card readers on crime by comparing the change in crime after the card readers are installed to similar buildings without card readers. Each of the 16 card reader buildings were matched with two comparison buildings based on similar location, size, visibility, and type. To control for possible spillover to other buildings on campus, all other campus buildings are also included as a secondary comparison group.

The buildings which received card readers are predominantly those with large classrooms, but include a small number of medical and research buildings. These buildings are often highly populated with students and openly accessible to the public with classrooms. In buildings with classrooms and faculty and graduate student offices, there exists a large number of potential victims and access for offenders. Installation of the card readers could reduce access to those buildings for potential offenders.

This study uses a Poisson regression model to estimate the effect of card readers on total crime and thefts in buildings according to the following form.

$$Y_{it} \sim Poisson(\lambda_{it}) = \beta_0 + \beta CardReader_{it} + \lambda comparison_{it} + \alpha_i + \zeta_t \tag{1}$$

where $Y_{it} \sim Poisson(\lambda_{it})$ is the number of total crimes or thefts in building $i$ and time $t$ (year-month). CardReader is a dummy variable that takes the value of 1 for months when the card readers were active and 0 otherwise. The comparison takes a value of 1 when the building's treated pair has an active card reader and 0 otherwise. Buildings which are not part of a treated building's comparison pair will have a value of 0 for all months and serve as a reference group. Parameters $\beta$ and $\lambda$ estimate the effect of card readers and comparison buildings relative to each other and all other campus buildings. In equation (1) $\alpha_i$ is the building fixed effect (N = 122), and $\zeta_t$ is the year-month (N = 138) fixed effect. Building fixed effects are used to control for differences between buildings that are time stable while

year-month fixed effects control for crime trends across the campus that are common to all buildings. Standard errors are clustered at the building level.

# 5 Results

Table 2 shows the effect of card readers on total crime and theft. Column (1) estimates the effect of the card readers without including year-month fixed effects while column (2) includes them. The regression coefficients are exponentiated to show the incident rate-ratio (IRR) or the relative rate of change in the number of outcome variables for every one unit increase in the predictor variable. The effect of card readers is statistically significant for total crime and marginally significant for theft ($p<0.1$) when conditioning solely on building fixed effects. Both total crime and theft are estimated to have declined by about a third, with total crime decreasing by 28% and theft decreasing by 33%. However, this effect disappears upon the introduction of year-month fixed effects. This indicates that the effect of card readers in column (1) is an artifact of the campus getting safer in general.

When predicting total crime, the IRR in column (2), row 1, is 0.93 (95% CI: .65, 1.35), showing that buildings with card readers have about seven percent fewer crimes per month after card readers relative to all other campus buildings. Theft has an IRR of 1.01 (95% CI: .70, 1.45) or a 1% increase in the number of thefts. However, for both categories these differences are not statistically significant from no difference. The standards errors for for both these categories are quite large, making the null results imprecise. These results suggest that card readers do not provide additional safety over and above the campus-wide decline in building crimes. The results also show no significant change in comparison buildings.

# 6 Discussion

Technology-assisted locks, such card reader or key-fob locks, are increasingly being used for building security. These tools allow more individualized control than key locks and are an attractive solution to the problem of limiting access control to specific people during set times. This highly specialized form of access control is commonly used in environments where access must be controlled for a large number of doors and people. This study is the first that assesses if card reader locks reduce crime in buildings.

Using administrative crime data from the university police department, the results indicate that card readers do not reduce building crimes relative to comparison buildings or the campus-wide decline in crime in all buildings.

The null effect may be due to the low baseline of crime in campus buildings. On average, each building reports under two crimes per year. One element of the low and declining crime rate may be the security system already in place across campus. The vast majority of campus buildings have some form of security, generally security guards or traditional key locks after hours. Card readers, therefore, are an incremental increase to an already robust security system. These findings, however, are limited to crimes within campus buildings on the campus studied. The increase in security through card readers may have driven some offenders off-campus towards easier targets or to nearby universities.

The additional security to the exterior of buildings may also inadvertently increase crime if inhabitants respond to the additional security by taking fewer precautions inside the building. If the new locks on the outside of the building make professors, for example, less likely to lock their offices, offenders who do gain access may have easier access to targets inside the building, negating the crime-reducing goal of the locks. A survey asking people who regularly use buildings which receive the locks if they changed their security precautions because of the locks could ascertain whether this possibility has occurred.

The usage of official police crime data rather than victim reports may also be a factor in the low crime rate. Using official police data under counts the number of thefts. Crime that goes unreported cannot be analyzed. It is likely, however, that the more severe the theft (i.e. the costlier the financial loss), the more likely the victim is to report. A 2008 report by the Bureau of Justice Statistics using National Crime Victimization Data found that the amount lost in a theft is strongly related to the likelihood of the police being notified (Rand and Robinson 2011). Thefts with a loss of under $50 are reported to police less than 20% of the time while more than half of thefts costing the victim $250 or more are reported. Therefore, this study may better evaluate the effect on serious crime than on more minor crime.

Most research on access control focuses on serious crimes such as burglary and robbery. As these crimes are relatively rare, the number of crimes included in the studies is often low. This study reduces this problem by using theft, a far more common crime, as its primary crime of analysis. This study does evaluate serious crimes - primarily assault and burglary - as part of the total crimes category. However, the number of these crimes is too low to evaluate separately from theft. Future research should use schools with a higher crime rate or combine a number of schools until the count of serious crimes is acceptable for analysis.

Figure 3 offers guidance on which universities and colleges are good targets for study. This graph shows the 452 public or private 2- and 4-year colleges with between 10,000 and 30,000 students that have reported crime data to the Department of Education during 2016. In particular, this graph shows the difference in the rate of burglaries per student across these schools. While the data does not have the numbers of thefts, burglary is a good proxy for the types of crimes that card readers can impact. The university studied here represents a typical case, with only slightly more burglaries (9 during 2016) than the average school (mean = 7.14). The relatively low numbers of burglaries across campuses lends support that this study is generalizable across many schools. It also limits the number of viable schools for

study as many schools have fewer burglaries than the one studied. Only 12 schools reported 40 or more burglaries during 2016. These schools, in particular the ones with ample resources to devote on increasing security such as Harvard (70 burglaries) and Stanford (54 burglaries), may be excellent locations to further this research.

This study differs from previous studies of access control as it was conducted on an university campus - a location where student safety, fear, and ability to learn are often prioritized above material loss. This study directly evaluates student safety through the limited number of non-theft crimes in the total crime category. However, it does not evaluate student fear of victimization. A reduction in theft may, in fact, have no impact on fear. If students are unaware of the ongoing crimes, or consider them insufficiently threatening, a reduction in crime may not reduce fear of it.

McCreedy and Dennis (1996) surveyed 760 college students about their own victimization, fear of crime, and willingness to take night classes. They found that victims of sexual offenses or stalking, and those who received a "lewd or threatening phone call" are less likely to attend night classes than non-victims (1996, 76). This indicates that crime victims change their behaviors as a result of being victimized, potentially to their educational detriment. The reduction in attendance on campus at night can be tested. If card readers lead to a safer campus, enrollment in night classes could increase if students feel safer going into buildings during the evening. Future studies on access control, particularly ones in educational settings, should focus on potential softer effects alongside crime reduction. Ensuring that students feel safe may be reason enough to utilize card readers.

The card readers record who uses their card to access a locked door. This information could potentially be used as an investigative tool for serious crimes, such as burglary, that occur in buildings. This information is useful for both determining potential suspects and finding witnesses to the crime.

There remains a number of questions about card readers that are unanswered by the

present study. The ubiquity of card readers, and similar technology-based locks, and the dearth of research on them make this a ripe field for study. These tools are used with growing popularity; to provide users with information regarding their effectiveness on a variety of crime- and non-crime-related issues, more research is needed.

Table 1: Design and security features for card reader, comparison, and other campus buildings.

| | Perimeter Doors | Floors | Square Feet (in 1,000s of feet) | Guard/ Virtual Concierge | Crimes Before Card Readers | Crimes After Card Readers |
|---|---|---|---|---|---|---|
| Card Reader (N = 16) | 7.25 (4.09) | 5.77 (2.18) | 89.81 (56.42) | 0.75 (0.45) | 0.17 (0.46), 283 | 0.15 (0.46), 74 |
| Comparison (N = 32) | 8.73 (6.26) | 5.68 (2.35) | 105.57 (90.34) | 0.34 (0.48) | 0.14 (0.43), Total: 505 | 0.13 (0.41), Total: 139 |
| Other Campus Buildings (N = 74) | 8 (9.77) | 5.81 (5.22) | 140.36 (138.19) | 0.45 (0.5) | | |

Table 2: Effect of building security on crime in campus buildings.

| **Variable** | **(1)** | **(2)** |
|---|---|---|
| **Total Crime** | | |
| Card Reader | 0.72* (0.12) | 0.93 (0.18) |
| Comparison | 0.67** (0.10) | 0.85 (0.15) |
| Year-month Fixed Effects | No | Yes |
| Building Fixed Effects | Yes | Yes |
| **Theft** | | |
| Card Reader | 0.74 (0.11) | 1.01 (0.19) |
| Comparison | 0.68** (0.10) | 0.89 (0.15) |
| Year-month Fixed Effects | No | Yes |
| Building Fixed Effects | Yes | Yes |

Each cell shows exponentiated regression coefficients, robust standard errors are in parentheses.
* $p<0.05$
** $p<0.01$

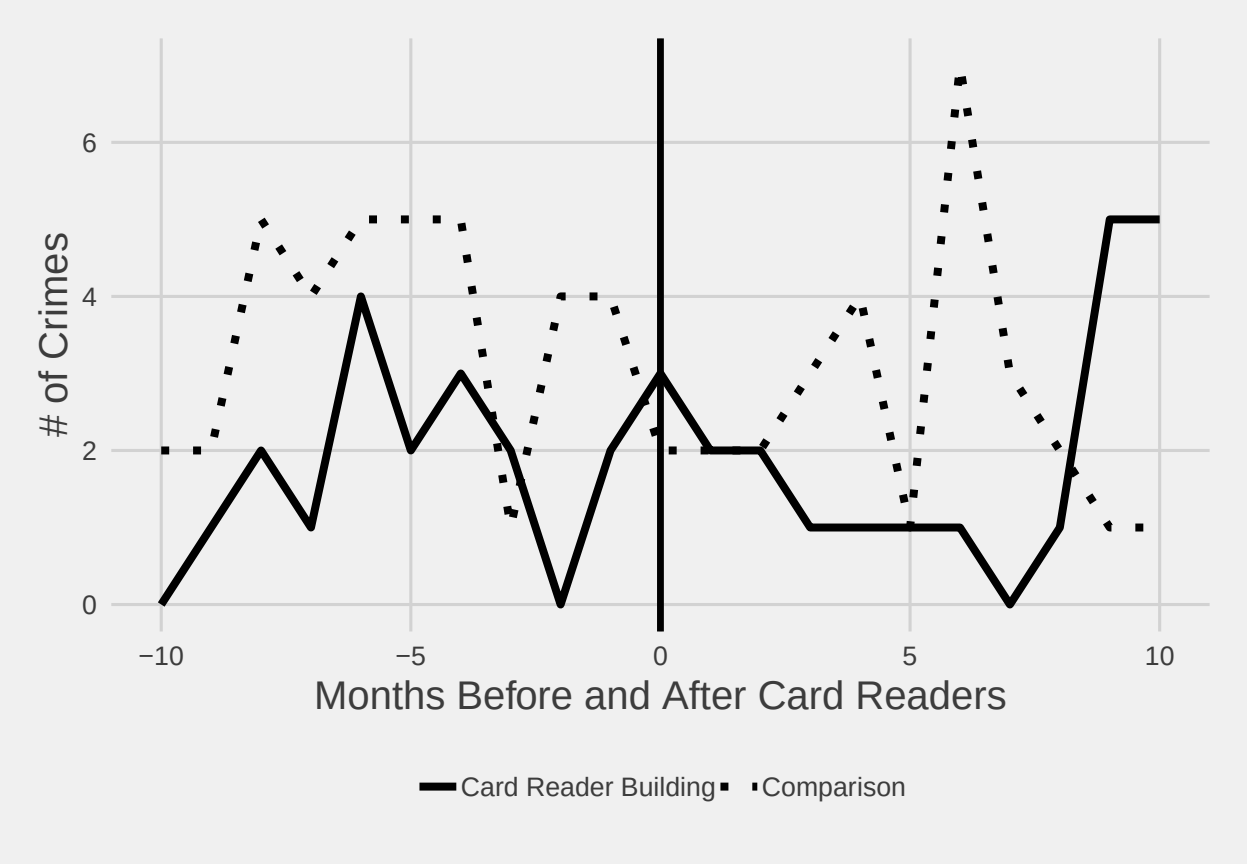


Figure 1: Crime trends for card reader (n = 12) and non-card reader buildings (n = 24) 10 months prior to and after card readers Four buildings (and their comparison matches) are excluded from this graph because they did not have ten months of post period.

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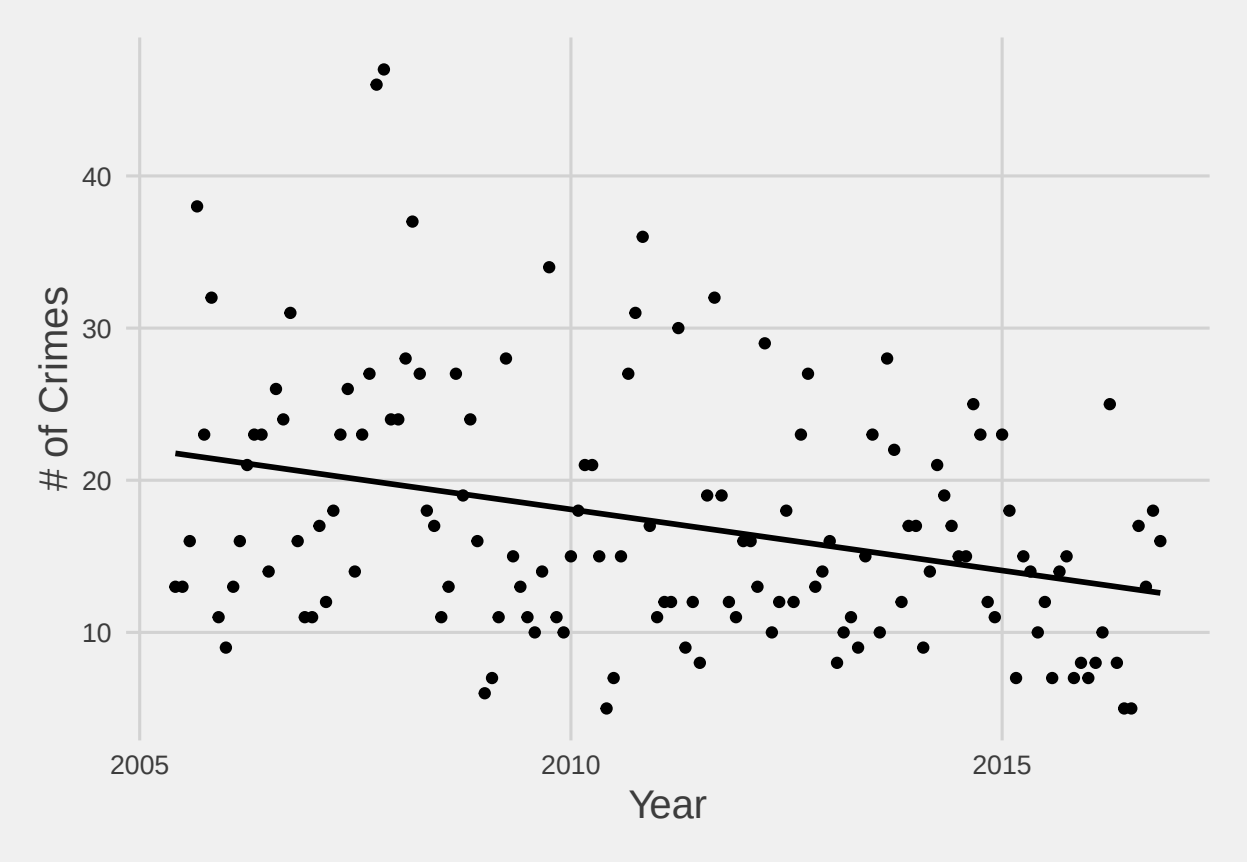


Figure 2: Total monthly crimes in campus buildings throughout the period studied.

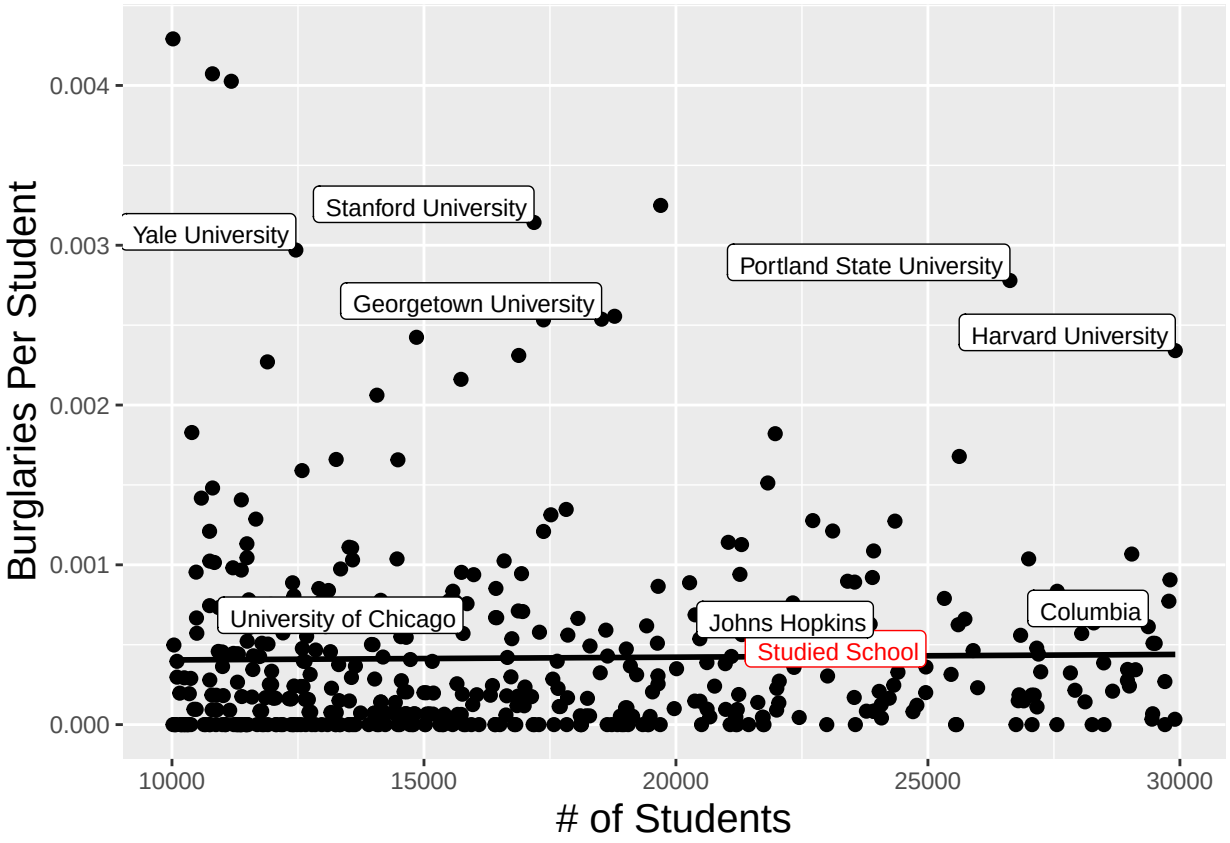


Figure 3: Burglaries in Public and Private University Campus Buildings - 2016 (N = 452)

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