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Burglary reduction and improved police performance through private alarm response

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ABSTRACT

Burglar alarms are the single most effective deterring and detecting measure for burglary. On net, alarms provide benefits to communities, but 94–99 percent of police responses to alarms are to false activations. Solving the false alarm problem could free up the resources equivalent to 35,000 U.S police officers. Response to false alarms is a private good while response to an actual crime is a public good. The paper analyzes a Public-Private-Partnership policy called Verified Response (VR) where the initial response is usually provided by private security under a competitive setting, and police respond only if a crime is verified. A case study of Salt Lake City, Utah is conducted using synthetic control methods to evaluate this program. The introduction of this policy is associated with an 87 percent annual reduction in police alarm response calls, a 26 percent reduction in burglaries, and faster response to all police calls. The paper relies on Public Choice theory to explain why this solution is not adopted in the majority of cities.

1. Introduction

An expansion in private security services has been observed since the 1960s in the US, Canada, the UK, Australia, and the Netherlands, among other countries. (See for example Van Steden and Sarre, 2007; Provost, 2017). Increases in private security yield a decline in various types of crime (e.g. Zimmerman, 2014). In particular, greater use of private security has been shown to reduce various property crimes, including burglary, without causing spatial spillover of such crimes (Meehan and Benson, 2017). In the US, Canada, and the UK, police respond to burglar alarm activations. In the US, these responses comprise 10–20 percent of calls to police, and each call involves 911-dispatcher time of approximately 11 min. Physical police response is usually by two officers for 20 min, and in total encompass an estimated 10–20 percent of urban patrol officer time. This occurs while 94–99 percent of these activations are false, resulting from user and technological errors.[1] The false alarm problem is typical of countries with electronic alarms. For example, in a UK study, 30 percent of alarms were triggered by insects and 10 percent by pets (Ransome-Croker, 2018). The annual estimated police cost of false alarm response in the US was $1.8 billion in the early 2000s, or the equivalent of 35,000 police officers (Blackstone et al., 2005). In 2016, the estimated cost of police response ranged between $75 and $160 per response (Goldfine, 2016).[2] Responding to false alarms generates small social benefits while generating opportunity costs in terms of police time and resources.

Numerous policies have been implemented to address false activations with limited lasting success. These policies include educating repeat activators, collecting fixed or escalating fines for repeat false activations, ceasing police response after a set number of false activations, and even imposing criminal charges on repeat activators (Blackstone et al., 2005). However, regardless of such actions, the rate of false activations remains well above 90 percent (Blackstone et al., 2005; Sampson, 2007). False response to burglar alarms is typical of emergency calls for fire and ambulance services, and solutions could be applicable to them.

This study focuses on a policy solution called Verified Response (VR). VR requires physical or visual verification of an actual or attempted penetration before police are dispatched. Alarm owners designate individuals, including themselves, or private response companies to examine the premises in person, or using cameras and smartphones to check it visually.

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[1] The police make the determination that response was to a non-event or was false.

[2] These costs do not include program management, billing, or court costs.

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We first present false alarm statistics from cities that have implemented VR over the past two decades. A case study of Salt Lake City (SLC) then analyzes the effectiveness of VR. Detailed data on police response time were provided by the City's police department, which made such analysis possible. We employ a synthetic control model to estimate the impact of VR on the annual levels of burglary and police alarm response in SLC. This approach constructs counterfactual trends of the burglary and alarm response numbers in SLC under the assumption that VR was never introduced and compares those numbers to the actual statistics. This is accomplished by collecting data from a selection of cities with similar characteristics to SLC, which do not have VR. This appears to be the best approach given the limited nature of the data among cities, which have adopted VR. In fact, among cities that have adopted VR, only SLC data were available at this level of detail and for a sufficient time to evaluate the impact of VR.

This paper introduces a good whose nature, whether public or private, is revealed only when the service is completed. The paper empirically analyzes whether police response to false alarms entails opportunity costs in delivering other public security services. Hence, we investigate whether police alarm response impacts police response to all emergency calls including crime related calls and whether this situation is an efficient use of police resources.

Section 2 presents the background of the burglar alarm industry and the source of the false response problem, as well as the impact of VR on adopting cities. In Section 3, we analyze the public and private characteristics of police response to burglar alarm activations. Section 4 presents the SLC, Utah case study, while Section 5 analyzes the synthetic control estimation. Section 6 provides a cost-benefit analysis of police response to false alarms and employs public choice theory to explain why a socially efficient solution is difficult to attain. Section 7 provides the summary and conclusions.

2. Background

Empirical studies have identified burglar alarms as an efficient mechanism for preventing burglaries. When a burglary occurs, alarm systems also reduce the time spent by burglars at the premises, yielding a lower value of stolen properties, and reduce the occurrence of violence. Two surveys of suburban homeowners found that an increased perception of security is the ultimate homeowner objective of security measures and a burglar alarm is the preferred such measure (Hakim and Buck, 1991 and 1995). A burglar alarm on its own reduces the probability of burglary more than any other preventive or deterring measure (Fishman et al., 1998). In a study that surveyed former burglars, nearly 60 percent said they would consider the presence of cameras or other surveillance equipment when selecting a target, and 40 percent of all burglars claimed that they would choose another target. By changing the behavior of potential burglars, alarm systems reduce burglaries (Seungmug, 2008). A UK study confirmed that alarms, CCTV and hidden cameras are effective in detecting and apprehending burglars. Property owners are likely to advertise their system to deter burglars while hidden systems lead to greater apprehension (Coupe and Kaur, 2005). Indeed, one social cost-benefit analysis of burglar alarms shows significant net benefits. These benefits accrue to the alarm owners, while most of the costs accrue directly to police and indirectly to non-alarm owners and owners of alarms that do not falsely activate their systems (Hakim and Shachmurove, 1996).

The social cost of alarm systems is the opportunity cost of police responding to false activations. Alarm activation is transmitted to a central station that then typically makes a verifying call to the premises. If someone answers the call and does not provide the pre-specified code, or the phone call is not answered, the central station contacts police for a physical check of the premises.

Given that only 1–6 percent of all alarm systems calls are to actual burglary related incidents, police in most communities assign a low priority to all burglar alarm calls, thus reducing alarm effectiveness. This reduction in effectiveness is compounded since burglars are probably familiar with police response time in their target communities. Response time to alarms is inversely related to the size of the city; in large cities police often ignore such calls or respond only after a long delay. Even in a medium size city, like SLC, before VR was implemented, police responded to an alarm, on average, in 40 min (Salt Lake City Police Department (SLCPD), 2001), while private response companies typically respond in 6–15 min. Moreover, a study of California cities found that only 8 out of 16,000 burglary alarm responses yielded an arrest (Gaines et al., 2007). Indeed, with both the high rate of false activations and the low priority normally given to burglar alarm responses, such low apprehension rates are to be expected.

Police departments have responded in different ways to reduce false alarms. Most communities use fines to discourage repeat false activations. Police in Cobb County Georgia, population 700,000, have even instituted a no response list that included over 3000 homes that were repeat offenders (Campbell, 2016). In the UK, in a 2000 statement by the Association of Police Chief Officers of England, Wales, and Northern Ireland (ACPO) it was determined that there is little possibility of significantly reducing false activations. Thus, wherever possible, especially in metropolitan areas, private response should be allowed, but if police respond, false alarm activators must pay the full cost imposed on police (Cahalane, 2001). In a 2012 statement, ACPO modified their previous policy to note that police would only respond to confirmed alarms. They noted that confirmation could be by a second activation indicating movement within the premises (CIA, 2013). In South Korea, where alarm ownership has significantly increased since 1993, private security companies provide the response while police regulate the personnel and the alarm systems to reduce their malfunctioning (Button et al., 2006). In South Africa, most alarm systems were linked to police at one time. However, the large number of false activations led police to require that all calls be diverted to private security companies and to physically respond before police are dispatched. Hence, police in South Africa have actually adopted VR (Minaar, 2005).

Alarm systems appear to be effective burglary deterrents for both residences and businesses (Fishman et al., 1998; Hakim and Fishman, 1998). Homes without alarm systems are, on average, 2.71 times, and commercial properties 4.57 times at greater risk of being burgled than homes and businesses with an alarm. Further, as the value of residential and commercial properties rise, the effectiveness of alarms rises. Audible alarms cause burglars to escape before entry. Of all incomplete burglaries, 74.3 percent are attributed to the siren sound. The average value of property stolen from alarmed homes is 74 percent of the value stolen in homes without alarms. Alarm systems can compensate for factors that enhance the likelihood of burglary, such as proximity to a highway exit or a location near a forest (Hakim, 2001). The best indication of the effectiveness of electronic alarms is that 94 percent of alarm owners are satisfied with their system and almost all alarm owners who move install a system in their new location (Hakim and Blackstone, 1997: 66–70, and Hakim et al., 2002). Another study of Newark, New Jersey (Lee, 2008) found that the existence of burglar alarms reduces burglaries without displacing burglaries to nearby homes. Neighborhoods with high residential alarm density experience fewer burglaries. Tilley et al. (2015), and Tseloni (2017) employed British data and questioned the effectiveness of alarm systems, suggesting that in the period 2008–2012 burglar alarms were less effective than in the 1992–1996 period in preventing burglaries or possibly even added to burglary risk. They note that external lights and double lock doors were most effective security devices.

Changes in private security provision have been linked to changes in crime rates. Instead of private security simply displacing crime from the protected home or business to un-protected targets (specific deterrence), evidence suggests changes in security guard provision generate spillover effects on the general level of crime in an area (general deterrence). Meehan and Benson (2017) find increases in private security are associated with reductions in burglary rates, as well as robbery and overall property crime rates. MacDonald et al. (2016) find private security at the University of Pennsylvania reduced both violent and property crimes in adjacent neighborhoods.[3] Cheng and Long (2018) found that a private security company called the French Quarter Task Force impacted crime levels and improved police services in the French Quarter region of New Orleans, Louisiana. The introduction of this private security service to this area reduced theft, robbery, and aggravated assault. Lee and Pinto (2009), model private security and public police as substitutes. According to this model, both may deter crime on their own, but a jurisdiction's public crime prevention investment reduces the incentive for private security investments by citizens. Reductions in private security investment attracts crime. The impact of increased public crime prevention on crime is therefore ambiguous.

In the context of VR, private security services and public police can act as complements by increasing specialization between the two entities within a region and improving performance. We investigate the impact of VR on burglary rates in SLC, as this should be the most closely related crime, and could increase the demand for private security. This could generate the same type of spillover benefits indicated by the previous studies. VR could also affect burglary rates by lowering response time of police to actual burglaries, thus increasing the positive externalities from valid alarm response. Separation of these two impacts on burglaries is difficult to achieve. Critics of VR, however, claim that reducing police response could encourage burglars.

3. Public and private goods

Alarm response appears to be a quasi-public good or local public good.[4] Alarm response to a valid burglary activation is a local public good exhibiting congestion, while penalties (pricing) for police response do not reflect optimal pricing policy (Daniels, 1981). It is unknown a-priori whether an alarm activation is false or whether a burglary or attempted burglary occurred. Only ex-post, when the officers are at the premises, or when the service has been provided, can they determine whether it was a real or a false activation. If police interrupt a burglary, they provide a local public good by possibly reducing the pool of criminals in the area through arresting and punishing those who are committing property crimes. Thus, they are providing positive externalities for those citizens within the impacted neighborhood, and the community collectively consumes this service. Exclusion from the spillover benefit of valid alarm response may be very costly and is typically not observed. Therefore, they are providing positive externalities for those citizens within the impacted neighborhood, and the service is collectively consumed by this neighborhood. If the alarm is valid, there are both private benefits to the burgled property and public positive benefits to the community.

The situation differs when police respond to a false alarm. User error or a technological problem could be the cause of a false alarm. For example, a user error occurs when a person enters the premises without punching in the right code onto the control panel. A technological problem occurs when a sensor malfunctions and the alarm is accidently activated. When police respond to a false activation, they bear monetary costs, while no one else in the community benefits from that response. If a car is disabled on a private driveway, the city does not get involved, but police service is provided for malfunctioning alarm systems or for those who falsely activate their systems. In addition, some police services might be denied elsewhere in the community. Only if the police false alarm response produces future burglary deterrence will this response generate spillover benefits to the community. This could be accomplished by responding to any alarm, valid or false, with low response times. Potential burglars could observe these response times to any alarm response, which changes the probability of apprehension and as a result, the expected punishment for burglary. However, our findings presented in Sections 4 and 5 suggest that burglary deterrence improves when treating false alarm response as a private good.

One could reasonably argue that the cost and associated price of monopolistic police providing a private good is higher than the cost would be under a competitive setting. Wages of private security officers are about 47 percent of those of public police officers, and labor is the primary cost of police alarm response (Blackstone and Hakim, 2010: 362, Blackstone and Hakim, 2013). In addition, VR shifts the financial burden from non-false activators and non-alarmed property owners to those who cause the alarm and receive this private service. In other words, the burden shifts from the general ledger paid by taxpayers, most of whom don't have burglar alarms, to user fees where those that cause the expense pay for it. Our evidence suggests that the effectiveness of response also improves under VR; the combined time of response, including both that of the private company and police for a verified burglary, is generally lower than when police solely respond to an activation. For example, Southern California police respond to an alarm activation at low priority within an average of two and a half hours (Hakim and Blackstone, 1997: 220). Private security officers respond, on average, within 15 min, and in case of a burglary, they request police dispatch, which occurs within 10 min. Thus, in case of an actual burglary, the joint public-private response is significantly faster, and increases the probability of apprehending the burglar (Hakim and Blackstone, 1997: 220).

The history of monitoring and response by private security is older than that of public police services. In London, England, the first public police agency was established in 1829, while private patrol units were in operation before, during, and well after this period. In 1828, private police units existed in 45 parishes within a ten-mile radius of London. Some of these areas had subscription-based foot patrols (Davies, 2002: 165), a precursor to private security patrols and alarm response.

4. The Salt Lake City experience with VR

We include basic data on eight of the 33 North American communities that have adopted VR and a detailed case study of Salt Lake City (SLC).[5] Table 1 shows the dates of VR implementation and the pre- and post- implementation false alarm numbers. Unfortu-

[3] Cameron (1988) in his review article on economics of crime suggests the possibility of spatial crime displacement resulting from increased police and private security

[4] See Samuelson (1954) and Holcombe (1997) for the evolution of the definition of public goods. We assume pure public goods are both non-excludable and non-rivalrous in consumption.

[5] These are the communities, which were able to provide the requested data. Data were obtained directly from the police departments. Freedom of Information requests were made for alarm response data in a number of other cities. In each case other than the ten used in this study, time series data on false alarms were either unavailable or were available for only a limited number of years. Every data request asked for annual police response alarm numbers, total annual false alarm response data, average annual police response times, and annual number of burglaries. If bur-

Table 1
Cities with VR and False Alarms Reported to Police.[a]

City	Date VR Implemented	False Alarms 1 yr. Before VR	False Alarms 1 yr. After VR	False Alarms 2 yr. After VR	2 yr. percentage change in false alarms
Salt Lake City, UT	Dec, 2000	9439	898	803	−92%
Breckenridge, CO	Jan, 2004	738	617	562	−24%
Broomfield, CO	May, 2004	2508	2411	2334	−7%
Lakewood, CO	June, 2004	7111	3666 (7 mo. of data)	5979	−16%
Burien, WA	Oct, 2004	1041	580	119	−89%
Milwaukee, WI	Sept, 2004	16,343	662	530	−97%
Aurora, CO	Dec., 2004	14,311	13,181	13,180	−8%
Dallas, TX	March, 2006	57,307	31,358		−45% (1 yr.)

[a] Of the cities listed in Table 1 only Salt Lake City is used in the synthetic control analysis. The donor pool of cities used in that analysis is constructed from cities with similar characteristics to SLC, but which have not adopted VR.

nately, police departments rarely keep burglar alarm response data for extended periods. In fact, among cities that have adopted VR, SLC is unique in the quality and length of these data. Unlike crime data collected by the FBI, burglar alarm response data are very rare. After contacting numerous police departments from small and large North American cities, only the ten cities used in this study had alarm response data for more than ten years. We sought data from any police department that indicated online that it had a specialized alarm unit or coordinator. Even among the ten cities from which we were able to collect an extended time series of data, collection methods over the past two decades have changed from paper based to electronic. This contributed to several years of data being lost even among these ten cities used in this study, and these data had to be interpolated. The vast majority of the data used are not interpolated, although a handful of observations are.[6] Among cities which have adopted VR, the data on alarm response from 1998–2016 are unique to SLC, and we have to rely on these time trends.

By 2016, most VR type adopters were small cities in the western US, and two in western Canada. Some large cities that adopted VR include Milwaukee, WI in 2004, Madison, WI in 2007, Detroit, MI in 2011 and San Bernardino County municipalities in 2009 (Hostetter, 2009). Indeed, most of these cities shifted to VR by an action of the police chief, probably prompting less resistance from the electronic alarm industry than happened in SLC, which changed its burglar alarm ordinance. Table 1 shows a sample of seven of the more than thirty communities which followed SLC and changed their alarm response to VR. Instituting VR in large cities may be more difficult since the lobbying by the alarm industry is likely more extensive.[7] This could be due to a concern, by these alarm companies, that other cities will follow and also adopt VR.

Implementing VR is associated with short-run reductions in false alarms. As indicted in Table 1, these reductions ranged from just 7 percent in Broomfield, CO to 97 percent in Milwaukee, WI over a two-year period. One possible explanation why the Colorado cities experienced the lowest percentage decline in false alarms is a longer grace period in assessing fines or possibly no fines at all. A senior police official in Broomfield Colorado indicated, during an interview with the authors, that the city rarely imposes any fines after responding to false alarms and allows officers' discretion to respond to alarm in non-peak periods. The same official stated that the city had an adequate number of officers and in conjunction with its focus on community policing encouraged such discretion to improve police- community relations. Without an actual penalty for not adopting VR, households will probably be less likely to adopt the usual VR prescribed private security initial response to alarms. It may not be a coincidence that Broomfield's change in false alarms is much lower than the other cities. The adoption of VR in Salt Lake City was also accompanied by a fine structure described below. The additional synthetic control comparison and time series data collected from SLC provide a picture of what occurred in SLC over a longer time horizon. This general trend exhibited in Table 1 supports the assertion that VR is likely responsible for a significant decline in police responses to false activations. Many of these cities are very different geographically, demographically, and politically but all exhibit significant reduction in false alarm calls. We first present the raw time series data from SLC and then employ the synthetic control method to examine if these data trends are attributable to VR implementation in SLC.

In SLC, the rate of police responses to false activations was 99 percent in 14 of the years between 1998 and 2013, and 98 percent in the remaining two years. The new VR ordinance, which became effective December 1, 2000 required physical verification of an actual or attempted burglary before police respond. The alarm response companies usually charge $35 per physical response. Unlike police, private security officers must obey all traffic rules. Upon evidence of intrusion, they request police dispatch. Private responders are not supposed to confront intruders unless lives are in danger. If signs of intrusion exist, police respond as a priority 1 case, which is a change from the low priority response before the ordinance change.

Even after the new ordinance, valid alarms maintained the same low percentage. However, police responded to over 8200 activations a year from 1998 through 2000 before dropping to less than 900 in 2001, mostly for false panic, robbery, and duress cases. These activations fell even more as the years progressed, showing a consistent decline to 350 in 2016 (Fig. 1).

SLC was the second city in the US to implement VR, and first through a change in its ordinance.[8] The proposed ordinance's change prompted the industry aggressively to try to prevent the

glary data were not available directly from the police department, it was collected from the FBI Uniform Crime Reports. (FBI, various years).

[6] False alarm data were missing from Fayetteville, North Carolina for 2003, 2010, and 2013. The data immediately prior and immediately preceding the missing year of data were used to interpolate these figures. We do not know the reason these data were not collected for these years in Fayetteville, but we acquired all of the historical data the police department had on false alarms. Because of a change in the method of data collection in Honolulu data from 1998 and 1999 were not available, so they were extrapolated from the 16 years of data we did have for Honolulu. Given the difficulty we had in acquiring any annual time series data on false alarms, and the lack of extreme variance in the data from these two cities, we elected to keep them in the donor pool with estimates of the missing data. The synthetic control method requires a balanced panel of data, so we couldn't use the information from these cities without this interpolation.

[7] Anecdotal evidence of this lobbying in Salt Lake City is provided on pages 10 and 11.

[8] Las Vegas was the first to implement VR in 1991 by a change in police policy. However, since the next police chief could easily change the policy, such non-ordinance policy changes may not attract as much attention and resistance from the adversely affected electronic alarm industry. This analysis focuses on SLC because

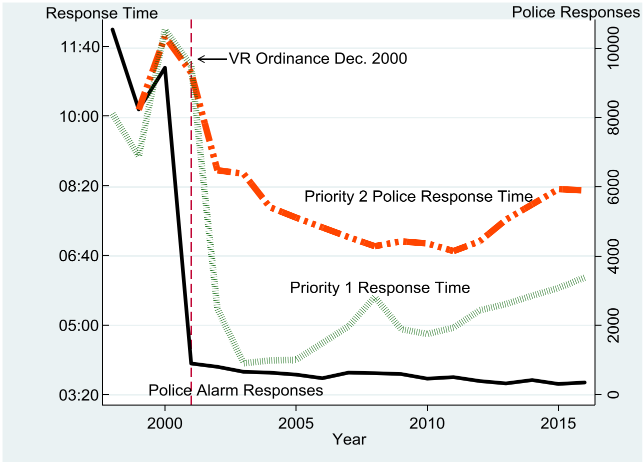

Fig. 1. Police Alarm Responses and Priority 1 and 2 Response Time*.
*Simple correlation coefficients between False Alarm Responses and Priority 1 & 2 is 0.77, and 0.74 respectively.

change, probably fearing a "snowball" effect. Indeed, once the VR ordinance was implemented, the benefits became evident in the form of significantly reduced police responses to false burglar alarms. The city also witnessed associated lower costs for patrol.

Until December 2000, the alarm ordinance in SLC provided four free police responses to false alarms and $100 fine for each false alarm response thereafter. The owner of the alarm system was responsible for the payment of the fine. In 1999, the SLC Police Department estimated their cost per response as $60 on 10,542 responses, or a monetary cost of $632,520 a year. In addition, police response time to high priority calls appears to be adversely affected by the large number of responses to the false burglar alarms, being over 10 min in 1999, slightly below the national average of 11 min (Table 1; Bialik, 2013).

After VR was approved, police responses became subject to an escalating fine; $50 for the first false response, $100 for the second, $200 for the third, $300 for the fourth, and $400 for all subsequent false activations in a year. To examine the impact of the ordinance, we analyzed data from 1998 through 2016. This long-term analysis is helpful to determine if short-run reductions in police response time are maintained years later.

The SLC Police data enable a breakdown of the total response time to its two components, namely, average time from received call to dispatch, and police physical response from dispatch to arrival at scene. This analysis will focus on the time from dispatch until the police arrive on the scene, which allows us to observe some of the trends in the use of scarce police officer time. Thus, we define response time as the time from dispatch to arrival on scene. Further, the data allow us to analyze police response to priority 1 & 2 calls separately as well as calls to burglary. Figs. 1 and 2 present police response time data, the number of false alarm responses, and the number of burglaries in SLC over the 1998–2016 period.

Table 2 and Fig. 1 show that response time for the average high priority 1 call[9] declined from 12:04 min in 2000 to 5:32 min in 2002 and stabilizes to around 5 min for the rest of the data period. Even police response time to priority 2 calls declined from 11:54 min in 2000 to 8:42 in 2002 and kept declining through 2016. This pattern identified in Fig. 1 suggests that the reduction in false alarm responses may have allowed police to more efficiently respond to both high priority 1 and lower priority 2 calls. In addition, the average total time of response to priority 1 calls, including the time each call comes into a 911 dispatch center to police arrival at the site declined from 20:12 in 2000 to 12:54 min in 2008 (SLCPD, 1998–2015). Faster dispatch could be attributed to reduced pressure on the 911 system of 8500 fewer false burglar alarm calls. Hence, SLCPD data suggest that VR saved on both the dispatcher and police response time by 8 min for priority 1 calls and by close to 7 min for priority 2 calls from 2000 to 2008. This impact on dispatch time suggests that VR could increase the efficiency of the entire emergency response system.

There may have been other factors that reduced police response time like more buses or public transportation to reduce traffic congestion, restricted bus lanes, or a shift from police cars to motor bikes. Indeed, Interstate 15 was expanded over this period to 10 lanes including two express lanes, and Interstate 80 and Interstate 215 were reconstructed which may have eased traffic on local SLC roads. However, the SLC police budget increased only 2.2 percent between 2000 and 2001, and we know of no other factors that played a role in reducing response time during that period. It is also noteworthy that over this period, patrol officers declined from 239 in 2000 to 198 in 2001, and by 2016 reached 164 (SLC Annual Budgets, Staffing Documents, Police, Operations Bureau, 2000–2016). Moreover, some patrol officers were shifted to bike patrol, which does not respond to burglar alarms. Hence, the decline in patrol officers and the shifting within the patrol division, if anything, should have increased the time of response while a decline in response time is evident.

The decline in response time is partially attributed to the significant decline in patrol response to false alarms.[10] Moreover, other possible affecting environmental and control variables usually do not significantly vary over a two-year period. Thus, the short-run (2000–2002) reduction in response times suggest that VR may well be an important reason for faster response to priorities 1 & 2 calls. Even though patrol officers fell over this period, false alarms responses per patrol officer fell by a substantial margin, as shown in Fig. 2.

Specifically, the decline in false alarm responses, per patrol officer, from 39.5 in 2000 to 2.4 in 2016 corresponds to the significant reduction in response time (Fig. 2). The reduction in the number and time allocated to false alarm responses per patrol officer likely led to faster response to other public security tasks.

Another contributing factor for the reduction in response time is the change in false alarms as a percentage of the total calls (combined priority 1 & 2 calls). The rate diminished from 56 and 65 percent in 1998 and 2000, respectively, to only 5 percent in 2001 and continuing to decline to less than one percent in 2016. The sharp decline in response time to both priority 1 & 2 events occurred in the few years following the change in ordinance, but not immediately. This suggests that the most significant impacts of VR may occur relatively quickly but with a slight lag. The immediate reduction in the number of police alarm responses after the December 2000 VR implementation may reduce pressure on police resources, but the planning and expectations of the police department may take a while to adapt. Thus, the one-year lag in response time reductions is predictable. We should also see this lag in burglaries. If the improvement in police/private security burglary response improves, according to a simple Becker (1968) model of crime we

of the quality of data provided by the city. Similar data were not available for Las Vegas over this period.

[9] "Priority 1 is defined as in progress calls that require immediate attention" while priority 2 are other calls (Rizzo, 2008.)

[10] From 2007 on, introduction of GPS to patrol cars is probably partly responsible for the low response times. The data on the number of patrol officers that respond to emergency calls may have been lower than we observed in the annual budgets for SLC. Some patrol officers operate on bikes and some specialized units which are included in patrol but do not respond to alarm calls. Thus, our observations are more conservative (interview with SLC police executive, November 13, 2017).

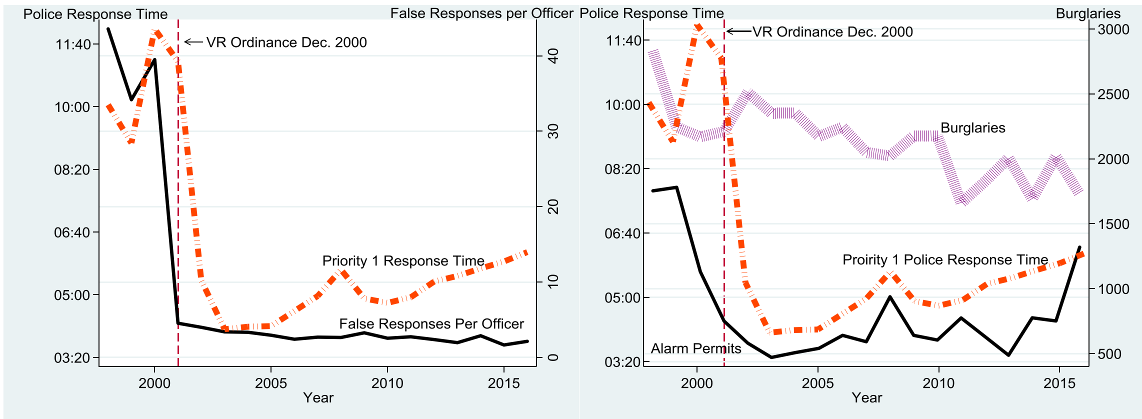

Fig. 2. ** False Alarms per Patrol Officer, Response Times, and New Alarm Permits.
** Simple correlation coefficient between false alarm response per patrol officer and priority 1 response time is 0.77. Simple correlation coefficient between priority 1 response time and number of burglaries is 0.40.

Table 2
False Alarm Time Series Data (Salt Lake City).[a]

Year	Permits	Police Responses	Valid Responses	False Alarm Rate	Police Response Time Priority 1	Burglary	Police Response Time Priority 2
1995	830					2950	
1996	1168					3015	
1997	1761				10:06	2911	
1998	1753	10,542	97	0.99	10:03	2831	
1999	1780	8236	23	0.99	9:02	2244	10:09
2000	1130	9439	64	0.99	12:04	2169	11:54
2001	750	898	5	0.99	11:12	2209	11:02
2002	580	803	10	0.99	5:32	2512	8:42
2003	470	658	8	0.99	4:05	2350	8:37
2004	507	634	5	0.99	4:09	2353	7:49
2005	540	577	5	0.99	4:10	2172	7:34
2006	640	473	7	0.98	4:34	2244	7:20
2007	591	635	8	0.99	4:58	2049	7:06
2008	937	619	7	0.99	4:39	2022	6:53
2009	640	594	6	0.99	4:54	2175	7:00
2010	604	461	6	0.99	4:47	2177	6:57
2011	774	504	7	0.99	4:56	1658	6:46
2012	631	391	6	0.98	5:21	1824	7:00
2013	487	323	4	0.99	5:30	2005	7:31
2014	775	420	4	0.99	4:42	1691	7:53
2015	751	307	3	0.99	5:53	2018	8:15
2016	1319	350			6:08	1727	8:13

[a] This Salt Lake City data on burglary and police responses to false alarms can be acquired at http://slcpd.com/wp-content/uploads/verified_response_summary.pdf.

should see burglaries decline, ceteris paribus, as the probability of apprehension would increase. The rational burglar's response to the improved response time is an increasing marginal cost of committing a burglary. This increase in marginal cost should influence burglars on the margin, some of whom will no longer engage in burglary. The information on improved response time should take time to disseminate among potential burglars, so the adjustments in expected marginal costs of burglary will take time to impact criminal behavior. The lag in burglary reductions is consistent with this model, and our findings. Finally, the decline in response time to both priority 1 & 2 calls shows the cost borne by the entire community of police providing response to false alarm calls.

As indicated by Fig. 2 and Table 2, the new ordinance appears to have had a restraining effect on the purchase of new alarm systems. New alarm permits, which were and are still required by SLC, declined by 62 percent using a five-year average before and after 2000.[11] Important evidence suggests that the alarm industry in SLC has been adversely affected by the adoption of VR. Still in 2015, the number of permits were at the same level as in 2001–2005. At the same time, the alarm industry nationally seems to have done well. Specifically, nationally alarm installations per dealer increased from an average of 348 per year in 2001 to 518 in 2005, or an increase of 66 percent (Security Sales & Integration, 2006).

5. Synthetic control analysis of VR in SLC

In this section, we introduce the synthetic control empirical model, which is a mechanism for analyzing comparative quantitative case studies. With the limited alarm response data for VR at our disposal, the SLC case is a good candidate for this type of analysis. We use the synthetic control approach to estimate the impact of VR on police alarm response and burglaries within SLC. The synthetic control approach is useful for identifying the impact of a unique policy innovation, introduced in one region or a small number of regions, on a set of outcomes. This method examines the impact of a unique policy change by comparing the actual outcome variables in those regions impacted by the policy to this same outcome variable in a select "donor pool" of regions not impacted by the policy change. The "donor pool" of cities or other non-impacted regions

[11] Our analysis is based on alarm permits. Since no penalty exist for not registering an alarm system, some may choose not to register their system. However, the issue of not registering existed through the entire period.

Table 3
Control Variables (predictors) Used for Alarm Response and Burglary Synthetic Control Model and Actual SLC Data.[a]

	Treated	Synthetic
Number of free police responses	4	3.529
Population	175,901	176258.3
City Police Officers	404.33	405.191
Unemployment Rate	3.2667	3.927
Income Per Capita (2015 $)	37421.51	37415.42
2000 Alarm Responses	9439	9448.33
1998 Alarm Responses	10,542	9837.8
2000 Burglaries	2169	2172.342
1998 Burglaries	2831	2834.946

[a] Income per capita data for each city were acquired from the St. Louis Federal Reserve Economic Database (FRED) https://fred.stlouisfed.org; Unemployment figures for each city are the annual average unemployment numbers from the Bureau of Labor Statistics https://www.bls.gov; Population figures were are U.S. Census Bureau estimates https://www.census.gov:.

is used to construct a synthetic outcome variable for the impacted regions absent the policy change, in essence the synthetic outcome is an estimated counterfactual of these outcome variables absent the policy change. Examples of this approach include the impact of a unique tourism policy on employment in the Argentinian province of Slavia (Castillo et al., 2017), the impact of nuclear power facilities on city level per capita income in Japan (Ando, 2015), and the impact of a unique tobacco control program on the consumption of tobacco in California (Abadie et al., 2010). However, these results may not be causal. The limited time series and dataset analyzed here provide insight into these interesting relationships but given the data constraints, we do not claim causation.

The notation we use to introduce this SLC synthetic control model follows the pioneering work of Abadie et al. (2010); Abadie (2020), as well as Ando (2015).

Let $Y_{it} = Y_{it}^N + \alpha_{it} D_{it}$ be the equation for the outcome variables, in this case, both police alarm response and the number of city burglaries. Y_{it}^N is the synthetic variable, which represents the outcome variable in the absence of the VR policy treatment. The N superscript on Y_{it}^N just differentiates the outcome variable in the absence of VR from the actual outcome observed in city i in year t, N = No policy intervention. This variable is essentially the counterfactual in the absence of VR, α_{it} is the effect of VR on city i in year t, and D_{it} is a treatment indicator, which takes values as follows:

$$D_{it} = \{ \begin{matrix} 1 & \text{If VR is active in city } i \text{ in year } t \\ 0 & \text{otherwise.} \end{matrix}$$

Within this comparative case study analysis Salt Lake City ($i = 1$) is the only treated unit, and the first year of the treatment is 2001 ($t = 2001$) and this treatment is active for each year during and after 2001. $D_{it} = 1$ if $i = 1$ (SLC) and $t \geq T_0$ where T_0 is the first year of the treatment (2001).The idea is to identify the "gap," or the impact of the treatment (VR) on the treated unit (SLC), labeled α_{it} below, between the actual outcome (here burglary or alarm response) Y_{1t} and the outcome in the absence of the policy Y_{1t}^N:

$$\alpha_{1t} = Y_{1t} - Y_{1t}^N \quad \text{for } t \geq T_0$$

The outcome variables (burglaries and alarms) for Y_{1t} are observed, for city 1 (SLC) in each year t. The "synthetic" outcome Y_{1t}^N is the outcome variable for each year t in the absence of the policy (VR), essentially the counterfactual in city 1 without VR (estimation procedure shown below). The difference between the actual outcome and the counterfactual outcome is the gap α_{1t}, which is the impact of the policy for each time period t, as the impact of the policy is examined for each year. In other words, the gap will be illustrated by the estimation procedure for each year of the data.

The estimation procedure for this gap and the synthetic outcome occurs as follows: Y_{1t}^N is estimated using a weighted average of these value in the cities in the donor pool. This donor pool is made up of the nine cities, other than SLC, included in the data set. Each city has a time series of predictors consisting of co-variates, which are non-outcome control variables, and outcome variables [alarm responses and burglaries].[12] These predictors are examined to determine city-level weights estimated to approximate the pre-intervention conditions in SLC. Weights in the donor pool are chosen to match the pre-VR situation in SLC so as to come as close as possible to mirroring their respective values during the pre-treatment period in SLC; essentially, a comparison of combined similarities during the pre-treatment period and a weighted average of the cities that most closely match the pre-VR characteristics of SLC. Table 4 shows these optimal weights attributed to each city used to construct the synthetic SLC. These weights can be represented by a vector $(K \times 1)$ *where* $\boldsymbol{W} = (w_2, \ldots, w_{k+1})'$. As indicated by Table 4, each city weight is greater than or equal to zero yet less than one, and the summation of these weights is equal to 1. A vector of optimal weights $\boldsymbol{W}^* = (w_2^* \ldots, w_{k+1}^*)'$ is used to estimate Y_{1t}^N and α_{1t} as follows:

$$\hat{Y}_{1t}^N = \sum_{k=2}^{K+1} w_k^* Y_{kt}$$

And:

$$\hat{\alpha}_{1t} = Y_{1t} - \hat{Y}_{1t}^N$$

This $\hat{\alpha}_{1t}$ "gap" is the estimated difference between the actual observed outcome and the estimated synthetic outcome $\hat{Y}_{1t}^N$ for city 1 (SLC) in each year t. This is illustrated by the difference (gap) between the dotted lines and the solid lines in Fig. 3. Weights are estimated such that $\boldsymbol{W}$ minimizes the difference between the predictors during the pre-VR period for the treated unit (SLC) and the

[12] We do not use all of the pre-treatment data from donor pool cities for burglaries and alarm responses as predictors, in accordance with the suggestions presented by Kaul et al. (2015), which uses Monte-Carlo simulations to demonstrate that employing all pre-treatment outcome variables biases the estimated treatment effect. It causes the estimation to focus exclusively on these pre-treatment outcomes and disregard the other covariates when it estimates the weights w_k. As they indicate: "We find that using all outcome lags [pre-treatment] as economic predictors results in estimates being more biased and less precise in terms of root mean squared prediction error, as compared to estimators which effectively use the covariates [non-outcome control variables] by employing only one outcome-related predictor. Furthermore, we find in line with theory that these results are largely driven by the fact that covariates are fitted rather poorly when all outcome lags are used, introducing a bias that can be substantial even for reasonably long pre-treatment timespans"... "the more the covariates are truly influential for future values of the outcome, the larger a potential bias of the estimated treatment effect can become, possibly leading to wrong policy conclusion" (Kaul et al. (2015), pg. 3 & 4). Within their demonstration of this bias, they elect to use only a single pre-treatment outcome predictor, which corresponds to the period immediately preceding the policy intervention, and compare this to estimates using all pre-treatment outcome variables as predictors. The estimation with the single pre-treatment outcome period reduces this bias for their selected dataset relative to using all pre-treatment outcome data. The overarching message from the paper is not to use all pre-treatment outcomes, and not specifically to use a single pre-treatment outcome. A weighted average of the pre-treatment outcomes or more than one pre-treatment outcome might be utilized depending on circumstances. We elect to use the first sample point available (1998) and the last sample point before the arrival of VR (2000) as our pre-treatment outcome data periods. We performed the estimation using only the last pre-treatment unit (2000), as was done in the simulations by Kaul et al. (2015), and obtain similar results to those presented here, as both show VR associated with reductions in burglary and alarm responses. We elect to utilize 1998 and 2000 data pre-treatment outcome values because the pre-treatment fit is much better using 1998 and 2000 outcome values relative to using other pre-treatment choices. Estimation was also performed using 1998 and 1999 as the pre-treatment data and results were again very similar.

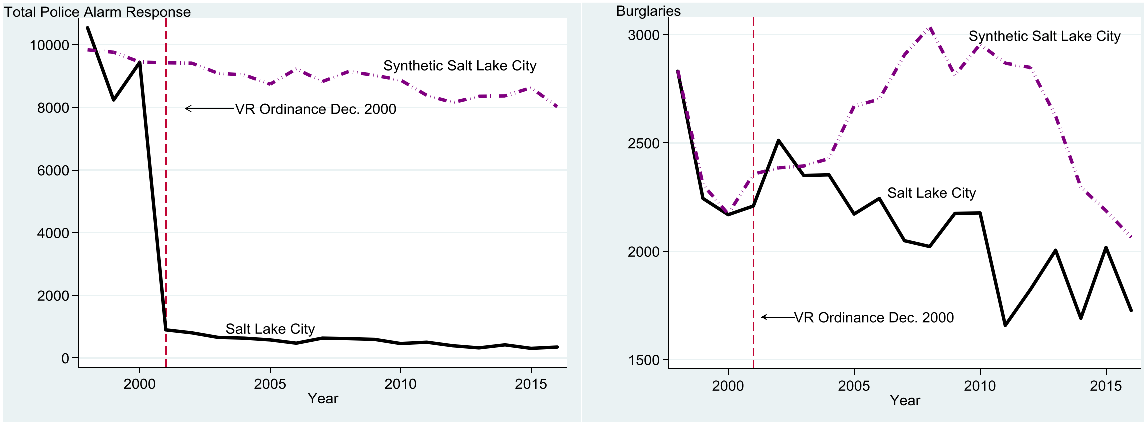

Fig. 3. Comparison between Synthetic Control Estimates For Police Alarm Response And Burglaries in Salt Lake City.

Table 4
Cities used in Donor Pool to Construct Synthetic SLC for Alarm Response And Burglary.

City	Weights used to construct SLC Synthetic Alarm Response	Weights used to construct SLC Synthetic Burglary	Average Population (1998–2016)	Real Income per capita
Fayetteville, NC	.216	.017	192,397	$33,617
Honolulu, HI	.102	.003	923,590	$48,004
Asheville, NC	.563	0	78,800	$37,505
Leewood, KS	.023	0	30,699	$60,313
Orlando, FL	.096	.236	225,212	$37,869
Evansville, IN	0	.412	119,867	$40,647
Irvine, CA	0	0	195,825	$55,212
Greensboro, NC	0	.061	253,385	$38,851
Stockton, CA	0	.272	279,029	$36,064

weighted average of these predictors for the control units within the donor pool.[13] The values of these predictors are provided in Tables 3 and 4; they show the constructed synthetic values from the donor pool and the actual SLC values. Table 4 shows the weights used for each of the cities within these estimations as well as population and income per capita numbers for each of the cities over the time period. Fig. 3 presents the alarm response and burglary model results.

As mentioned in the beginning of Section 4, time series data on police alarm response are very rare. Our donor pool of cities was constructed by contacting police departments across the U.S. and Canada in mid-size cities (larger than 30,000 people smaller than 1 million people) to find annual data on police responses to the alarms. The nine cities listed in Table 4 and SLC were the only cities that were able to give us at least 10 years of time series data on alarm responses. The process of determining weights for the cities actually used to estimate the synthetic SLC will often generate weights of zero for units within the donor pool. In fact, in the pioneering work of Abadie et al. (2010) only 5 of the 38 regions in the donor pool were assigned a non-zero weight for constructing the synthetic estimation.

Even with our current data limitations, one simple indication for the accuracy of the synthetic model is how closely the synthetic predictors match the actual treated SLC figures. As evidenced from Table 3, these predictors are relatively close. The pre-treatment synthetic estimations illustrated in Fig. 3 do not show great fit with the actual data, but the post-treatment results suggest a large divergence in the predicted (synthetic) alarm response numbers and the actual data for SLC after the implementation of VR. The gap between the two is large and persists over time. The average gap between the synthetic estimate and the actual number of police alarm responses over the VR period is 8,253. That suggests on average an annual impact of 8,253 fewer alarm responses in SLC over the 16 years post VR implementation. The annual gap between the synthetic SLC police alarm response prediction and the actual outcome is shown by the difference between the synthetic SLC and the actual data; this can be interpreted as the estimated effect of VR on police alarm response. Using the year 2000 alarm statistics, as a base year (the last year in which SLC did not have VR) this estimated annual impact would amount to an 87 percent reduction in the annual number of police alarm responses. Again, this interpretation is suggestive given the data constraints and pre-treatment data fit, but this relationship portends a large impact. SLC also observed a small decline in false alarms responses in 1999 and 2000 (relative to 1998, see Table 2 and Figs. 1 and 4). This drop is much smaller than the post VR change but might be indicative of an 'anticipation effect.'[14] The move to VR was well publicized by the SLCPD and public debate on the issue included an article in a local newspaper in early 2000.[15] Fig. 3 results also indicate a difference between the "synthetic" burglaries in SLC and the actual numbers a year after VR was implemented. Fig. 3 suggests that reduced resource pressure may have contributed to reductions in burglaries. On average, the gap between the synthetic SLC burglaries and actual burglaries in SLC is 560 less per year, a 26 percent drop in the annual number relative to the 2000 SLC burglary statistics.

One might expect that the reductions in alarm ownership, indicated by Fig. 2, would have encouraged more burglaries within the

[13] For additional details on the synthetic control estimation procedure see Abadie et al. (2010) and Abadie (2020).

[14] We thank an anonymous referee for pointing this out, and for the 'anticipation effect' name.

[15] This piece was published in *The Enterprise Newspaper* and documented the debate over police vs. verified response to alarms (Jones, 2000).

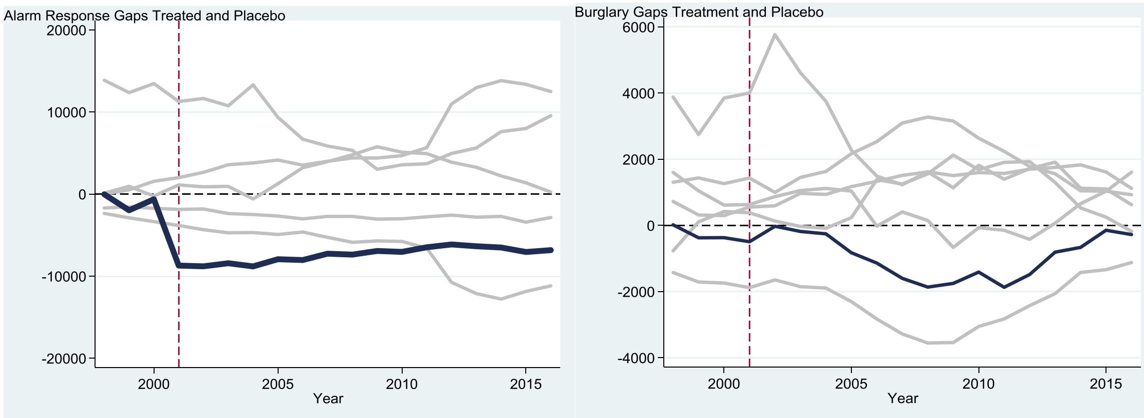

Fig. 4. Placebo Results Alarm Response and Burglary.

community. As burglar alarms fall, or the number of new alarm systems stagnates, rational burglars may respond by increasing their efforts. However, the synthetic control results presented in Fig. 3 suggest an opposite impact. This 26 percent reduction in burglaries relative to the control group of cities might be the most significant change to social welfare relating to VR. The pre-treatment data for burglaries in Fig. 3 also show a better fit than the false alarm response estimation. Examining the response time trends in Fig. 1 tends to support this idea. Increased police efficiency due to reductions in time devoted to false alarm response could well have translated into reductions in average response times for both priority 1 and 2 calls. In fact, Blanes et al. (2018) find large and significant impacts of response time on the ability of police to clear crimes. As response times increase (decrease), clearance rates decrease (increase). They find this relationship exists with all crimes, including burglary. These findings are consistent with ours. If police are quicker to respond to burglaries, the probability of burglar apprehension increases, thus increasing the perceived costs of undertaking any burglary. Rational burglars will reduce their activities in the City, as is observed in Fig. 3. Except for 2002, when burglaries increased, burglaries have trended down through 2016. Overall, burglaries decreased in SLC between 1996 and 2016 by 43 percent, from 3015 burglaries in 1996 to 1727 in 2016. Immediately prior to VR in 1999 and 2000, burglaries were around 2,200. It is also important to note the lag in the reduction in the number of burglaries, and this should be predictable, as information about the improved effectiveness of response to burglaries probably would not occur immediately. It might take years for this information to be observed by potential criminals.

To examine the robustness of these results we use the placebo test suggested by Abadie et al. (2010). This placebo test uses every city in the donor pool and applies the same synthetic control estimation to each city one by one. Using the same intervention period (2001) and synthetic control procedure to each of the cities within the donor pool this placebo test constructs an estimated gap for each city. This gap is the difference between the actual and synthetic predictions, this estimation is repeated one by one, for each city in the donor pool. These gaps show the projected pre-2001 (pre-VR in SLC) and 2001–2016 results for each of these cities (represented by the light grey lines). The results are presented in Fig. 4, and we can visually examine whether similar or larger estimates exist for the other cities. If a city in the donor pool replicates the Salt Lake city estimated gap, which were small differences between synthetic and actual results pre-VR and the large post-VR implementation gaps (these gaps are negative as both synthetic results for SLC burglary and alarm response were projected to be higher), it would be cause for concern, and indicate that VR really wasn't generating this estimated impact (gap). If these gaps are of similar size or larger throughout the post intervention period, it would reduce confidence in the estimated impact of the VR intervention. The results in Fig. 4 suggest this is not the case for alarm response, as the immediate and large impact for the SLC estimation (in orange) are identifiably different from the results obtained from running the same procedure on the other cities within the donor pool. Only one of the placebos (Leawood, Kansas) comes close to the SLC impact, intersects and overtakes the estimated impact, but this isn't until 2011, 10 years after the treatment was assumed.

The placebo results shown in Fig. 4 also provide the same estimation technique but applied to burglaries over the same period. These results show one placebo that has a larger gap in the synthetic and actual burglary numbers than does the SLC results. But, this large gap for this placebo city exists both before and after the treatment period, suggesting that the gap did not change as VR was introduced in SLC. This large gap both before and after the treatment period also suggests that the city might be an outlier. This potential outlier is Leawood, Kansas in both the alarm response and burglary placebo tests. It is important to note, as indicated in Table 4, that Leawood was only assigned a small weight (.023) for constructing the synthetic Salt Lake in the alarm response estimation, and a weight of zero in the burglary estimation. Leawood has a much smaller population than Salt Lake City and is different on many other dimensions, and the other cities in the sample are probably better candidates to construct a synthetic Salt Lake, which is consistent with the weight assigned by the optimization. Given our small sample of cities in the donor pool, and the small weight Leawood is assigned in the estimation, it is probably unwise to exclude it from the estimation and just note that it is a probable outlier. Overall, the Fig. 4 results do suggest a larger burglary deterrent effect of VR in SLC than in the placebo estimations.

An additional robustness check was also done using traditional panel data difference-in-differences regression estimation with the treatment (SLC after VR introduced) and control group (donor pool cities) remaining the same as the synthetic control model above. Both fixed effects and random effects models were estimated, and VR is associated with reductions in alarm responses and burglaries in every specification, but the estimated magnitudes differ depending on the specification. VR was associated with a reduction in alarm responses ranging from 48 to 73% and a reduction in burglaries ranging from 7 to 23%.[16] The upper bounds of these estimates are

[16] These estimates are available upon request; all models used clustered standard errors by city. Models estimated using city level fixed effects and without year fixed effects resulted in negative and significant (at 5% level) results for the impact of VR

Table 5
Before-After Winners and Losers per Year.

Group	Before	After	Net Gain/Loss
Non-Alarm Owners & Non-activators Alarm owners	-$8.19	+$0.89	+$9.08
Average Alarm Company[a]			−$5411
Average Alarm Owner	+$42.72	−$60.52	−$103.24

[a] We subtracted from the expected number of installations in SLC assuming no change in ordinance the actual number of installations to determine the number of lost installations attributed to the new ordinance for each year 2001 through 2015. Then we multiplied the number of lost installations by the annual incurred profits and summarized the profits for all 15 years, 2001 through 2015 and divided it by 15 in order to obtain the average annual per installer lost profit of $5,411.

relatively consistent with the synthetic control results presented above.

6. Cost benefit analysis

Table 5 provides some back-of-the-envelope estimates of the gains and losses to the affected groups in SLC, including non-alarm activators, the average alarm company, and alarm activators. In 2000, SLC Police calculated their cost per response at $60 (Schaenman et al., 2012: 21). This cost consists primarily of the time spent by two patrol officers and the appropriate cost of vehicles. False alarm activators of 1–4 times a year were proportionately subsidized in the range of $60 and $240.[17] Over the data period, the average number of responses per alarm owner per year was 0.712, the majority of activators gained net benefits as the community at-large subsidized them. In fact, under the previous ordinance, an average alarm owner received a modest subsidy of $42.60 per year. Under this old ordinance, repeat activators of up to nine were subsidized, as the costs of fines were less than the actual costs of police response; those who falsely activated their system 10 times in a year obtained no subsidy. Those falsely activating their systems 11 or more times a year overpaid for the service, yielding reverse subsidization of the community where the fines they paid were larger than the cost of services provided. However, it is unlikely that many had 11 or more false activations. Thus, most false alarm activators had a strong incentive to maintain the old ordinance, absent the knowledge that the police response time and burglary decreased.

Under the new VR ordinance, if private security responds to an alarm, no cross-subsidization of alarm owners occurs; the users directly pay for the services they obtain. However, if private security dispatches police when it mistakenly identified an activation as a valid alarm, the community still subsidizes the alarm owners. But, beginning with the fourth false alarm (verified by private security), the activators subsidize the community.

As expected, VR yielded a decline in the collection of alarm fines by 51 percent a year over the 5-year period after VR was adopted. This decline is attributed to both the VR element of the new ordinance and the significant increase in fines that begin with the first false activation.

In order to calculate costs and benefits for the different groups considered, we use the trend of police responses that had existed from 1998 through 2000. We generated what might have been police alarm responses under the old ordinance without VR for the years 2001 through 2016. We then calculated how much police saved assuming their average total cost equal to $60, and the community's resource cost under private response to be $35, which is the price charged by the local private response companies.

Table 5 provides these cost-benefit figures broken down on a per person basis. The affected groups are alarm owners, non-owners of alarms, alarm companies, alarm response companies, and the police. Under the old SLC alarm ordinance, the average alarm owner was subsidized by $42.72 (Table 5). The cost of false alarms to non-alarm households was $8.19 a year, and community households enjoyed an additional $0.89 in fine collection from the new ordinance or a total net gain of $9.08 (Table 5). We also include data on the financial impact of VR on alarm companies in the city, taking into account the reduction in installations (Fig. 2) over the period. Incidentally, alarm owners under the old ordinance who experienced intrusion also lost because of delayed police response, and subsequent increases in the probability of being burglary victims, which is another hidden social cost.

The evidence above suggests that use of police to respond to burglar alarms is a socially inefficient outcome, and possibly causes regressive distributional issues, as relatively higher income households tend to be the households with burglar alarms. Police response also contributes to longer response time for all police calls, which is a hidden social cost.

Alarm owners comprise 16–18 percent of households, while at most 13 percent of all households falsely activate their alarm systems. It seems that the majority (87 percent) of households in the community and the police should favor a VR ordinance. Alarm owners in general may resent the potential for fines because they cannot predict whether they will be false activators. While the groups that benefit from maintaining the pre-existing ordinance are small, their monetary losses from adopting VR are high, and the majority's gains are very low. Thus, the benefitting group of alarm owners who falsely activate their systems 1–4 times and the alarm companies operating in SLC were motivated to lobby members of City Council to reject a VR based ordinance.

Extensive lobbying efforts were initiated in SLC against the implementation of VR by the Utah Alarm Association (UAA.) The UAA took out a full-page advertisement in the *Deseret* Newspaper and alleged that the police would not respond to alarms and heavy fines will be imposed on false alarms. Representatives of UAA also argued before City Council against the proposed ordinance. Even after the ordinance was implemented, the Alarm Industry Research and Education Foundation conducted a survey in SLC and reported that 65 percent of residents believed that police should respond to all alarms even before they are verified (LaRochelle, 2006). Butterfield (2003) presents an example of alarm companies imposing political pressure on local communities to continue subsidizing police response to alarms. In response to the potential implementation of VR, Southern California alarm companies came together to pay Cerrell Associates Inc. for lobbying efforts to keep the police responding to all alarms. These lobbyists attended local city council meetings and spread negative information about the effectiveness of VR in SLC. They argued that burglary rates increased in SLC after VR was implemented. These alarm companies obviously have an incentive to engage in "rent seeking" (Tullock, 1967).

Indeed, lobbying and the active resistance of the alarm industry and the apathy of the public as a whole may have held back the spread of VR in cities across the U.S. On the other hand, several police departments including SLC strongly support VR, as the Salt Lake City police department published a public summary of their experience with VR entitled *Verified Response Really Does Work* (slcpd.com, 2004). In spite of the success of VR and police support for it in the VR adopting communities, residents may be

on both burglaries and alarms. Models using year fixed effects and no city level fixed effects generated negative and significant results (at 5% level) for the impact of VR on alarm responses and negative but not significant results for VR on burglaries. Results with two-way fixed effects (both city and year) yielded negative and significant results for VR on burglaries at the 10% level, and alarm responses at the 15% level. Because of the limited sample size, only 10 cities, these results should be interpreted with caution and the synthetic control estimates provided a preferred avenue for examining the impact of VR on alarm responses and burglary.

[17] To be conservative, we are using the cost for police response of $60 for the entire period. Therefore, we are understating the savings to SLC for recent years.

reluctant to have private security responding rather than police. Further, the alarm companies had a strong interest in maintaining largely free police responses (e.g. Jimenez, 2007; NESA, n.d.). After all, they almost certainly expected, and indeed the experience has proven them correct, that substituting private guard verification contributed to reduced sales of alarm systems.

Allowing private security to respond initially to alarms gives police departments the ability to reallocate resources to higher valued public security uses, including faster response to all emergency calls. By improving emergency and real-crime response, the city should subsequently reduce crime in the long-run.[18] This also encourages specialization and thus more efficient alarm response by private security companies, as well as police who may choose to maintain the service under a competitive setting. As specialization increases, productivity tends to increase, reflecting improved response times and lower burglaries in SLC. Competition among public and private response entities unleashes innovation on both alarm systems and the management of response services.

Replacement of a public monopoly with competitive market provision also yields probable redistributive effects. Alarm ownership, and resulting police response to false activations, is more prevalent with affluent members of the community (Hakim and Buck, 1991: 81–91). Thus, a reduction of police response to false activations shifts police resources to mostly less affluent neighborhoods and may serve an equity objective of government.

The fine structure for police response to false alarms, in particular escalating fees, is a product of monopolistic police pricing and becomes obsolete in a competitive setting. Interestingly, the electronic alarm industry generally supports escalating fines that adversely affect a small number of repeat activators, like banks, jewelry stores and other high value businesses that are required by their insurers to have alarm systems, and thus they have price inelastic demands for alarm systems (Margulies, 2014). However, the alarm industry generally lobbies against VR, which adversely affects all false alarm activators and makes ownership of an alarm system more expensive, and therefore reduces the purchase of new systems (Fig. 2), and possibly reduces usage of existing systems. Some may argue that reduction in response time by police does not yield improvement in social welfare since burglars merely displace their activities to nearby jurisdictions. In order to provide some indication of burglary displacement after the introduction of VR in SLC, we examine burglary trends in all adjacent counties to SLC. We examined these trends as burglary started to decrease in SLC (around 2004), following the introduction of VR. The 2004 burglary rates are compared to the pre-VR burglary rates in these counties. Using the FBI uniform crime reports data (Crime in the United States, 1999 and 2004), we observe that in three of the six adjacent counties to Salt Lake, burglary rates decreased from 1999, one year before VR, to 2004, and in three other counties burglary rates increased.[19] There does not appear to be a clear indication of displacement. Many empirical studies find no evidence of the displacement of crime due to increased security measures or police (Eck, 1993; Leong and Eng, 2014). In fact, Meehan and Benson (2017) and Zimmerman (2014) find that increases in private security activity act as a general crime deterrent, not just as a specific deterrent. As the presence of private security increases in an area, overall crime rates decline, and are not displaced to other areas. Thus, increased private security activity and improved response times increase the marginal cost of attempted burglary, and it is likely that some potential burglars decide not to burgle. This could explain the decline in SLC burglary witnessed following VR.

The adoption of private alarm response does not require complete restructuring of alarm response for all police departments. In small suburban and rural communities in particular, police might wish to maintain alarm response, competition from private companies and even other adjacent public police departments could be allowed under a competitive alarm response policy. Response would then only be provided by police if the price of response is competitive to private security companies, or preferences of residents were such that they were willing to pay for a police service premium for police response.

7. Summary and conclusions

This paper considers police and Verified Response policies to burglar alarms. VR appears to be a more efficient method of Public-Private-Partnership than exclusive police response. Our synthetic control results suggest the introduction of VR decreased police alarm response by 87 percent annually. The second contribution of the paper is in measuring the opportunity costs of patrol when responding to false burglar alarms. Some may suggest that when police are diverted from their routine activities to respond to a burglar alarm activation, the opportunity cost is zero; instead of riding around, patrol is diverted to alarm response. When patrol responses to false alarms decreases, significant time is saved and used instead for response to other police services. This includes faster response to valid burglar alarms, which, according to our results, correlate with reductions in annual burglaries. Both response times and burglaries have fallen in SLC after VR was introduced. The reduced time of response to all burglary related incidents for both alarmed and non-alarmed properties may become ubiquitous knowledge among burglars and raises the expected cost of burglary.

The third contribution of this paper is in explaining why VR type policies are slow to be adopted by cities. A small group facing significant losses from shifting to a VR based ordinance might exert successful resistance by lobbying city council to avoid a change. This case is similar to lobbing groups that prevent reducing subsidies to farmers, where the social cost is higher than the value of jobs saved (Smith and Goodman, 2015). Public Choice theory explains the persistence of these programs by pointing to the significant benefits to a relative few while the costs are dispersed thinly over a much larger population. In the case of alarm response, constituents are also unaware of the real opportunity costs of delayed police response to other calls.

The entire SLC community in the post 2000 ordinance era enjoys faster dispatch and police response time to both priority 1 & 2 calls. If police respond to an actual burglary and capture criminals, the entire community benefits from the reduction in the pool of burglars. Burglary deterrence also occurs, as the perceived cost of committing a burglary rises as response time decreases. The marginal benefit of the burglary falls because expected time to burglarize goes down (less time to accumulate valuable property) and the marginal cost of the burglary goes up as the probability of apprehension increases. This is consistent with the experience of SLC, as indicated by our synthetic control analysis. As response time has decreased over time so have burglaries. Results suggest the intro-

[18] Some argue that the opportunity cost of police approaches zero. However, Benson and Rasmussen (1991) find that increasing police resources allocated to drug crimes is associated with higher rates of property crime. As police spend more time, effort, and resources pursuing drug crimes the marginal cost of engaging in property crimes falls and property crimes tend to increase. Blanes et al. (2018) find that reduced response times also increase crime clearance rates and could reduce crime rates.

[19] The three counties with burglary reductions seem to have larger magnitude changes than the counties with burglary increases. From 1999–2004 burglary rates (per 100,000 people) fell in Morgan county by 32%, by 15% in Tooele County, and 9% in Wasatch County. While the observed burglary rate in Summit County increased by 26%, 10% in Utah County, and 5% in Davis County. The direction of these trends is the same, relative to the pre-VR rates, if we look at 2003 data, or from 2000–2004, and four counties saw declining burglary rates in 2002 relative to 1999. In other words, no clear evidence of displacement can be found.

duction of VR is associated with a 26 percent annual reduction in burglaries.

Adoption of VR has and will reduce both the usage of burglar alarms and the purchase of new systems since the subsidization of alarm activators stops. Free or below cost responses to false activations artificially encouraged purchase and use of alarm systems. Providing police responses at no charge for most alarm activators reduces the incentives for alarm owners to install technologically updated systems. Alarm systems are much older than other similar electronic devices like smartphones, TVs, and computers. Such subsidization may even reduce the incentive to develop more sophisticated alarm systems that reduce false alarms.

Finally, the problem of response to false burglar alarm activations has generated numerous intuitive solutions by both local governments and the burglar alarm industry without significantly reducing the problem. It seems that VR, which does appear to reduce false alarms and may improve the allocation of police resources, should be considered for adoption.

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