Home Office

Reducing criminal opportunity: vehicle security and vehicle crime

Research Report 87

Nick Morgan, Oliver Shaw, Andy Feist and Christos Byron

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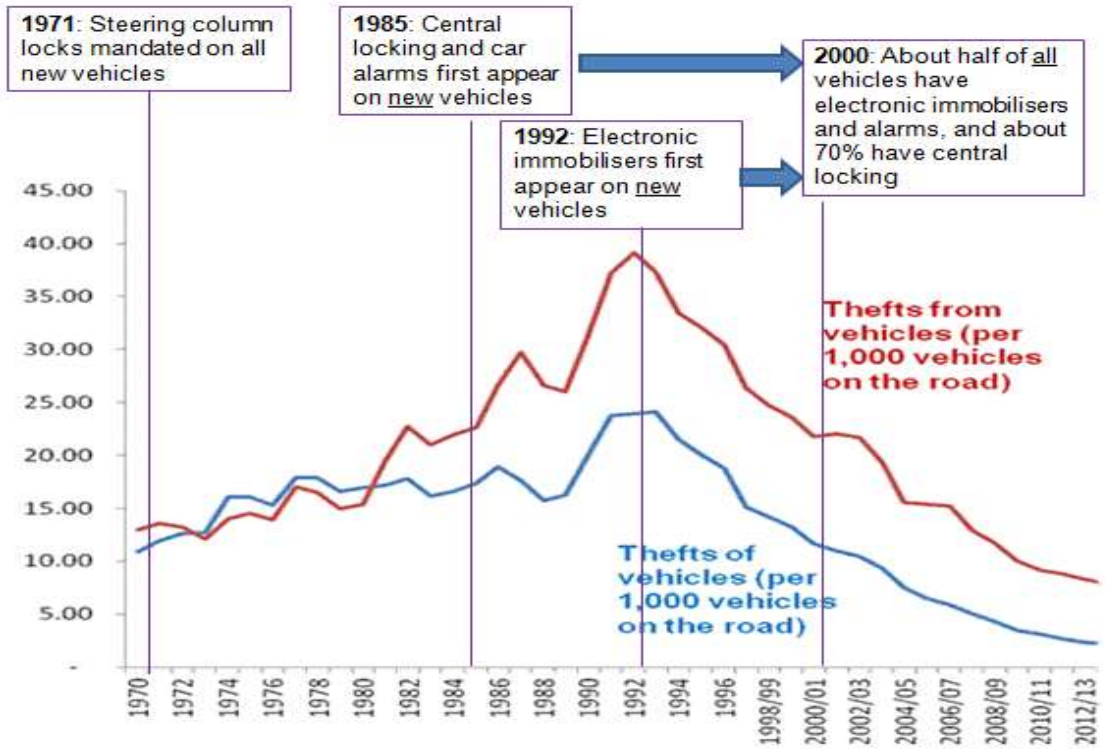
Executive summary

This report analyses trends in vehicle security devices and tries to determine the extent to which improved security has driven down vehicle-related theft in England and Wales and other nations.

For the first half of the 20th century, few vehicle thefts were recorded and vehicle security devices were rare. Then thefts started rising in the 1960s and steering locks were introduced as a result. These checked rather than halted rising crime, leading to a 'second wave' of security devices in the 1980s and 1990s including central locking, car alarms and – most importantly – electronic immobilisers[1]. To begin with, these devices appeared to have little effect as vehicle crime levels rose faster than ever up until 1993. But then crime began to fall sharply as many of the 'second-wave' devices spread through the vehicle fleet, see Figure 1. Using a mixed-methods approach, this report attempts to assess the degree to which improved vehicle security might have caused the vehicle crime decline by reducing the number of opportunities for would-be offenders. Findings are supportive of a marked crime-reduction effect. But the results also suggest that security has not been universally effective, nor does it seem to be the only factor that has made vehicle crime rise and fall so sharply over the last 50 years.

Figure 1: Police recorded thefts of and from vehicles in England and Wales (per 1,000 vehicles on the road) and accompanying security developments



Sources: Department for Transport statistics (Table VEH0103); ONS police recorded crime.

[1] Electronic immobilisers are devices fitted to vehicles that prevent the starting of the engine without the key. They were designed to prevent thieves 'hot-wiring' vehicles.

The key policy issues arising from the analysis are as follows:

- Different types of security devices have had different levels of success in reducing theft, partly because some crimes are harder to prevent than others. Within vehicle crime, for example, evidence in this report suggests that there were two clear instances of security devices driving down thefts of vehicles: steering locks and electronic immobilisers. But, despite the similar trends shown in Figure 1, the evidence that security was involved in the large reductions in thefts from vehicles is less clear. For all but the most organised offender, stealing a vehicle requires the ability to drive it away, which provides a clear 'break-point' for security to target. This is not quite the same for offences like theft from vehicles or burglary where multiple points of entry need to be secured and there is no direct equivalent to not being able to drive the car away.

- The evidence also suggests that security devices that have been proven to be effective have worked because they made the theft more difficult, not because they led to more offenders being caught. Vehicle crime detection rates changed little through the sharp rise and fall in offences. Also, the devices with the strongest evidence of effectiveness required no knowledge or conscious action by the consumer – most people do not know their car has an electronic immobiliser, and are not required to switch it on.

- Another reason for the variable effectiveness of security devices is longevity. Whereas previous devices (e.g. steering locks) seem to have kept thieves at bay for a limited period, electronic immobilisers have remained a strong deterrent for more than two decades.

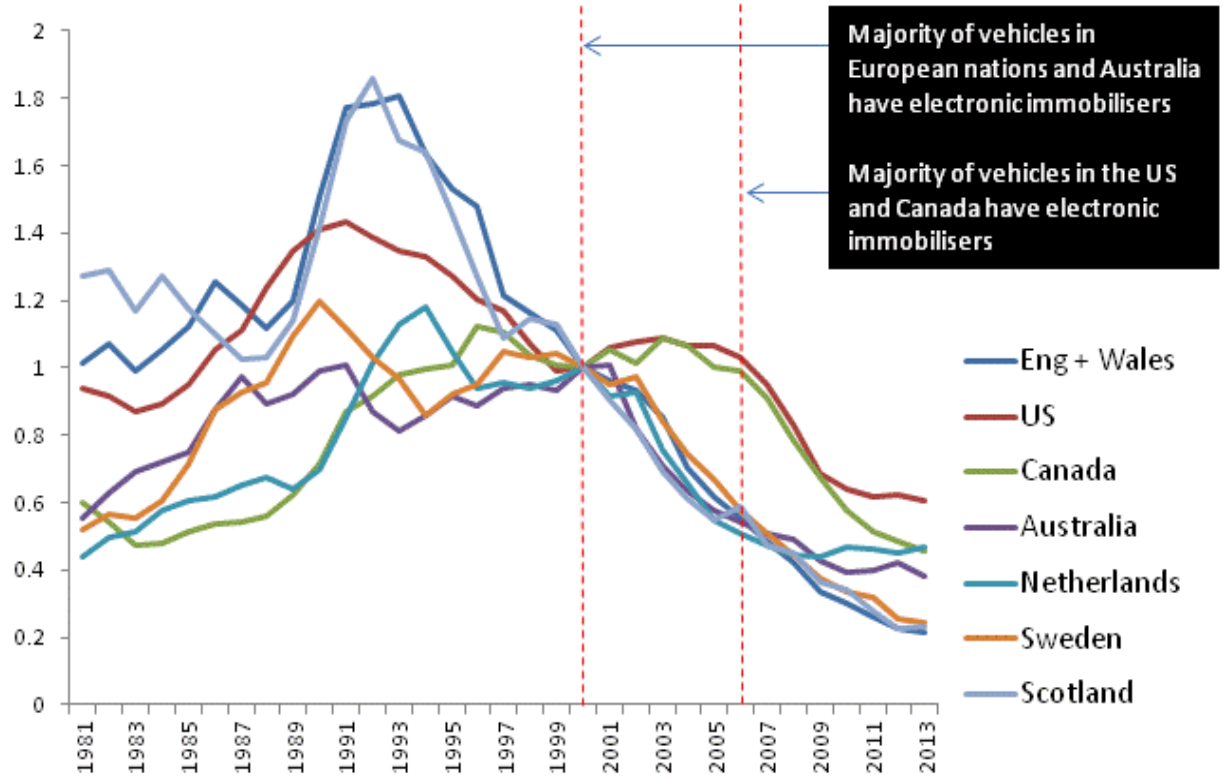
- The speed with which a new security measure spreads is almost as important as the effectiveness of the device itself. Highly effective security may have little effect on overall crime if it protects only a minority of the target population. This is demonstrated by analysis of the spread of electronic immobilisers. Whilst the devices first appeared between 1989 and 1992 in all seven nations studied, estimates suggest it took between eight and 14 years for half the vehicle fleet to become protected. During that period, theft trends varied. While vehicle crime fell in England and Wales, it continued to rise until 2001 in Australia, where the initial effects of improved security were most likely overwhelmed by other upward crime pressures until the pool of unprotected vehicles became sufficiently small.

- The spread of electronic immobilisers happened more quickly in Europe and Australia than in the US or Canada due partly to the presence and timing of legislation mandating the installation of electronic immobilisers in new vehicles, see Table 1. This creates a 'natural experiment' for determining both the effectiveness of the devices and the timing of their impact. As Figure 2 shows, despite the variation in trends to that point, once electronic immobilisers were installed on around half the vehicle fleet all these nations saw a sharp decline in vehicle thefts of around 40 per cent.

Table 1: Findings from cross-national analysis on electronic immobilisers

	Eng + Wales	Scotland	Netherlands	Sweden	Australia	US	Canada
Dates of electronic immobiliser spread							
Estimated first appearance of electronic immobilisers in mass market vehicles	1991-92	1991-92	1991-92	1991-92	1989-1990	1988-1992	1988-1992
Year in which electronic immobilisers mandated on new vehicles	1998	1998	1998	1998	2001	None	2007
Estimated year in which 50% of all vehicles have electronic immobilisers (threshold)	2000	2000	2000	2000	2000	2006	2006
Changes in numbers of police-recorded vehicle thefts							
Five years pre-threshold	-33%	-31%	-5%	9%	9%	-2%	-6%
Five years post-threshold	-41%	-35%	-44%	-39%	-46%	-34%	-46%

Figure 2: Recorded vehicle thefts in five nations, indexed to 2000 (2000=1)



Sources: Police figures for different nations, full sources in Technical Appendix.

- Several further conclusions follow from these results. Legislation requiring new vehicles to have an electronic immobiliser probably played a part in reducing crime rates by speeding up the spread of devices. But had the legislation applied to all vehicles rather than just new vehicles, more crime might have been prevented because spread would have been faster. Legislation may also have been important in putting the onus onto manufacturers rather than consumers – there was little evidence of consumers retrofitting electronic immobilisers to existing vehicles.[2]

- A common criticism of security is that it simply displaces crime somewhere else (i.e. if

[2] The only instance that could be found of retrofitting occurring in significant numbers was in Western Australia. But even then, significant government subsidies were provided and take-up was only partial leading to mandatory retrofitting a few years later. See Appendix 4.

would-be offenders cannot steal a new vehicle, they will steal an older vehicle without an immobiliser). Overall, the analysis is consistent with other studies in finding that while displacement does occur it rarely overwhelms the effect of improved security completely. Offenders did switch to stealing older vehicles, but overall thefts still went down. However, two further points need to be made. As the example of Australia demonstrates, displacement can eliminate crime-reduction gains for a number of years if there is still a sufficiently large pool of unprotected targets available. Secondly, improved security seems to have deterred all but the most committed offenders, which has had a large effect on the volume of thefts in many nations. But some of the remaining offenders switched to higher-harm vehicle theft methods, like car-key burglary and robbery, as a result.

- The findings in this report also touch on the validity of the 'security hypothesis', which has suggested that improvements in the quality and quantity of security may be the main reason why overall crime has fallen. This report offers mixed support. On the one hand, the cross-national evidence from Table 1 and Figure 2 demonstrates that electronic immobilisers clearly drove a reduction in thefts of vehicles. But for many nations, England and Wales included, the crime decline was already well underway by the 2000s, which is when electronic immobilisers seemed to have their greatest effect.

- Vehicle crime in England and Wales rose and then fell very quickly in the period before electronic immobilisers reached 50 per cent penetration (Figure 1). There have been examples of security improvements driving large changes in trend like this, but these occurred when a large proportion of the target population was protected in a very short space of time, as happened with steering locks in the Federal Republic of Germany in the 1960s or more recently with mobile phone security[3]. This was not the case with the second wave of vehicle security devices, like central locking, alarms and immobilisers. At the 1993 turning-point in recorded vehicle crime, estimates suggest only the newest cars would have had electronic immobilisers, amounting to fewer than five per cent of vehicles on the road, and thieves had shown a preference for stealing older vehicles anyway.

- The percentage of vehicles with other security features - car alarms, mechanical immobilisers and central locking - would have been higher in 1993, but the evidence of effectiveness for these devices is more mixed than for electronic immobilisers. Analyses of theft rates by age of vehicle show that only vehicles manufactured from 1992 onwards had markedly lower theft rates even though car alarms and central locking began appearing in new models in the mid 1980s. In addition, the fact that thefts increased so sharply in the early 1990s, as central locking, mechanical immobilisers and car alarms were spreading through the vehicle fleet also suggests they were not the catalyst for the initial drop in crime. Even taking into account all the improving combinations of security devices, there was still a large pool of unprotected vehicles during the 1990s and both Car Theft Index data and findings from the Crime Survey for England and Wales (CSEW)[4] show that during the initial period of the vehicle theft decline, rates fell sharply in vehicles without security as well as in protected vehicles. Overall then, the analysis suggests that vehicle security - and electronic immobilisers in particular - made an important contribution to an already falling trend rather than causing the initial crime turn-around.

[3] This is discussed in Appendix 1.
[4] Formerly the British Crime Survey.

- Two exploratory attempts were made to model the proportion of the fall in thefts of vehicles attributable to electronic immobilisers. Retrospectively attempting to establish causality and quantify the size of effects is fraught with difficulty due to the lack of a control group, so these results should be treated as exploratory only. But the two different methods produced reasonably similar results, tentatively suggesting that at least a quarter and possibly as much as half of the drop in thefts of vehicles in England and Wales could be attributed to electronic immobilisers. No estimates were attempted for thefts from vehicles.

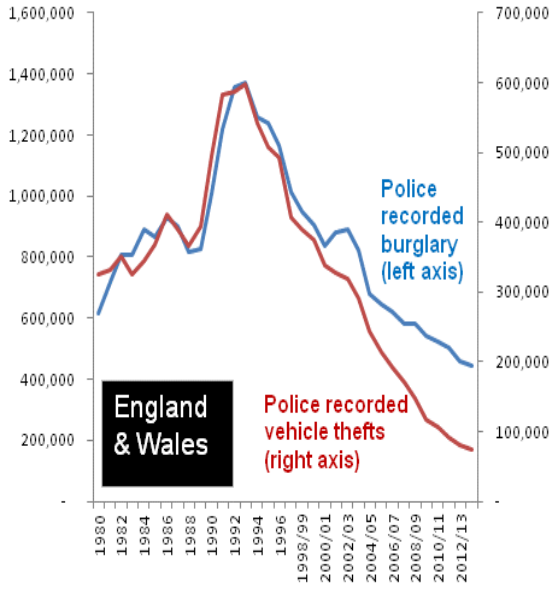
- That other factors were probably involved is also suggested by the fact that other types of crime tended to peak at the same time as vehicle-related theft and then fall with an initially similar trajectory. Certainly the rise and fall in vehicle crime was highly correlated with burglary in England and Wales and Australia, and with violence in the US, see Figure 3. This implies either that:

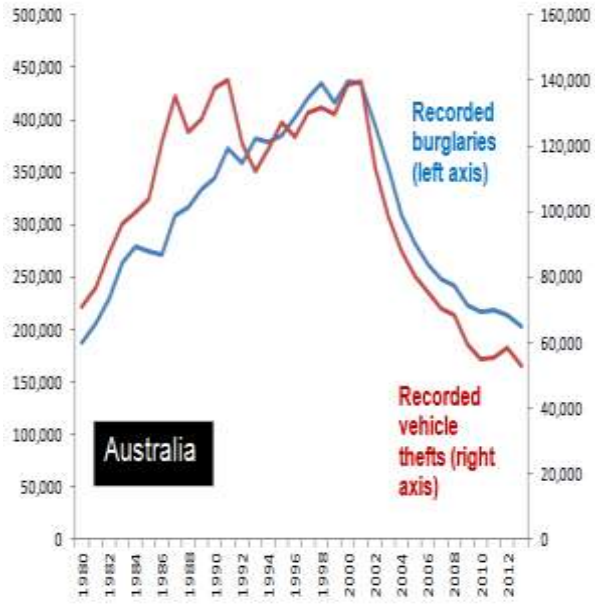
  - improved vehicle security had a marked effect on other crime too; or

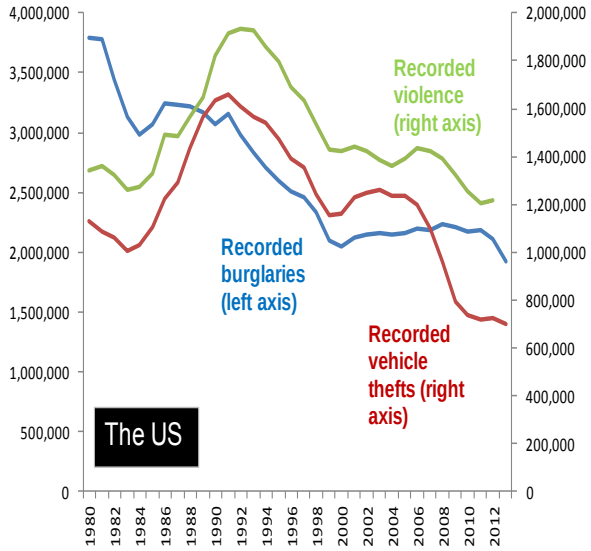
  - that that there was a simultaneous and equally large improvement in other types of security: household security in England and Wales and Australia, and security relating to violent crime in the US; or

  - that there was a large shift upwards and then downwards in some other factor, or combination of factors, that would affect crime trends more generally.

Figure 3: Panel of charts showing police recorded thefts of vehicles and selected other crimes in England and Wales, Australia and the US







Sources: Police figures for different nations, full sources in Technical Appendix.

- This analysis found little convincing evidence for the first option. The second option was not covered in this study. Security improvements on houses and other products were not examined in detail and neither were place-based security devices like CCTV. So it is possible that these had a separate effect on vehicle crime, burglary and other types of vehicle crime. In relation to the third option, it is important to ask what might have driven such a change. There is a vast literature on possible reasons for the crime drop and it is beyond the scope of this report to summarise them. Changes to policing, economic conditions, incarceration rates and long-term demographic shifts may all have played some role, as may the timing of drug epidemics. Previous Home Office research has shown that epidemics also follow a sharply rising and then falling pattern and affect multiple crime types. In that light, one further finding from this report – that joy-riding declined relative to more profit-driven theft even through the vehicle crime rise – may be relevant.

- The final section of this report looks at the nature of vehicle crime today. Overall, vehicle crime levels are about a fifth of what they were in the mid 1990s, despite eight million more vehicles on the roads[5]. However, if this impressive decline is linked to the gradually reducing pool of vehicles on the road without electronic immobilisers, as data suggest, then some of the downward pressure on crime may be petering out. Fewer than three per cent of vehicles on the road in 2013 were made before 1997, meaning virtually all vehicles now have electronic immobilisers. So to further reduce crime, new interventions to tackle the minority of thieves who have been able to get around current security levels may be required.

- Indeed, the latest figures for the year to June 2015 showed a three per cent increase in police-recorded thefts of vehicles in England and Wales, the first rise in two decades. This appears to be mainly due to an increase in stolen scooters and motorcycles. Motorbike thefts fell in line with other crime from 1995 to 1999, but from 1999 numbers of thefts have been quite stable, while thefts of cars fell sharply. This was probably due to the fact that motorbikes are less well protected by security for the simple reason that they are easier to transport away from the scene without cracking the immobiliser. It also means that trends in motorbike/scooter theft can now drive trends in overall vehicle theft. Exploring ways to better protect motorcycles may therefore be an important element of future thinking on vehicle crime prevention.

- Finally, a crucial policy question that this report has been unable to resolve fully is whether new technology is changing vehicle security dynamics again. The technology to overcome electronic immobilisers certainly exists and is available[6] but current theft rates suggest it is not being used by a large number of offenders (relative to the 1990s). There are perhaps four reasons.

  1) There are simply fewer would-be offenders now – so even though the technology exists, it is not being used.

  2) The price, and the need to buy the technology in advance (i.e. to plan the theft), may raise the bar sufficiently to deter many opportunist car thieves. If high crime levels of the past have been predominantly about less-organised offenders exploiting straightforward opportunities that required little preparation or planning, then it is possible that the new methods of theft may have only a small impact on crime levels.

  3) Other types of security, like CCTV or number-plate recognition technology, continue to make vehicle theft unattractive to more opportunistic offenders.

  4) Word simply has not spread yet. This is the most worrying option – i.e. that once the knowledge of electronic compromise spreads from more seasoned offenders to more casual ones, thefts will start to rise.

- Presently it is hard to know which of these explanations applies. Either way, but particularly in the case of the fourth, there is a case for manufacturers and others to be thinking carefully about a 'third wave' of vehicle security to ensure they stay ahead of the technological curve.

[5] CSEW figures show that the number of vehicle crimes in 2013/14 was 22 per cent of the corresponding figure in 1995. The equivalent for police recorded crime (which peaked in 1993) is 23 per cent.
[6] See for example: https://www.newscientist.com/article/mg20827894-500-criminals-find-the-key-to-car-immobilisers/

1: Background, aims and structure

The idea that security might be an important driver of crime has come a long way in the last 40 years thanks to pioneering work by Home Office researchers among others. Indeed, the origins of what is now called 'the security hypothesis' can be traced to the growing recognition that 'opportunity' is a key driver of crime. Three papers tell the story of this process: 'Crime as Opportunity' (Mayhew *et al*. 1976), 'Opportunity Makes the Thief' (Felson and Clarke, 1998) and 'Opportunity Makes the Thief. Really? And so what?' (Clarke, 2012). As these papers outline, 'opportunity theory' began as an opposition movement. It challenged the perceived wisdom of the time, which placed criminals at the centre of the quest to reduce crime, rather than crime itself. The new adherents wondered whether crime could be reduced not just by making people less criminal but by changing the crime environment to make situations less conducive to crime. As Ronald Clarke put it:

> *Is opportunity a cause of crime? The question was unavoidable because if opportunity is a cause, then reducing it could be expected to reduce crime without displacing it; if opportunity merely determined when and where crime occurred, but did not cause it, then the expected result of reducing opportunity would simply be to displace it.*
>
> Source: Clarke, 2012.

This inquiry began a body of work that drew together several different theoretical strands, in particular 'routine activity theory' (Felson, 1998), 'crime pattern theory' (Brantingham and Brantingham, 1991) and 'rational choice theory' (Clarke and Felson, 1993). The links between these approaches and opportunity is eloquently outlined in Felson and Clarke (1998) and interested readers are signposted there. But briefly, routine activity theory suggests that crime is influenced by what people do on a daily basis rather than simply being driven by ingrained criminological tendencies. Crime pattern theory looked at how crime was influenced by aspects of place and physical geography and not just individuals; and rational choice theory suggested that an individual's actions could be influenced by aspects of the environment that changed the costs and benefits of committing a crime.

One of the most important aspects of this research agenda was that it focused on designing and testing on-the-ground interventions that could have immediate crime-reduction impacts. There are now hundreds of studies which suggest that altering the crime environment to lower opportunity can reduce crime. Though these studies vary considerably in the quality of their research design, most attempts to summarise the evidence base conclude that situational crime prevention, as it has become known, is effective. For example, a recent systematic review of interventions that aimed to reduce repeat victimisation found that crimes decreased by one-sixth, on average, relative to controls (Grove *et al*., 2012). Burglary interventions produced the biggest crime reduction effects and of these, the authors found that "*appropriately tailored and implemented situational crime prevention measures, like target hardening and neighbourhood watch, appear to be the most effective*" (ibid.). A review of 102 situational interventions also found a high level of effectiveness and while displacement did occur in some cases, it never completely offset the main crime-reduction effect and in some cases a diffusion of benefits occurred (Guerette and Bowers, 2009). The concepts of displacement and diffusion are crucial

when evaluating opportunity/security effects, so Appendix 1 explores these issues in more detail.

A wide range of approaches came to be incorporated under the opportunity banner. For example, although improved security and target hardening was clearly part of the approach, Felson and Clarke (1998) also link opportunity theory to problem-oriented policing, defensible space architecture, and crime prevention through environmental design. For evidence of the effectiveness on these approaches see Weisburd, *et al*. (2008) and Cozens, *et al*. (2005). This in turn meant that opportunity approaches could be applied to crimes other than just theft. A review of evidence on violence in the night-time economy found that several elements of the physical and social environment predicted violence levels.[7] And more recently the techniques of situational crime prevention have been applied to crimes as diverse as internet child pornography (Wortley and Smallbone, 2006), suicide bombings (Clarke and Newman, 2006), and organised crimes of various kinds (Tremblay *et al*., 2001; Bullock *et al*., 2010; Chiu *et al*., 2011).

Overall, Clarke (2012) summarises the achievements of work on opportunity and security as follows.

1) *It has supported the development of situational crime prevention, a highly effective means of crime control.*

2) *It has helped make credible the claim that the cumulative effect of situational prevention, whether or not implemented under that label, has brought about widespread drops in crime in Western countries.*

3) *It has helped to clarify that most criminological theories are theories of criminality not theories of crime – in other words, criminological theorizing has been preoccupied with the question of why certain individuals or groups become involved in crime and not the question of why crime occurs. This latter question cannot be answered simply by explaining why some people are more likely to be delinquent or criminal; it must also be explained by how situational factors facilitate or encourage the actual commission of criminal acts.*

4) *It has supported the development of an alternative set of crime (or opportunity) theories that will enable the growth of crime science.*

There is a considerable body of evidence to support the first, third and fourth of these points. The second point – that situational crime prevention may have been the main cause of the crime drop – provides the context for the rest of this paper.

There have been a number of attempts to link opportunity and security to aggregate-level crime trends. As Felson and Clarke (1998) pointed out, “for a long time, the routine activity approach provided the best explanation for the rise in burglary in the United States and western Europe during the 1960s and 1970s.” This was based on the increase in women’s labour participation during that period, which left more houses empty during the day, and consumer/technological growth which meant more tempting (and light-weight) products available to steal. This was extended to violence too:

[7] Although this *suggests* that situational interventions might reduce night-time economy violence it does not conclusively prove it in the way that an evaluation of a particular intervention would.

> "*the most general explanation of crime rate trends is an indicator of the dispersion of activities away from family and household settings. As people spend more time among strangers and away from their own homes, their risk of personal and property victimization rises*."
>
> Felson and Clarke, 1998

This hypothesis has been challenged from two directions. Firstly by Eisner (2008), who notes that many of the variables used to explain the rise in crime – more disposable income to spend on alcohol, urban growth and increased leisure time – were also rising from 1840 to 1950 when all available evidence suggests that homicide, violence and some types of property crime were declining across the developed world. More recently, the hypothesis has been somewhat wrong-footed by the crime drop, which has featured sometimes very sharp falls in the rates of violence, theft and homicide without an obvious curtailment in either the opportunity to socialise and consume alcohol or the number of stealable goods people own.[8] And while some environmental changes seemed to have had surprisingly large effects – Clarke and Mayhew (1988) showed that making domestic gas less poisonous reduced UK suicides markedly without displacement to other methods – other changes had surprisingly little effect. For example, the Licensing Act 2003, which came into force in November 2005, abolished set licensing hours in England and Wales, effectively allowing bars and pubs to sell alcohol on a 24-hour basis if they obtained a licence. In the run-up to implementation, there was widespread concern that the legislation would lead to '24-hour drinking' and an increase in associated problems (Hough *et al*.,2008); a concern perfectly in line with opportunity theory. Yet an evaluation suggested that the change had essentially no effect on the overall volume of offences. All that happened was that a small amount of the violence that previously occurred earlier in the evening was displaced to the early hours (ibid.)[9]

Recently then, some opportunity proponents looking for effects on *aggregate-level* crime trends have moved away from routine activities to an extent, and focused instead on security. This has given rise to the 'security hypothesis', which has been set out in a series of recent papers (see in particular Farrell *et al*. 2014).

Briefly, the argument is that increasing opportunities for offending (more cars on the road, more consumer goods to steal etc.) drove up crime but also generated a security backlash. That is, rising crime led to fear of crime which led to pressure from consumers and governments for security improvements (van Dijk and Vollaard, 2012). These arrived in the form of improved anti-theft devices on cars and houses, but also public-space measures like CCTV, private security guards and so on. In other words, opportunity drove crime up and security has driven it back down again.

Evidence in support of the security hypothesis mainly comes in two forms: studies testing the effectiveness of security devices in a local context; and studies looking at the introduction and

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[8] This is not to say that opportunity played no role in the declines of these offences. Some situational interventions aimed at reducing criminal opportunity may have contributed (e.g. CCTV or problem-solving policing). The point being made is that the opportunity and routine activity theories that had been used to explain the rise in crime did not suddenly turn around in such a way as to offer an explanation for the fall. People continued to buy goods, more and more women entered the workplace and socialising in the night-time economy continued.

[9] The retrospective nature of the evaluation meant that it was not as robust as a randomised control trial or a quasi-experimental design, so its findings should be treated slightly cautiously. However, the fact that violence – whether measured by police figures, the Crime Survey or hospital data – continued to decline through that period suggests the Licensing Act cannot have caused meaningful upward pressure on violence at the national level. One possible reason is that, as the evaluation showed, the actual number of premises that extended their hours was quite 'modest' (Hough *et al*., 2008).

spread of improved security nationally to see whether it correlates with falling crime.[10] The impact of electronic immobilisers has been central to the hypothesis because it has been studied in both contexts. Research has demonstrated that cars with electronic immobilisers are far less likely to be stolen than cars without immobilisers (van Ours and Vollaard, 2014; Farrell, Tseloni, and Tilley, 2011; Brown, 2013). More recently though, it has also been suggested that the introduction and spread of electronic immobilisers played an important part in causing the crime turning point in nations like England and Wales, the US, the Netherlands and Australia (Farrell *et al*., 2014).

Research has also examined the effectiveness of other security measures. Farrell *et al*. (2011) suggest that vehicles with certain combinations of security (particularly electronic immobilisers and central locking) were up to 25 times less likely to be stolen than vehicles without security. Other studies have focused on how the benefits of improved housing security may have reduced burglary rates (Vollaard and van Ours, 2011; Tseloni *et al*., 2014). But to this point the evidence that improvements in housing security coincided with crime's turning point is more limited.[11] This is important because – as Figure 3 demonstrates – the crime drop occurred in many types of crime more or less simultaneously. In England and Wales and Australia, for example, burglary and vehicle theft rose and fell with very similar trajectories. For the security hypothesis, this implies either that:

- marked security improvements occurred on houses and cars at more or less the same time; and/or that

- the benefits from a particular security device 'diffused' almost instantaneously from one crime type to the other.

Farrell *et al*., (2014) have suggested two mechanisms by which the benefits of vehicle immobilisers may have spread to other types of acquisitive crime and violence. The first of these, the *debut crimes hypothesis,* is based on the evidence that vehicle theft is frequently one of the first offences that offenders commit, but that it can be followed by a long and diverse criminal career (Cooper *et al*., 2013). This means that deterring vehicle theft may stop a criminal career at the earliest stage, preventing other types of offences. The other possibility, the *keystone crime hypothesis*, is based on the evidence that stolen cars are used to commit, or are implicated in, other crimes like burglary or theft from vehicles. Many of the vehicle theft offenders interviewed by Light *et al*., (1993) said they stole cars to commit other crimes or to sell-on the contents (often the stereo) rather the vehicle itself. Thus, deterring theft of vehicles might prevent various other crime types.

This paper seeks to add to the evidence base by attempting a systematic examination of trends in vehicle crime and the spread of vehicle security devices, particularly electronic immobilisers, in England and Wales and six other nations.

[10] Brown (2015) also finds some support for the security hypothesis in a study that surveys offenders about reasons for the crime drop. In interviews with nearly a thousand offenders in 2012, 15 per cent of the sample or 31 per cent of those who offered an explanation (most gave no response or said they didn't know) mentioned better security in their explanation of crime's decline, making it the most common single explanation.

[11] Whereas electronic immobilisers began appearing at about the same time as the vehicle crime turning point in England and Wales in 1993, CSEW data suggest that the important changes to housing security – better window and door locks – started earlier and gradually improved through both the sharp rise and fall of burglary shown in Figure 4. Tilley *et al*. (2014) have recently argued that the sharp turn-around in burglary may still be due to security if security is measured via *quality* rather than quantity, and they also suggest a possible role for other household improvements, like double glazing.

Aims and Structure

Aims

The main aims of this paper are as follows:

i) to outline the main trends in vehicle security and vehicle crime in England and Wales, with briefer descriptions of trends in several other nations;

ii) to model the spread of electronic immobilisers in England and Wales and assess their likely crime impact;

iii) to test the modelling results against actual crime trends, both within England and Wales and internationally, to see whether the data suggest that electronic immobilisers reduced vehicle crime and if so when;

iv) to analyse the effects of electronic immobilisers on other types of crime i.e. to look for signs of displacement and/or diffusion of benefits;

v) to analyse the current vehicle crime landscape in England and Wales to see whether security still provides a deterrent.

Throughout these sections, policy-relevant conclusions are also drawn out wherever possible. One of the most important of these relates to the overall extent to which security has driven down vehicle crime. It is difficult to know where to prioritise resources for the future if past trends have not been fully explained. In relation to the 'security hypothesis' and the fall in crime, it is therefore important to point out that this paper only covers the aspects of the hypothesis that relate to vehicle crime. The paper does not look at improvements in housing or other types of security (including some that could have applied directly to vehicle crime, like CCTV and number plate recognition technology), or at other aspects of situational crime prevention. It is perfectly possible that these made important and separate contributions to the crime decline and it is also possible that these interacted with the security devices examined here to enhance their effectiveness. In this report, the intention is simply to assess the role played by security improvements made to the vehicle itself, and in that sense this paper is only a partial examination of the security hypothesis.

Structure

The remainder of the report is divided into five sections and a number of appendices. The first section (Chapter 2) provides background information on long-term trends in vehicle security and vehicle crime in England and Wales. In Chapter 3, data from England and Wales are used to model the spread of immobilisers and the timing of their likely impact in relation to the crime turning point in the mid 1990s.

Chapter 4 continues the examination of the likely timing of an electronic immobiliser impact by examining trends in vehicle thefts and methods of theft nationally and at police force area level within England and Wales. Police Recorded Crime (PRC) and Crime Survey for England and Wales (CSEW) data are used.

Chapter 5 employs a panel dataset with seven nations (England and Wales, Scotland, the US, Canada, Australia, the Netherlands and Sweden) to test for the magnitude and timing of any electronic immobiliser impact on numbers of vehicle thefts and whether the benefits diffused to

other crime like burglary.

Chapter 6 analyses current data on vehicle crime to ascertain whether the security improvements from the 1990s are still effective. This is followed by a brief conclusion, outlining the main findings.

Six appendices provide further information on some aspect of the analysis or in some cases they explore some conclusions which do not directly relate to the relationship between vehicle security and vehicle crime in England and Wales, but which may be of interest. Details of the appendices are shown below:

Appendix 1: Diffusion, displacement and switching

Appendix 2: The effect of LoJack on car thefts in the US

Appendix 3: Why does crime spike?

Appendix 4: Two local-area case studies: Western Australia and Merseyside

Appendix 5: Other factors that might have driven vehicle crime trends

Appendix 6: Time series modelling

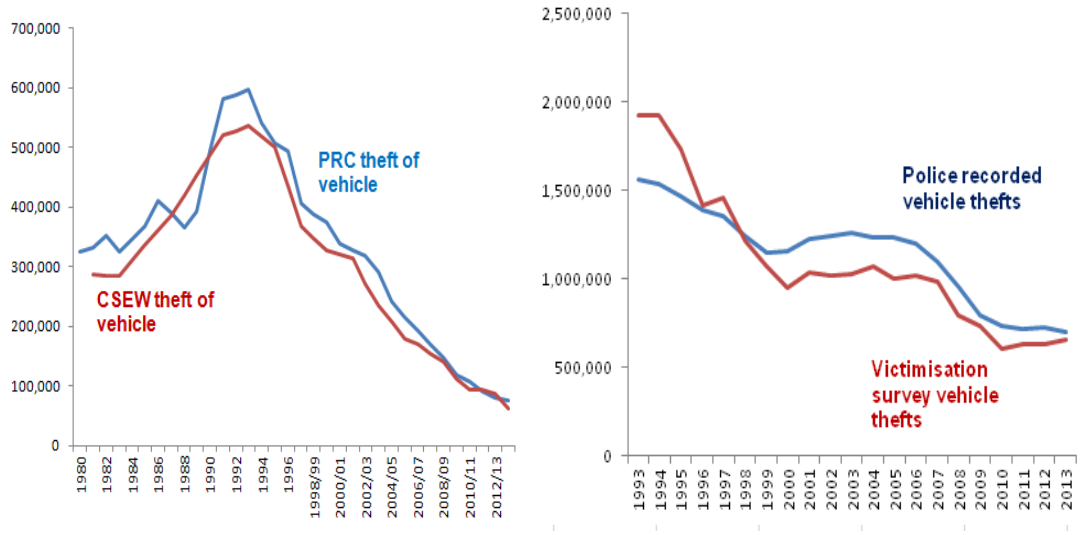
Data

For England and Wales, the main datasets used are the Crime Survey for England and Wales (CSEW), Police Recorded Crime (PRC) and the Car Theft Index (CTI). For the analysis testing the effects of electronic immobilisers, PRC is mainly used for the central variable of interest: the number of motor vehicle thefts.[12] The main reason is that police statistics are available for a large number of nations over several decades and are also available sub-nationally in some instances. This gives police recorded crime a huge advantage – in terms of sample size – over victimisation surveys, which are the other possible source of figures on vehicle thefts.

Police statistics suffer from well-known limitations. They capture only the crimes that are reported to and recorded by the police and are therefore subject to any variation in reporting rates or in recording practice. Because of these limitations it is often preferable to use victimisation surveys when looking at trends in crime. However, vehicle theft (and to a lesser extent burglary, which is also used throughout this report) may represent an exception to this general rule. This is because vehicle theft tends to be one of the best reported and recorded offences and is therefore subject to far less variation due to changes in recording practice. The Crime Survey for England and Wales (CSEW) suggests that reporting rates for vehicle theft are consistently above 90 per cent, most likely because victims are required to report the offence for insurance reasons. As a result, for England and Wales and the US (two nations with comprehensive victimisation survey data), there is a high degree of similarity, both in the level and trend of vehicle theft nationally, between police statistics and victimisation surveys, see Figure 4.

[12] A full list of sources for these statistics is provided in the Technical Appendix.

Figure 4: Comparison between vehicle thefts as recorded by police statistics and by victimisation surveys in England and Wales (left) and the US (right)



Sources: Office of National Statistics (ONS) for England and Wales; FBI Uniform Crime Reports and the National Crime Victimisation Survey for the US.

It would seem that, in the case of vehicle theft, police statistics are comparable in their reliability to victimisation surveys. Hence they are used throughout this report and details of how recording practice changes and crime-type changes were incorporated can be found in the Technical Appendix. Where possible, survey data are also employed to triangulate results.

Descriptions of the method and other data used are provided within each section, with supplementary material in a Technical Appendix (Appendix 7).

2: Vehicle security and vehicle theft in England and Wales

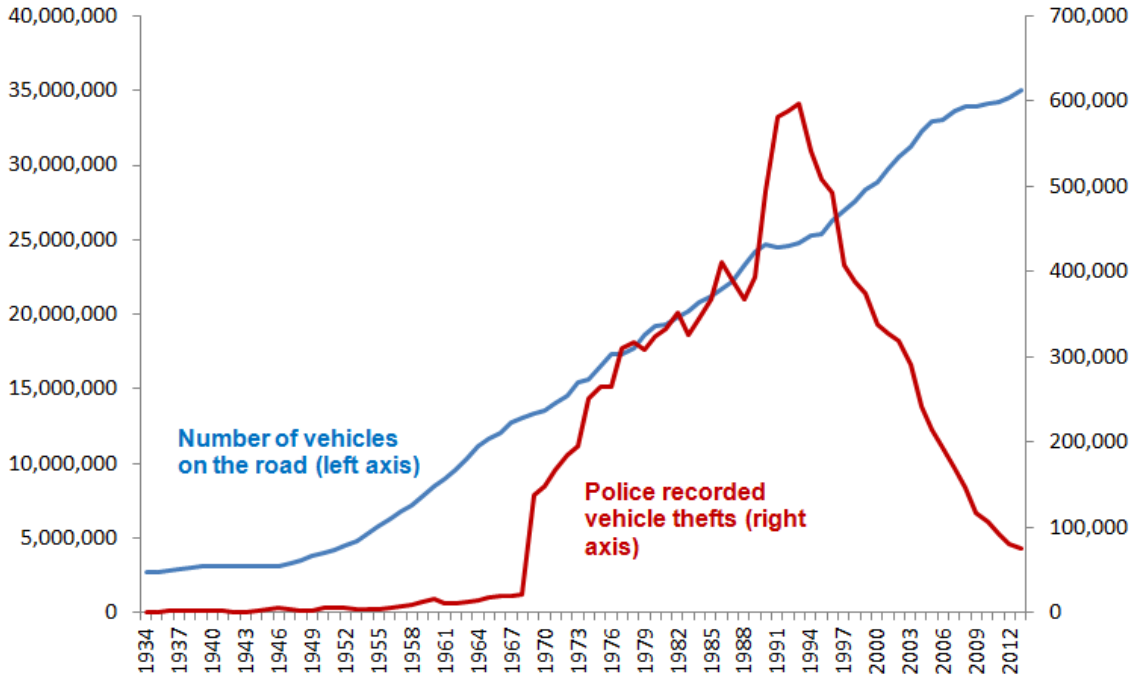
This chapter looks at existing evidence on the history of vehicle security and vehicle theft. It also highlights some evidence gaps, which the subsequent analysis will try and fill.

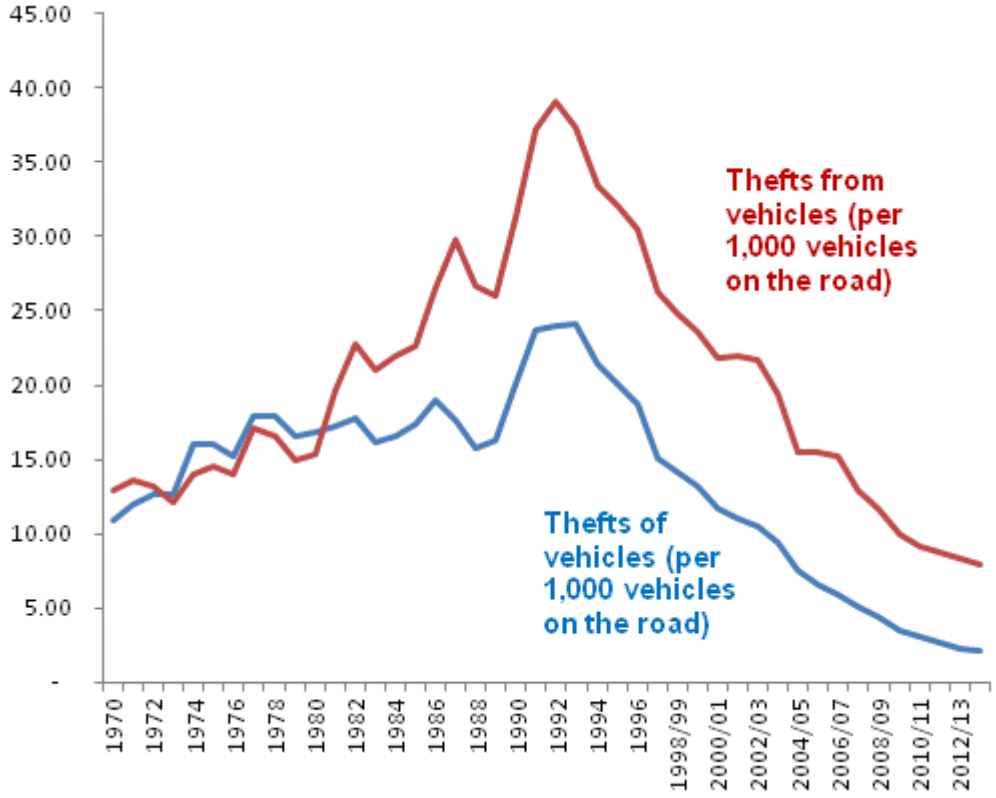
The first vehicles and the first wave of vehicle security

According to the National Motor Museum, the first motor vehicle appeared in the UK in the 1890s and official statistics show that by 1909 there were nearly 150,000 motor vehicles on the road. There was little in-built security on these early vehicles, with the cabs of the first cars being completely open (Webb, 1994). Registration plates were introduced in 1904, partly with the intention of preventing re-sale of stolen vehicles, but anecdotal evidence suggests this was hardly enforced initially (Webb and Tilley, 2005). Gradually security became more of a concern and door-locking systems and devices for protecting ignition switches were introduced and improved (Karmen, 1981).

Despite the initially rudimentary security, statistics on vehicle theft through the first half of the 20th century suggest that theft levels were very low, see Figure 5. However, there is evidence of concern about vehicle theft registering with the Metropolitan Police Service as early as 1918 (Webb and Tilley, 2005), and the number of thefts were probably not as low as Figure 5 implies as they did not include thefts in which the vehicle was subsequently recovered. These were included from 1968 onwards, and, as the 1968 step-change in the red line in Figure 5 (top chart) demonstrates, this had a very large effect on the number of thefts recorded. Indeed, statistics show that from 1968, the majority of police recorded thefts were cases in which the vehicle was recovered. This can occur because the theft was motivated by joy-riding, by the need to travel, or by desire for the contents of the vehicle rather than the vehicle itself. Stolen vehicles that are not recovered are often sold abroad or stripped for parts (Light *et al*.,1993; Sallybanks and Brown, 1999).

Figure 5: Vehicles on the road and vehicle thefts, England and Wales (top chart); rates of theft of and from vehicles per 1,000 vehicles on the road (bottom chart)





Sources: Department for Transport statistics (Table VEH0103); ONS police recorded crime.

Figure 5 demonstrates the remarkable rise and fall in vehicle thefts that has occurred over the last half-century. Webb (1994) argues that the growth of both vehicles on the road, and the number of thefts, through the 1950s and 1960s led to demands for improved security. This culminated in the introduction of legislation in Europe and in the US in the 1960s and 1970s

which for the first time required manufacturers to fit cars with steering column locks[13] (ibid.)

The impact of the legislation has been examined by Webb (1994). He shows that steering locks had a significant effect on vehicle theft rates in the Federal Republic of Germany (FRG) where legislation made them mandatory on all vehicles in 1961. The number of thefts fell 20 per cent in three years after the legislation (ibid.). Thefts started to increase again after that, but at a rate roughly proportional to the growth in vehicles on the road, hence the rate of vehicle theft stabilised. However, there was some evidence of displacement into motorbike theft and the legislation had no apparent effect on theft *from* vehicles. Webb (1994) also suggested that there were positive impacts on vehicle thefts in the UK and the US though these were more muted and delayed because steering locks were only mandated on *new* vehicles rather than all vehicles, so they spread through the vehicle fleet gradually. In England and Wales, there was no immediate fall in the absolute volume of thefts, but by the late 1970s and throughout the 1980s vehicle theft in England and Wales rose in line with, rather than faster than, numbers of vehicles on the road.

This first wave of improved security provides an introduction to three concepts that will be important to the rest of this paper.

1) Timing: It shows that the impact of security devices may be different depending on whether they are introduced on all vehicles or only on new vehicles. If they are installed on all vehicles simultaneously an effect can be expected immediately; if they are installed on new vehicles, the main effect on crime is likely to be delayed.

2) The security arms race: The German example suggests that devices may be successful initially but that success may wane over time as thieves gradually find ways to bypass security.

3) Displacement and diffusion: A key question for this report is whether the net impact of vehicle security on crimes other than vehicle theft is negative, positive or neutral. In the case of steering locks, it appears that in the Federal Republic of Germany there may have been some displacement to other crimes (though almost certainly not enough to offset the gains from better security in cars), while in the other nations the effect was broadly neutral. There was no evidence for diffusion of benefits, even to theft *from* vehicles.

The vehicle crime rise of the 1980s and early 1990s and the security response

During the 1980s, there were some important changes in the nature of vehicle crime in England and Wales. As Figure 5 shows, throughout the 1970s, both thefts of vehicles and thefts from vehicles had risen faster than the number of vehicles on the road. But in the 1980s, theft of vehicle rates stabilised, while the rate of thefts from vehicles accelerated. Webb (1994) lists three possible reasons for this divergence in trends.

- Security: Security devices may have suppressed 'theft of' offences but had little effect on 'theft from' offences. This would apply if the effect of steering column locks were delayed until the 1980s when enough vehicles on the road had the devices.

[13] For a description of these steering column locks and details of the original legislation, see Webb (1994).

- Increased reporting: The Crime Survey showed that reporting rates for thefts from vehicles increased from 30 per cent in 1981 to 55 per cent in 1991 (though rates decreased again after that). By contrast, reporting rates for thefts of vehicles rose only from 90 per cent to 95 per cent. Reporting could therefore account for a large proportion of the 141 per cent rise in police-recorded thefts *from* vehicles over that period. But it does not explain all of it, because the Crime Survey – which is unaffected by shifts in reporting to the police – shows a 92 per cent rise in thefts from vehicles over the same period.

- Better items to steal: Many researchers suggest that the increasing tendency for vehicles to contain desirable stereo systems and/or radios was an important cause in the rise of thefts from vehicles during the 1980s. In a survey of offenders in Manchester, 77 per cent said they would break into a car to steal the radio/cassette player (Smythe, 1990).

While there is good evidence for all these factors playing a role, trends also suggest another shift in the nature of vehicle crime occurring at that time. Up to 1980, thefts of vehicles were dominated by incidents in which the vehicle was subsequently recovered, suggesting that joy-riding was the primary motive.[14] But from 1980, there is some evidence to suggest that vehicle crime became more about financial gain. The rise in thefts from vehicles is one example[15], but another is that within thefts of vehicles, numbers of thefts in which the vehicle was subsequently recovered stabilised in the 1980s and only 'unrecovered' thefts increased (Webb and Laycock, 1992). Given that unrecovered theft normally implies a profit-motive (either the car is broken up for parts or exported) whereas recovered theft can imply joy-riding, these trends suggest that vehicle theft became more profit-motivated during the 1980s.

At this time, one of the explanations offered was that improved security had ended (or at least seriously curtailed) the 'culture of car theft' and joy-riding that had persisted in the 1970s. It was felt that security had been part of the reason why vehicle crime seemed to have become more the domain of serious profit-driven offenders (who might be less deterred by security) rather than younger thieves seeking mainly excitement and a relief from boredom (Clarke and Harris, 1992; Webb and Laycock, 1992, see also Appendix 5). Certainly, there was much discussion of improved security during the 1980s, led by the Home Office. Southall and Ekblom (1985) showed the potential for vehicle security to be markedly increased with "minimal interference to the design of cars, at relatively little cost and in a manner which imposes no inconvenience to the motorist". This was part of a process aimed at cajoling industry to take security more seriously.

The statistics show that vehicle security almost certainly did improve during the 1980s. While Ekblom (1985) found that only a handful of new and very expensive models of car had central locking in 1985, by 1991 the Crime Survey suggests that more than a third of vehicles did. It also suggests that around a quarter (23%) had mechanical immobilisers and about the same

[14] Distinguishing between joy-riding and for-profit theft based on whether the vehicle was recovered has become commonplace in studies of vehicle theft. But the measure is far from perfect. As Gant and Graborsky (2001) point out, a proportion of recovered vehicles are stripped of their parts and then burnt out, suggesting profit was the main motive. Likewise, there is some evidence that cars were stolen simply for their radios (Light *et al*., 1993) and that the vehicle was then discarded afterwards, which is another example of a 'recovered' theft being committed for profit. Offender interviews also blur the boundary between joy-riders and professional thieves; many offenders appear to start as the former and end up as the latter (Light *et al*., 1993; Dhami, 2008). In that light, it is interesting that van Ours and Vollaard (2014) found that electronic immobilisers were effective in reducing unrecovered thefts as well as recovered ones. Even some so-called 'professional' thieves clearly found them to be a deterrent.

[15] Webb and Laycock (1992) show that a change in police recording practice means that if anything the divergence between thefts of and from vehicles during the 1980s is probably *under*-estimated. In 1980, thefts in which the vehicle was subsequently recovered but with property missing were recorded as 'thefts from vehicle' but after 1980 they were included in the theft of vehicle category.

proportion (23%) had alarms, see Table 2.

Table 2: Trends in vehicle security precautions for the main or sole vehicle in all vehicle-owning households

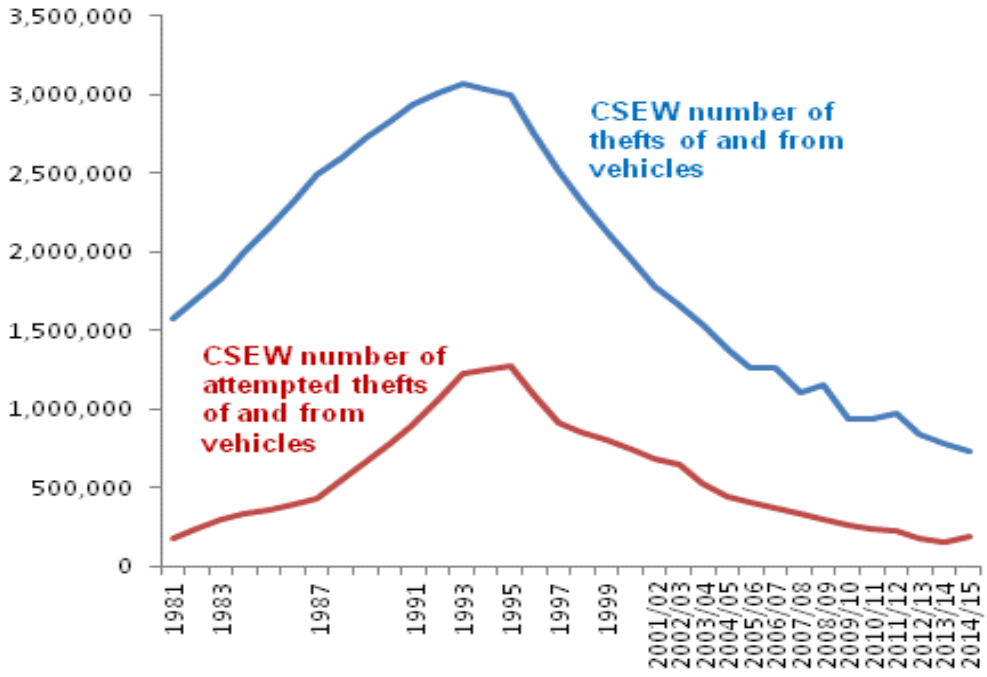
	1991	1995	1999	2001/02
Car alarm	23%	38%	49%	54%
Central locking	35%	50%	66%	75%
Any immobiliser	23%	46%	63%	70%
Electronic immobiliser	n/a	n/a	45%	55%
Mechanical immobiliser	n/a	n/a	40%	42%
Any audio security	n/a	n/a	74%	80%
- removable stereo	n/a	n/a	42%	44%
- security pin number	n/a	n/a	55%	63%

Note: The increases in car alarms, central locking and 'any immobiliser' are all significant between 1991 and 2001/02 as are the increases in electronic immobilisers and 'any audio security' from 1999 to 2001/02.

Source: ONS, Crime Survey for England and Wales.

In addition, people had become far less likely to leave their vehicle unsecured. Field tests in which researchers checked cars in car parks showed that around 22 per cent of vehicles were left unlocked in 1971, but this had fallen to four per cent by 1992 (Webb and Laycock, 1992). As already discussed, the proportion of recovered thefts fell from around 80 per cent to around 60 per cent (according to both police and Crime Survey data), suggesting that casual thieves were being deterred, a fact reinforced by trends in attempted thefts, see Figure 6.

Figure 6: Thefts of and from vehicles and attempts, England and Wales from 1981 to 2014/15



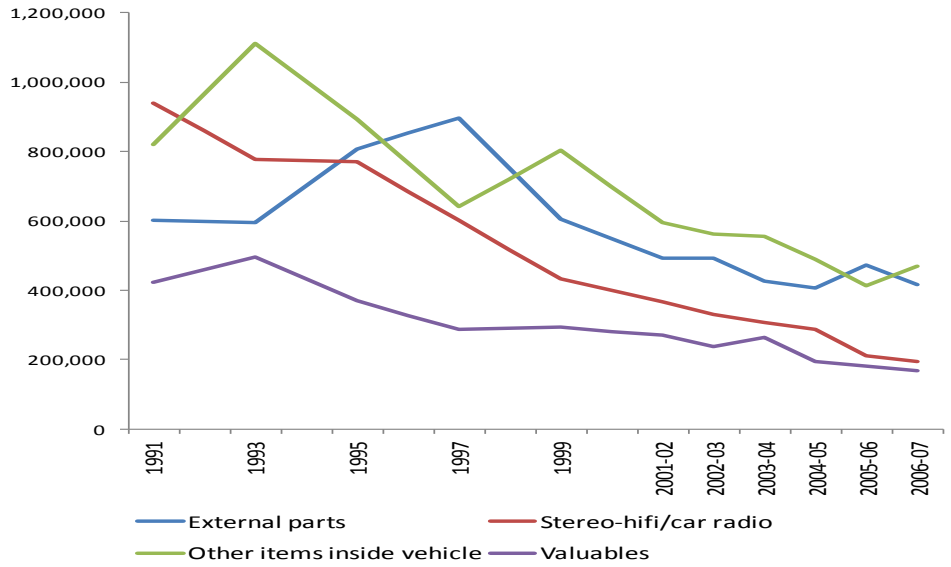
Source: ONS, Crime Survey for England and Wales.

Figure 6 suggests that in 1981, only around one in nine theft attempts were unsuccessful. This proportion increased through the 1980s so that during the early 1990s around 40 per cent were unsuccessful, which suggests that thefts of and from vehicles became harder during the decade.

However, despite these apparent improvements in security, vehicle crime of all kinds surged markedly in the early 1990s, whether measured by the Crime Survey or by police figures (see Figures 5 and 6) and the consensus was that the security improvements to that point remained insufficient to deter large-scale theft. In a 1992 paper, which contained interviews with car thieves from Greater Manchester, 20 per cent claimed they could enter a car and drive away in 30 seconds or less with a further 18 per cent saying the process would take between 30 and 60 seconds (Webb and Laycock, 1992). A year earlier, WHICH? magazine published similar estimates showing the inadequacy of car security (WHICH?, 1991). So, although central locking was later suggested to be an effective security measure, particularly in conjunction with an electronic immobiliser (Farrell *et al*., 2011), it was either not widespread enough or not effective enough to prevent the rapid rise in vehicle crime of the early 1990s (or both). Table 2 shows that around a third of vehicles had central locking in 1991 and about 50 per cent did in 1995, a decade after Ekblom noted the presence of the first centrally locked cars.[16]

It was not just internal car security that was coming under threat. Theft from vehicles also surged to new levels in the early 1990s, following a slight lull in thefts around 1987/88.[17] It is hard to piece together the types of items stolen during this crime surge and during the later decline, because data are imperfect. But CSEW trends are available from 1991, see Figure 7, and some additional conclusions from earlier years can also be drawn (notably that external parts were probably the most stolen items in the late 1980s as well as in the late 1990s – see the Technical Appendix).

Figure 7: Numbers of 'theft from vehicles' incidents by item stolen



Note: As multiple types of items can be stolen in an incident of theft, the combined total of items in the chart above will exceed the number of incidents of thefts from motor vehicles.

Source: ONS, Crime Survey for England and Wales.

[16] In relation to views on central locking at this time, see: http://www.independent.co.uk/news/uk/car-thieves-beat-remote-central-locking-systems-new-antitheft-coding-devices-could-cost-up-to-pounds-200-per-vehicle-susan-watts-reports-1564804.html

[17] The 'lull' is visible in the police recorded crime trend in Figure 4, but not in the Crime Survey trend as the survey was only run every four years at that point.

Despite the inconsistencies in the data, the analysis of items stolen in thefts from vehicles suggests four tentative conclusions.

- Though other evidence suggests stereo thefts increased through the 1980s (Smythe, 1990), the trends in Figure 7 show that stereo thefts peaked in 1991 at the latest and declined thereafter.

- Thefts of external vehicle parts made up a sizable component of all thefts from vehicles, featuring in between a quarter and two-thirds of thefts depending on the year. Thefts of external parts seem to have surged in 1987 (see Technical Appendix) and to a lesser extent in 1997.

- For the final years of the rise in thefts from vehicles (1991 to 1993), thefts of other items from inside the car – i.e. not stereos or exterior fittings – also drove up theft levels.

- From the crime peak to 2014 thefts of virtually all types of items have fallen.[18] The fall in stereo thefts has been particularly sharp, the decline in thefts of external parts and valuables from inside the car, slightly less so.

A number of reasons have been offered for the high levels of thefts of external car parts. Sallybanks and Thomas (2000) suggest three possibilities:

i) that the cost of replacing these parts fed a stolen goods market;

ii) that stolen number plates were used to alter a vehicle's identity;

iii) youth 'crazes' for wearing car badges.

Other authors have also cited this final point (see Clarke and Webb, 1999), and the apparently high levels of external parts theft at the end of the 1980s would fit with available evidence on the youth fashion 'craze' which was sparked in England and Wales by members of US rap-rock group 'the Beastie Boys' wearing Volkswagen car badges in their music videos (ibid.). Newspaper articles from 1987, when songs by the Beastie Boys were high in the charts and the band toured the UK, suggest that badges were very easy to remove and that thefts were rife in both the US and the UK at that time. Reports suggest that Volkswagen dealerships gave out hundreds of free replacements each day to replace stolen badges (Bromley, 2012).[19]

The Car Theft Index and the arrival of electronic immobilisers

As a result of these rising vehicle crime levels, and given the growing influence of situational crime prevention in general, there was increased pressure applied by the Home Office for vehicle manufacturers to further boost security levels. This culminated in the publication of the first Car Theft Index in 1992 (Houghton, 1992). It graded types of cars by their theft rates with the aim of informing consumers about the vehicles most targeted and hence encouraging manufacturers to beef up security. Several types of security were promoted, including alarms, window etching and central locking. But perhaps the most promising was the electronic

[18] If the 'other' category is broken down it becomes clear that 'electrical goods' is an exception. Thefts in which electrical goods were taken increased markedly from 2005/06, though this may simply reflect a widening of the categorisation to include GPS navigation devices. See the Technical Appendix for more on this.

[19] See https://news.google.com/newspapers?nid=2202&dat=19870730&id=SOYIAAAAIBAJ&sjid=jfwFAAAAIBAJ&pg=1410,3141621&hl=en

immobiliser, which aimed to prevent thieves 'hot-wiring' vehicles once entry was gained. Electronic immobilisers were devices fitted to vehicles to prevent the starting of the engine without the correct key.

They seemed to have started appearing on special high-end models of car in the UK, the US and Australia during the late 1980s and early 1990s. Brown (2013) speaks of certain 'anti-theft devices' that resembled electronic immobilisers appearing on a few top-of-the-range cars in the US from around 1987. Geason and Wilson (1990) say that "an electronically-operated deadlock system" was fitted on the top-line Commodore (Australia's top-selling brand of car in the early 1980s) in 1989 and also mention special security concept cars from the UK. Research suggested that these new cars with electronic immobilisers had markedly lower theft rates (Geason and Wilson, 1990; Hazelbaker, 1997).[20]

Even so, spread of the devices seems to have been quite gradual initially. Modelling by Farrell *et al*. (2014) using the CSEW suggests that electronic immobilisers were a negligible presence before 1993 in England and Wales, relative to total cars on the road. In interviews with UK car thieves carried out in 1992, the devices were not mentioned once and though there was some evidence of older vehicles being easier to steal than newer ones, car security in general was largely regarded as risible – probably because at that point there were still so many relatively unprotected vehicles on the road (Light *et al*., 1993).

The spread of electronic immobilisers was given fresh impetus in 1995 by European Union Directive 74/61/EEC, which made installation of electronic immobilisers on all new passenger cars sold in the EU mandatory from October 1998 (Farrell *et al*., 2014). The result was that many more manufacturers began fitting electronic immobilisers on new models in anticipation of the law change. A survey of anti-theft measures by the Society of Motor Manufacturers and Traders (Dixon, 1996) found that electronic immobilisers were standard equipment on 95 per cent of new UK manufactured models and 74 per cent of imported models in 1996. The survey examined 879 models accounting for over 80 per cent of new registrations. Brown and Thomas (2003) suggest this may over-estimate the speed of the spread of electronic immobilisers slightly. They say that although by 1994 immobilisers were widely fitted to most new mid- to top-of-the-range cars, (medium/large/luxury saloons, sports cars, 4x4s and people carriers), minis/superminis and small saloons were not widely fitted with electronic immobilisers until around 1997. These types of car made up just over 60 per cent of the vehicle fleet according to 1996 Car Theft Index data.

Despite these difficulties in determining the exact speed of spread, when the law came into effect in 1998, it can be taken for granted that virtually all *new* vehicles in England and Wales (and indeed throughout Europe) had electronic immobilisers. But it would take some time for the majority of *total* vehicles on the road to be protected. Data from the Crime Survey suggest that about 45 per cent of vehicles remained without electronic immobilisers by 2001/02, though overall vehicle security had clearly improved through the 1990s, see Table 2. By the late 1990s, crime had begun to fall. Police recorded thefts from vehicles declined from 1992 and thefts of vehicles started falling from 1993. Total crime, as measured by the CSEW dropped from 1995. This sets up the possibility that the second-wave security devices (those in Table 2) were wholly or partly responsible for the crime turn-around.

[20] Bässman (2011) notes that the exact date at which electronic immobilisers first appeared is further complicated by the fact that descriptions of 'electrical systems' are very similar to electrical immobilisers yet were "much easier to overcome" (ibid.).

Evidence relating to the effectiveness of specific security devices

As Farrell *et al*. (2011) have noted, the different types of security in Table 2 aim to prevent different types of vehicle crime. Farrell *et al*. (2011) rated security devices on their own and in combination with other devices. The metric they developed was the 'security protection factor' (SPF), which compared theft rates of vehicles with different combinations of security against theft rates for vehicles with no security, using CSEW data from 2001 to 2007. An SPF of 3, for example, would imply that the vehicle with that level of security had a theft rate three times lower than a vehicle with no security. This was done for both theft of and theft from vehicles. Though their results have some important caveats[21], the authors generally found that the more devices a vehicle had the better it was protected with the most effective combinations of security having theft rates up to 25 times lower than vehicles with no security. In addition though, they also found that, with the exception of car alarms, most devices offered better protection against theft of the vehicle than against theft from the vehicle. The best combinations of security resulted in 'theft from vehicle' rates that were around six and half times better than no security, rather than 25 times lower for 'theft of vehicles'. In other words, theft from vehicles was found to be harder to prevent than theft of vehicles. As Southall and Ekblom (1985) point out in their paper aimed at designing perfect vehicle security, this is likely to be because vehicle immobilisation has a single aim: preventing the thief from starting the car without the keys. Entry to the vehicle, which is all that is needed for theft from vehicle, can be achieved through the doors, the windows, the boot or the bonnet, requiring multiple types of effective security (ibid.) Thefts of external items do not even require entry to the vehicle, making them even harder to prevent.

For that reason it is important to examine the effectiveness and spread of vehicle devices in relation to the thefts in which they aimed to prevent.

Thefts of external parts: Security measures aimed at reducing these thefts include alarms and target hardening of external parts. Available evidence suggests car alarms first started appearing in the mid 1980s but spread only very gradually, such that around half the vehicle fleet remained without them in 1999 (Table 2). In their CSEW analysis, Farrell *et al*. (2011) found that, on their own, alarms had only a very marginal effect on reducing theft of vehicle rates (SPF = 1.2) but were slightly more effective against thefts from vehicles (SPF = 1.5).

There is also some evidence that target hardening of external parts occurred – for example the use of locking wheel nuts may have reduced thefts of wheels (Sallybanks and Thomas, 2000) and Volkswagen did redesign their badges to try and reduce thefts – but current news articles suggest that a motivated thief can still steal a very large number of car badges in a short space of time[22], which perhaps suggests that the downward trend in external parts thefts was more to do with changing fashions and the end of the craze for wearing badges.

[21] The Farrell *et al*. (2011) results have some limitations, most of which are acknowledged by the authors. There are several factors unaccounted for that might confound the results, notably the age of the vehicle and the location and behaviour of the owner (presumably people who buy more secure cars are also more security conscious in other ways and may live in less crime-prone areas). In addition, the results cannot necessarily be taken to be nationally representative as the CSEW weighting system was not used and the question used to generate the denominator for the calculation (i.e. security on the *total* population of vehicles) refers only to households' main vehicle rather than all vehicles – see the Technical Appendix for more on this. Finally as van Ours and Vollaard (2014) note, victim surveys may not measure vehicle security particularly well as many people are not clear about what an electronic immobiliser actually is. In that light, it is important to note the difference between CSEW predictions of electronic immobiliser spread and those generated by modelling from the CTI data (Figure 12). If vehicle owners were systematically under-reporting the presence of electronic immobilisers on the CSEW through the 2000s, as Figure 12 suggests, this would affect the SPF calculations.

[22] See for example: http://www.mirror.co.uk/news/uk-news/coventry-car-badge-thief-woman-2917847 and http://www.manchestereveningnews.co.uk/news/local-news/boys-are-arrested-stealing-car-badges-930021

Thefts from inside the vehicles

For thefts of items from inside the car, alarms, audio security and central locking may all have been relevant. Table 2 suggests that audio security was present on about three-quarters of all vehicles by 1999, but limited data are available before that. As such, it is hard to determine whether improved security was the main factor in the decline of stereo thefts throughout the 1990s and 2000s. Evidence on their effectiveness is somewhat mixed. Braga and Clarke (1994) report statistical data from Germany and Australia suggesting that security-coded radios have reduced theft and Kock *et al*. (1996) report that thieves avoided these radios. On the other hand, there are some reports that thieves defeated coding with little difficulty (Sutton, 1998).

More data are available on central locking, which was first seen in vehicles in the mid 1980s and was present on about half of all vehicles in 1995. Though no studies could be located that test the effect of central locking using experimental or quasi-experimental methods, the results from Farrell *et al*. (2011) suggest that on its own central locking halves the rates of thefts from vehicles (SPF = 2.0). This suggests that the spread of central locking might have played an important role in reducing thefts from inside the vehicle. Yet evidence demonstrates that the number of vehicles with central locking must have been increasing through both the sharp (52%) rise in thefts from vehicles from 1989 to 1992 (which Figure 7 shows was mainly an increase in items stolen from *inside* the vehicle) and during the fall thereafter. Therefore, if central locking was the deciding factor, a sharp 'tipping point' must have occurred.[23] Though this is certainly a possibility, a survey of offenders carried out in 1992, on the eve of the crime turning point, suggested that alarms were more of a deterrent than locking at that time (Light *et al*., 1993).[24] In fact the report concluded that: "Vehicle security is seen as lamentably weak, offenders having little or no trouble in overcoming door and ignition locks." This does not suggest that the growing penetration of cars with central locking was about to reverse the trend in vehicle theft. And though alarms may have been a greater deterrent, their spread was even more gradual than central locking, according to Table 2.

Overall then, the current evidence suggests that better security almost certainly put some downward pressure on trends in thefts from vehicles and that this would have been likely to accelerate as more vehicles became protected by devices like central locking and car alarms. However, the fact that certain types of thefts are much harder to prevent with these devices (notably thefts of car badges) and that generally their spread through the vehicle fleet was gradual, it seems likely that other factors were also involved in the very sharp crime turning point.

Thefts of vehicles

Arguably, all the devices in Table 2 might have had a crime-reduction effect on theft of vehicles. Of those devices, however, only mechanical and electronic immobilisers might be expected to *only* have an effect on theft of vehicles as they prevent the vehicle being driven away and do

[23] It might be argued that there is no need for a 'tipping point' argument in relation to 'theft from vehicles' because of the introduction of electronic immobilisers in 1992, which conferred very large security benefits when employed in conjunction with central locking. There are two points to bear in mind with this argument. The first is that electronic immobilisers were present on very few cars at the crime turning point in 1993 and though most of the vehicles with electronic immobilisers would also have central locking, there would still have been a large pool of vehicles with central locking only and an even larger pool without either. In the 1991 CSEW, 40 per cent of households' main vehicles had no central locking, alarm, or mechanical/electronic immobiliser. Secondly, Farrell *et al*., (2011) found that – as expected – adding an electronic immobiliser to a vehicle with central locking conferred relatively little additional benefit in relation to theft *from* vehicles.

[24] Specifically, 34 per cent of the offenders in the Light *et al*. (1993) sample said that they would be deterred from vehicle theft by the presence of any alarm; a further 27 per cent said it would depend on the make and/or model. However, many of those who said they would be put off by a car with an alarm added that they would simply move on to another vehicle rather than giving up on the theft entirely.

not offer any deterrent against entering the vehicle or external-part theft. Only partial data are available on the introduction and spread of mechanical immobilisers, which were consumer-purchased products fitted usually to the steering wheel and aimed to prevent the vehicle being driven away. Manufacturers of these items first appeared in the mid 1980s[25] and the CSEW suggests that around one in four households owned one by 1991. The survey did not explicitly separate electronic and mechanical immobilisers until1999, but given that electronic immobilisers would have been rare until 1992 it seems likely that most of the 23 per cent of households in 1991, who said they had an immobiliser (Table 2), had a mechanical immobiliser or 'crook lock', as they were better known. During the 1990s penetration of mechanical immobilisers reached around 40 per cent and then stalled. In all likelihood this was because more effective electronic immobilisers were beginning to be installed in a larger and larger number of vehicles. Testing by experts found that many mechanical immobilisers could be overcome quite quickly.[26] But Farrell *et al*. (2011) found that a mechanical immobiliser on its own had an SPF of 2.8 for theft of vehicles compared with an SPF of 4.0 for electronic immobilisers, suggesting that many thieves operating in the 1990s were not particularly expert. In combination with central locking the SPF for mechanical immobilisers increased to 5.4 (compared with 11.8 for electronic immobilisers, though as with other devices, the SPF figures were far lower for theft *from* vehicle).

Like car alarms and central locking then, the spread of mechanical immobilisers began during the late 1980s. In the absence of other factors, it is not clear therefore why thefts would have increased so markedly during the early 1990s when numbers of cars on the road with the devices would have been rising from a negligible to a noticeable level. The only device which was *first* introduced to the mass-market in line with the crime turn-around was the electronic immobiliser. And as the SPF results show, it is also the device with the most evidence of effectiveness. In fact, the effectiveness of electronic immobilisers has also been tested in a number of other ways including via more robust, quasi-experimental methods and in all cases it has been found to reduce 'theft of vehicle' rates significantly (see Brown, 2013 for a review). As such, the next two sections focus on the evidence relating to electric immobilisers. The next chapter attempts to model their spread through the vehicle fleet in England and Wales and Chapter 4 looks in more detail at trends in vehicle theft and methods of theft.

Conclusion

The existing evidence on vehicle security and vehicle theft demonstrates that both were minor concerns generally through the first half of the 20th century. Rising crime of the 1960s changed this and governments mandated the installation of steering column locks. This had an immediate impact in the Federal Republic of Germany where the devices were mandated on *all* vehicles simultaneously, and possibly a more muted and delayed impact in England and Wales, and the US, where they were only mandated on new vehicles, meaning that they took much longer to spread through the vehicle fleet.

Despite having some success, steering column locks failed to halt the overall rise in vehicle crime which continued through the 1980s and accelerated in the early 1990s in England and Wales. During this period there is some evidence that a greater proportion of thefts were profit motivated and fewer were motivated by joy-riding. Thefts *from* vehicles surged particularly high. This was probably driven by a trend for stealing external parts like vehicle badges and increasing thefts of vehicle stereos up to 1991.

[25] See for example: https://en.wikipedia.org/wiki/The_Club_(automotive)
[26] See: http://news.bbc.co.uk/1/hi/uk/732669.stm

Rising crime of the 1980s prompted a ‘second wave’ of security devices including car alarms, mechanical immobilisers and central locking. There is some evidence of success for these devices although the rapid acceleration in crime in the early 1990s probably occurred after they had started spreading through the vehicle fleet.

There is far stronger evidence for the success of electronic immobilisers which would have begun appearing more or less in line with the point in 1992/93 when vehicle crime of all kinds began to fall sharply. Like other ‘second-wave’ devices, electronic immobilisers were introduced on new vehicles only – a process that was mandated across the European Union in 1998. The legislation speeded up the spread of electronic immobilisers relative to other second-wave security devices (which spread very gradually) but even so, it probably took a number of years before most vehicles were protected.

This review of existing evidence has a number of evidential gaps. More evidence is required on the methods and types of theft that drove the early 1990s’ rise in vehicle crime given that most measures suggest security was improving at that time. Were car alarms and central locking only successful in conjunction with electronic immobilisers or was their initial effectiveness overwhelmed by other upward pressures? The evidence is clear that electronic immobilisers were effective during the crime decline, but it is not clear on exactly *when* they would have affected national-level crime trends and how big that effect might have been. The rest of this report aims to examine these questions and draw out policy conclusions.

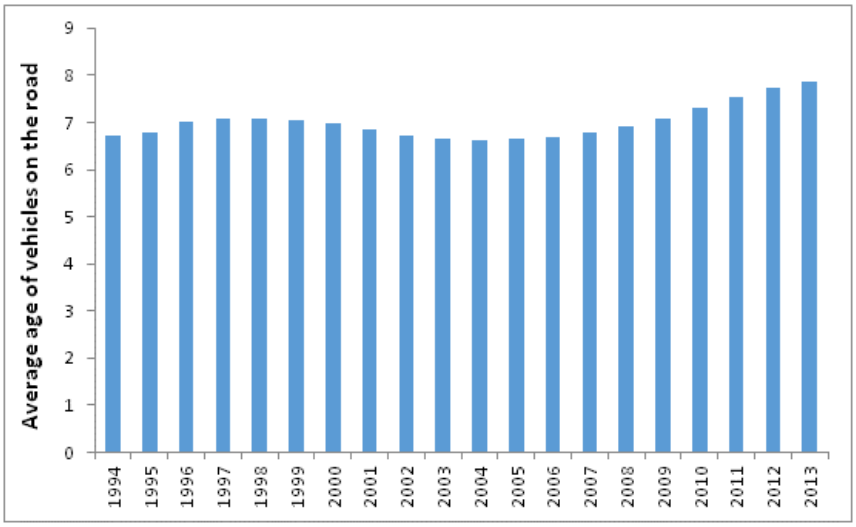
3: Modelling the spread of electronic immobilisers and the timing of their likely impact on vehicle thefts

This chapter examines the spread of electronic immobilisers in more detail. Though much of the research is not of the highest quality (few studies have control groups for example), the evidence that electronic immobilisers are effective is consistent – see Brown (2013) for a review. Most studies find that the devices have a large crime-reducing effect on theft rates, relative to vehicles without electronic immobilisers. This suggests that transforming the vehicle fleet from one without electronic immobilisers to one in which all vehicles have the devices would be likely to markedly reduce numbers of thefts. But the *timing* of that impact has been less well explored. Given that electronic immobilisers were not introduced on all vehicles at the same time, it is hard to know exactly when thefts would have begun falling. Would the impact begin when they were first introduced on new vehicles? Or would it only become visible later, when a sufficient portion of the fleet became protected and displacement to older, unprotected vehicles was more difficult? Answering this question is the main aim of this section.

There are at least three reasons why the main impact of electronic immobilisers might be delayed.

- The vehicle fleet is mostly comprised of older vehicles: New vehicles make up a minority of vehicles on the road. Office for National Statistics data consistently show that for the period 1994–2013 only about eight per cent of cars on the road in Great Britain (England, Wales and Scotland) were less than a year old, and the average vehicle was around seven years old, see Figure 8. So because electronic immobilisers were first introduced on new vehicles only, their spread through the fleet would have been gradual. Laycock (2004) estimated that it would take around a decade for the majority of vehicles on the road to be protected.

Figure 8: Average age of vehicles on the road, Great Britain



Source: Office for National Statistics.

- Thieves prefer to steal older vehicles: Studies show that, both before and after the introduction of electronic immobilisers, theft rates were higher for older vehicles, even taking into account their greater numbers on the road. In the 1992 Car Theft Index, the highest rate of theft occurred in vehicles registered in 1985 (Houghton, 1992). Sallybanks and Brown (1999) list five reasons: improved security on recent models; older vehicles having higher demand for used parts; knowledge of how to steal older vehicles being more widely disseminated among car thieves; older vehicles being more common in areas in which car thieves operate; and older vehicles being more susceptible to insurance fraud.

- Displacement: If the introduction of electronic immobilisers on new vehicles caused thieves to switch (to an even greater degree) to older vehicles, then the initial benefits of the devices could be all or partially offset. Evidence of such displacement has been identified by Brown and Thomas (2003) and van Ours and Vollaard (2014), and the issue is explored further below. The offsetting effect of displacement might be large at first, given the considerable pool of vehicles without electronic immobilisers, but could be expected to reduce over time as that pool shrank.

For these reasons, most researchers agree that it would probably have taken a number of years from the point at which electronic immobilisers were first fitted on new vehicles until they had a material impact on vehicle theft trends. For example, Houghton (1992) notes that:

"*.... improvements in car security introduced into new vehicles by manufacturers will take many years to impact upon the overall level of car crime – even if they are effective and all manufacturers adopt them*."

Cherbonneau and Copes (2006) say:

"*The overall benefits of the recent legislation mandating electronic immobilizers to newer cars manufactured after 1997 may only exist after a sufficiently large proportion of cars are protected by immobilizers; meanwhile target displacement to unprotected vehicles is likely to occur*."[27]

The model

To try and model the exact timing of impact, three main data sources were used.

Car Theft Index (CTI) data: The CTI was first produced in 1992 and then ran annually from 1997 to 2006, after which it was discontinued. The series was based on car theft data from the Police National Computer and on information provided by the Driver and Vehicle Licensing Agency which was used to calculate numbers of cars on the road. By combining those two sources of information, the Index provided the most stolen types of cars in Great Britain relative to their presence in the vehicle fleet. The 1992 Index employed a different methodology from the subsequent publications, each of which contained data from the previous year. For example, the Index titled '2006 Car Theft Index' used data on thefts and cars on the road from 2005. So in terms of data, there is a consistent series available from 1996 to 2005. It relates to cars only, however; motorbikes and commercial vehicles are excluded.

Office for National Statistics (ONS) vehicle data: ONS produce a series for total vehicles on the road in Great Britain and a series for total *cars* in Great Britain broken down by age of the car.

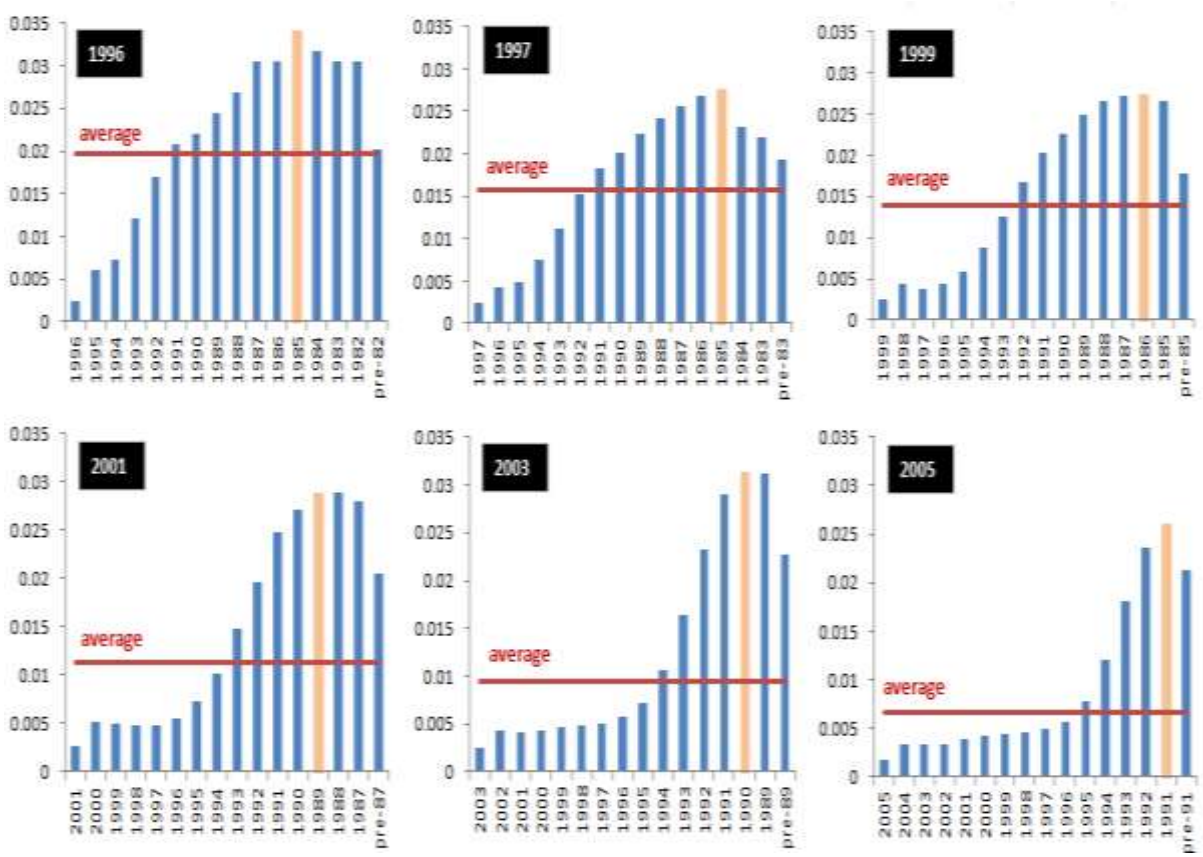
Police recorded crime data for vehicle thefts: Total motor vehicle thefts data were sourced from

[27] Sallybanks and Brown (1999) gave a label – "the reduced pool theory" – to the hypothesis that the impact of electronic immobilisers on vehicle theft would be likely to grow as the pool of unprotected vehicles became smaller.

ONS for England and Wales and from the Scottish Government for Scotland.

The first task was to try and estimate the proportion of *new* vehicles that would have had electronic immobilisers, annually. To help with this, the total number of thefts recorded in each year of the CTI was broken down by age of the stolen vehicle. This is shown for a series of years in Figure 9.

Figure 9: Thefts rates of cars stolen between 1996 and 2005, by year in which the car was manufactured



Source: Car Theft Index.

Methodological notes: The y-axis shows thefts rate computed by dividing the number of car thefts by the number of cars on the road, according to the Car Theft Index. This is done by year of registration (x-axis). So the highest bar on the first chart represents the number of thefts, in 1996, of cars made in 1985 divided by the total number of cars on the road in 1996 that were made in 1985. The average lines on these graphs are simply the total number of thefts for each year divided by the total number of cars on the road in that year, according to the Car Theft Index data. The mode year in each case is highlighted orange.

The first chart, for thefts in 1996, demonstrates thieves' preference for older vehicles, regardless of immobilisers. Cars registered in 1985 have the highest theft rates that year, even though cars made later, in 1988 for example, would not have had electronic immobilisers either. In part, this may demonstrate the initial effectiveness of devices like central locking, car alarms and mechanical immobilisers, which would have started appearing on vehicles from around 1985 onwards. Moving forwards a year, the 1997 chart shows a very similar distribution of thefts, but the rates have decreased regardless of the age of the vehicle. Between 1996 and 1997, the Car Theft Index data show that theft rates on cars made in the 1990s (so ones that may have had electronic immobilisers) fell by about 17 per cent, while rates of cars made in the 1980s or before (which would have been very unlikely to have electronic immobilisers) fell an almost identical 16 per cent.[28]

[28] The data from which these figures are computed are shown in section 2 of the Technical Appendix. Kriven and Ziersch (2007) find similar results during the early years of the crime drop in Australia (2000–2004) with shifts in the age distribution of thefts suggesting electronic immobilisers were effective alongside large drops in thefts for vehicles of all ages. Brown (2013)

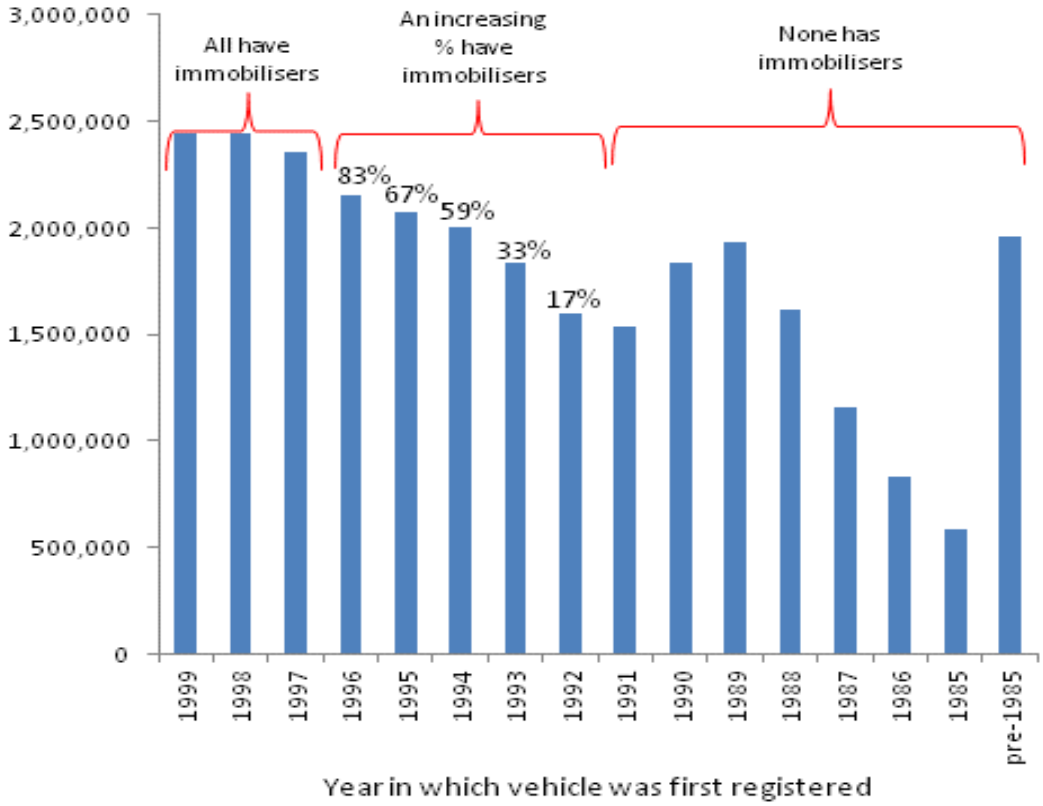
Thereafter though, the distribution of thefts changes considerably. Theft rates stay low on vehicles made in 'post-immobiliser' years (manifested by a lengthening left-hand tail of the distribution) but rise on older models made in 'pre-immobiliser' years, probably as a result of partial displacement. Cars registered in 1990, for example, were stolen at a rate of about 0.02 in 1997 and at more than 0.03 in 2003 despite an overall decline in theft rates between those dates. Whilst this clearly suggests the effectiveness of security introduced on cars made after 1992, it also suggests that there was still a large pool of cars made in 1990 that were more easily targeted. In other words, the earlier security devices – like car alarms, central locking and mechanical immobilisers – were either not as effective as electronic immobilisers or they were not installed in enough vehicles in the early 1990s to deter thieves.

By 2005, all cars up to ten years old have below-average rates of theft, a clear sign that something has changed thieves' behaviour, given that ten-year-old cars were among the most popular at the beginning of the series. Taking the charts collectively, the transition to lower theft rates seems to occur in cars made between 1992 and 1996, with all cars made after that year having low theft rates in all charts and cars made before 1992 having low theft rates to begin with but high rates by the end of the series. This transition period is largely consistent with the qualitative evidence relating to the spread of electronic immobilisers, which probably first appeared on the mass market around 1992 and were installed on the vast majority of new vehicles by 1997 (Dixon, 1996; Brown and Thomas, 2003). In other words, whether or not electronic immobilisers would have achieved this reduction of theft rates on their own or were helped by the combination of additional security devices like car alarms and central locking, the evidence suggests that it was only once electronic immobilisers first appeared in mass-produced vehicles that the long-term pattern of vehicle theft really changed. Other security devices would have been present on cars made between 1986 and 1991, but thieves still found ways to steal these in large numbers eventually. For cars made after 1992, however, and certainly for those made after 1996, theft rates *remained* low showing that thieves were more permanently deterred.

For the purpose of modelling impact, it was therefore assumed that the numbers of vehicles on the road with electronic immobilisers was negligible before 1992, but that it increased linearly from that year until 1996 and that by 1997 all new vehicles were equipped with the devices, a year earlier than the law enforced this. Under these assumptions, it is possible to split the figures for total cars on the road between those with electronic immobilisers and those without, for each year. The method for this is shown graphically in Figure 10 for a sample year (2000) with the full results in Table 3.

concluded from these results that: "The significant reduction in vehicle thefts observed in Australia was owing to factors other than just the introduction of electronic immobilisers."

Figure 10: Vehicles on the road in 2000, broken down by year to show how trends in vehicles with electronic immobilisers were constructed



Source: ONS vehicle statistics.

Note: The percentages shown are the percentage of vehicles registered in those years that are assumed to have electronic immobilisers. So the size of the blue bar indicates the number of vehicles registered in each year (which clearly does not increases in a linear fashion) whereas the percentages indicate the proportion of new vehicles for that year that are assumed to have electronic immobilisers, and these percentages do increase linearly. i.e. the 1991 value is 0 per cent and the 1997 value is 100 per cent.

Table 3: Vehicles on the road in Great Britain broken down by the estimated percentage with and without electronic immobilisers

Year	Total vehicles on the road (ONS)	Estimated number of vehicles with electronic immobilisers	%	Estimated number without electronic immobilisers	%
1991	24,511,000	-	0%	24,511,000	100%
1992	24,577,000	653,999	3%	23,923,001	97%
1993	24,826,000	1,321,250	5%	23,504,750	95%
1994	25,231,000	2,014,207	8%	23,216,793	92%
1995	25,369,000	3,400,416	13%	21,968,584	87%
1996	26,301,921	5,219,513	20%	21,082,408	80%
1997	26,973,790	7,552,522	28%	19,421,268	72%
1998	27,538,412	10,009,459	36%	17,528,953	64%
1999	28,367,560	12,588,515	44%	15,779,045	56%
2000	28,897,581	15,145,392	52%	13,752,189	48%
2001	29,747,130	17,925,963	60%	11,821,167	40%
2002	30,556,673	20,739,325	68%	9,817,348	32%
2003	31,207,359	23,293,103	75%	7,914,256	25%
2004	32,258,856	25,943,061	80%	6,315,795	20%
2005	32,897,383	28,025,893	85%	4,871,490	15%
2006	33,070,484	29,461,370	89%	3,609,114	11%
2007	33,650,981	30,921,740	92%	2,729,241	8%
2008	33,883,382	31,849,531	94%	2,033,851	6%
2009	33,958,429	32,426,713	95%	1,531,716	5%
2010	34,120,148	32,934,665	97%	1,185,483	3%
2011	34,228,594	33,290,013	97%	938,581	3%
2012	34,522,322	33,750,973	98%	771,349	2%
2013	35,034,487	34,383,277	98%	651,210	2%

Source: ONS, Car Theft Index.

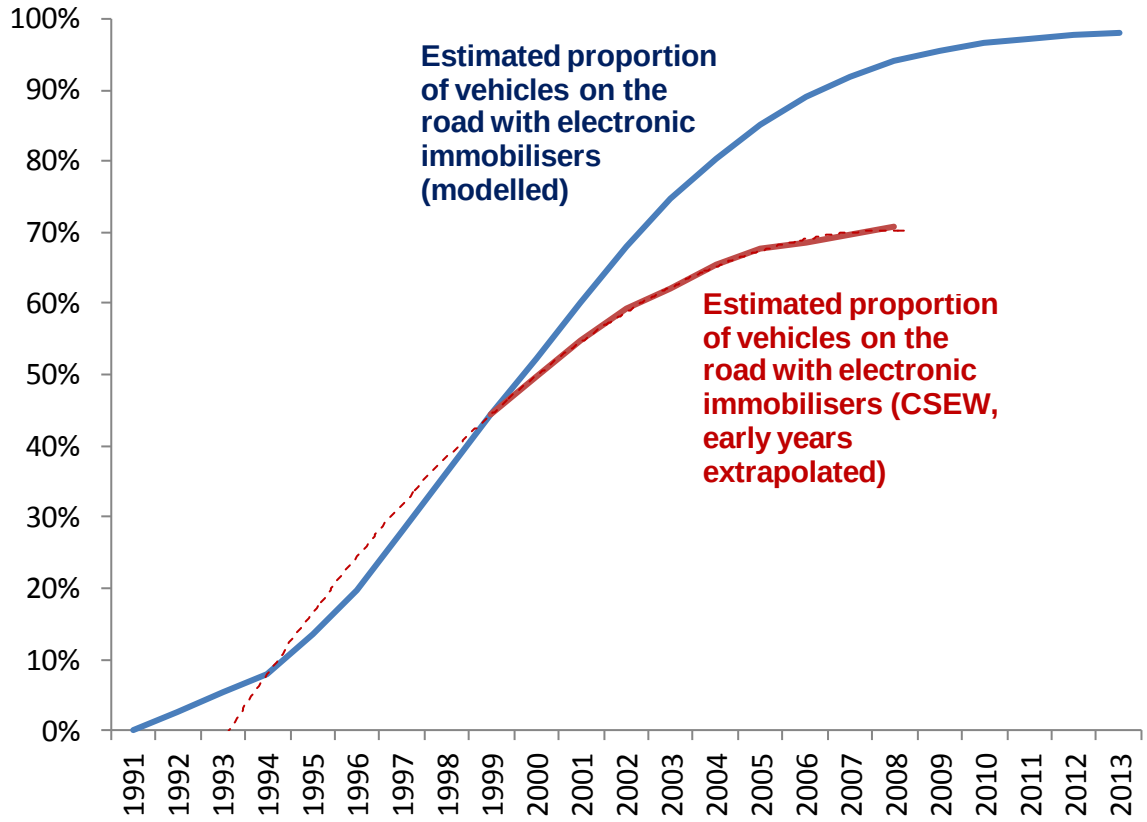
This method does not take into account the possibility that older cars may have been retrofitted with electronic immobilisers once their effectiveness became clear. If this was done to any significant degree the results could change. However, no data could be located to estimate retrofits and van Ours and Vollaard (2014) examined retrofitting in the Netherlands and concluded that its rate of application was almost certainly "low".[29] Furthermore, the modelled estimates are comparable with the series from the CSEW, which asked respondents from the 1999 survey onwards whether their main vehicle had an electronic immobiliser. Following Farrell *et al*., (2014) this trend has been extrapolated back using a polynomial trend-line[30] and is shown alongside the modelled estimates from the Car Theft Index in Figure 11. Though there are differences, particularly in the more recent period, generally the two methods tell a similar story for the initial spread of electronic immobilisers. Both suggest that up to around 1995 probably fewer than ten per cent of vehicles had electronic immobilisers, and that it took until around 2000 for more than half of vehicles to be protected.[31]

[29] Also, Potter and Thomas (2001), looking at data from Western Australia, showed that retrofitting an immobiliser to a much older car achieved less marked reductions in theft rates than immobilisers on newer cars. They speculated that older vehicles may have other weak spots.

[30] The CSEW question asks about security on respondents' *main* vehicle so it is possible that these estimates may under- or over-estimate the spread of electronic immobilisers slightly depending on whether second or third cars are more or less likely to be new than the primary household vehicle.

[31] The divergence between the two series from 2000 onwards may be related to the fact that, as van Ours and Vollaard (2014) point out, some of the general public may be unaware of the presence of an electronic immobiliser on their own vehicle. This may be why fewer vehicles appear to have electronic immobilisers on the CSEW than via the modelling method.

Figure 11: Estimated trends showing percentage of vehicles on the road with electronic immobilisers



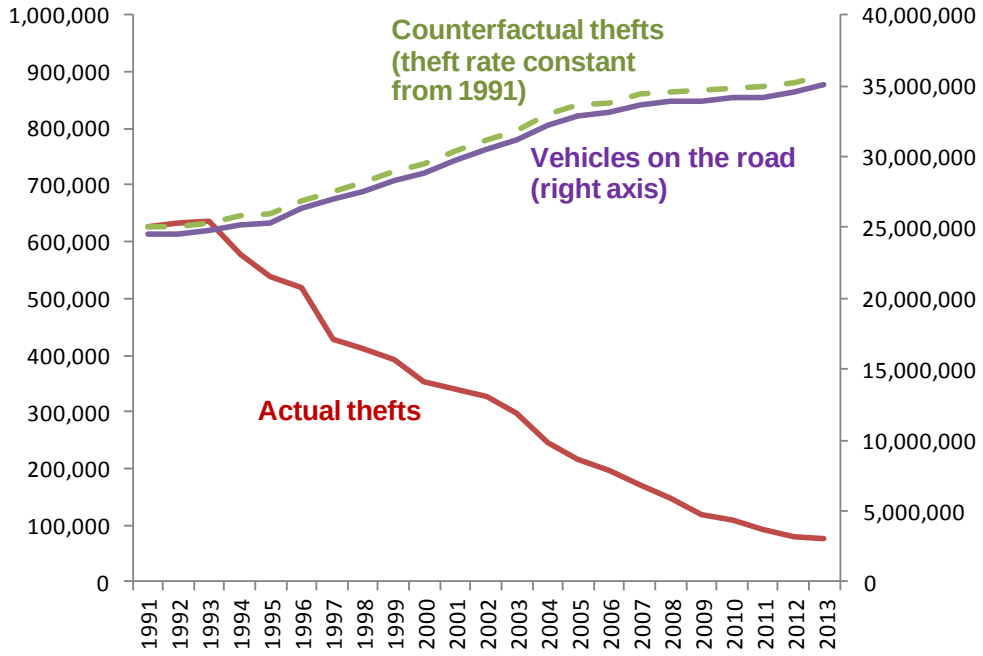
Sources: Car Theft Index; CSEW; Farrell *et al.*, 2014.

The next aim of the modelling was to understand how this gradual spread of electronic immobilisers would influence the timing of the impact on theft trends. To do this, the number of vehicles on the road was used as a baseline. It was assumed that – in the absence of changes to security levels and other factors – the number of vehicle thefts would track the number of vehicles on the road. As Figure 5 showed, this was more or less true through the 1970s and 1980s. As the number of cars increased, the number of thefts rose by about the same proportion.

So, to model the *counterfactual,* the estimated theft trend in the absence of electronic immobilisers, it was assumed that the *rate* of theft (per vehicle on the road) would have remained constant. In 1991 there were 626,181 vehicle thefts in Great Britain[32] and 245,110,000 vehicles on the road (ONS) giving a theft rate per vehicle of 0.026; or 26 per 1,000 vehicles. Our predicted counterfactual trend assumes this rate stays constant as the number of cars on the road increases. This is shown in Figure 12.

[32] There were 581,901 in England and Wales according to police recorded crime statistics (ONS) and a further 44,280 in Scotland, according to the Scottish Government.

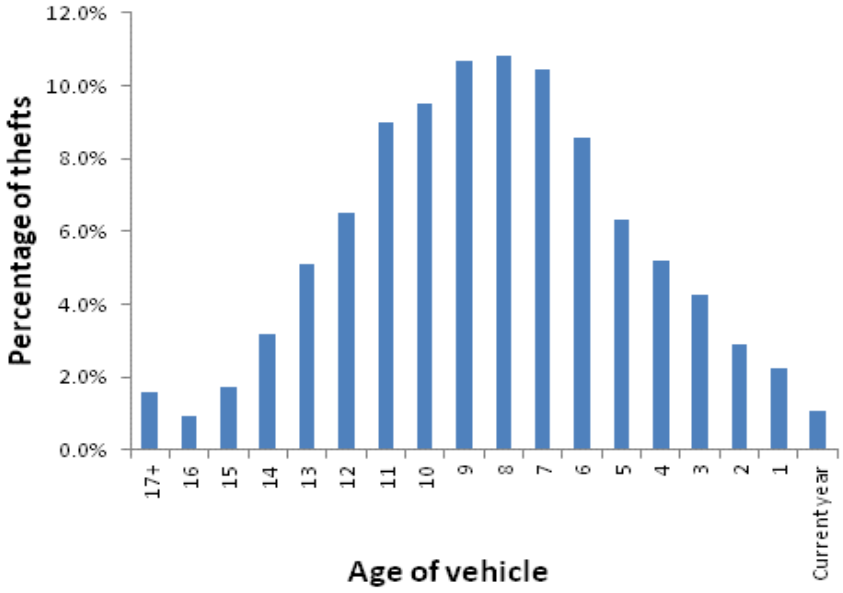
Figure 12: Chart showing total vehicles on the road in Great Britain, numbers of vehicle thefts and hypothetical numbers of thefts had the 1991 theft rate been maintained



Sources: ONS, PRC, Scottish Government.

The effect of electronic immobilisers was modelled by assuming that vehicles without them continued to be stolen at the same rate while vehicles with electronic immobilisers were stolen at a reduced rate. To calculate the rate of theft for vehicles *without* electronic immobilisers the overall theft rate from 1991 was used but this was adjusted for age of vehicle using the earliest year for which the age breakdown of car thefts was available (1996), see Figure 13.[33]

Figure 13: Distribution of car thefts in Great Britain in 1996 by age of vehicle

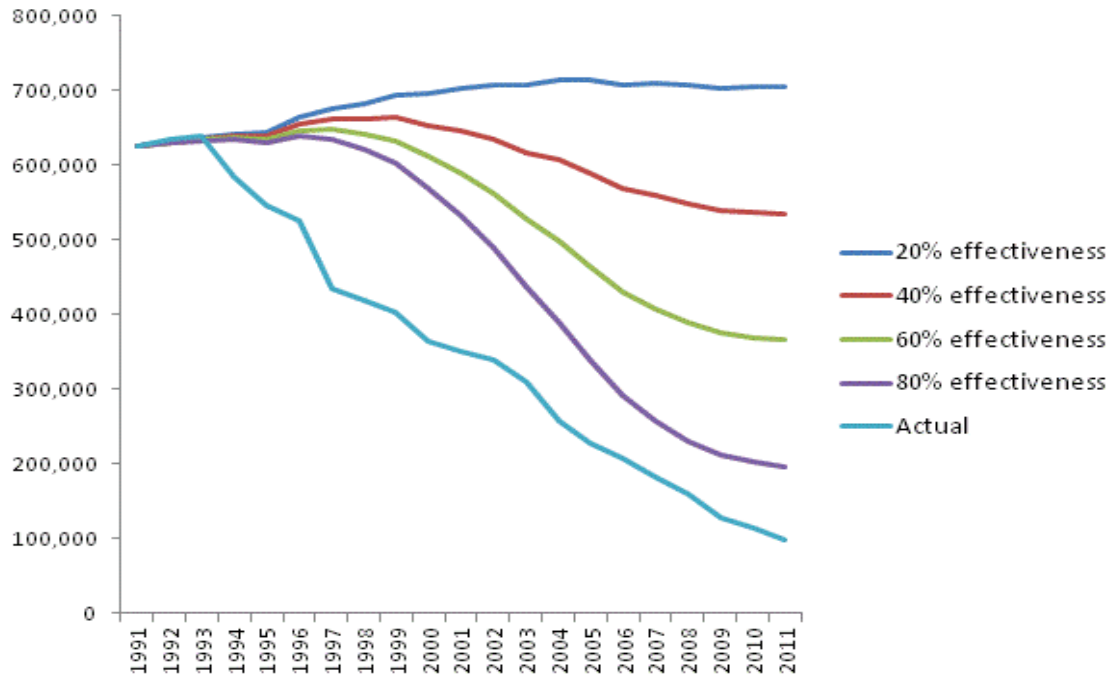


Source: Car Theft Index 1997.

[33] It would have been preferable to use the distribution from the 1992 Car Theft Index, to capture the distribution *before* electronic immobilisers appeared, but unfortunately this used a very different methodology for gathering data on thefts, and hence was not deemed suitable.

The total number of thefts in 1991 was distributed according to the distribution shown in Figure 13, and a rate for each age of vehicle was calculated. In other words, in the absence of electronic immobilisers, it was assumed that vehicles almost a decade old would continue to be stolen at a higher rate than newer vehicles. To model the reduction in rate caused by electronic immobilisers, scenario analysis was used. Rates of theft on vehicles *with* electronic immobilisers were reduced by a fixed proportion (relative to the counterfactual). These proportions were 20 per cent, 40 per cent, 60 per cent and 80 per cent (and are effectively net of displacement – see below), so the aim was to illustrate the resulting trends at different levels of immobiliser effectiveness. The results are shown in Figure 14.[34]

Figure 14: Modelled trends in vehicle thefts at different levels of assumed electronic-immobiliser effectiveness



There are several points to make about Figure 14. Firstly, it is important to recognise that the measure of effectiveness is a 'net effect' that takes account of any hypothetical displacement. So "40 per cent effectiveness" could mean that rates of theft fell 40 per cent in vehicles with electronic immobilisers and rates of theft in older, unprotected cars were unaffected. Or it could mean that theft rates on new cars fell 60 per cent, but that a third of this effect was offset by displacement to older vehicles. Evidence suggests the latter is more likely. Brown and Thomas (2003) offer empirical evidence of displacement to older vehicles in England and Wales and van Ours and Vollaard (2014) actually quantify the effect using data from the Netherlands for 1995 to 2008. They find that on average through the period, theft rates on cars with immobilisers were reduced by 72 per cent but that "*displacement to older, less-protected cars was substantial during the first 10 years after the regulatory change."* They calculated that this displacement offset the theft reduction by more than a third, meaning the net effect was a reduction in the theft rate of 46 per cent for protected cars relative to non-protected cars.

Figure 14 also shows that the bigger the net effect of immobilisers, the larger the reductions in thefts through the period. However, even an 80 per cent net effect does not produce a reduction in thefts as great as the reduction that actually occurred. Furthermore, irrespective of the level of

[34] The actual computations are shown in the Technical Appendix.

effectiveness, the modelled theft trends are much flatter through the early years of the series, when numbers of vehicles with electronic immobilisers were relatively small. Levels of modelled thefts do not decrease by more than five per cent (relative to their level at the beginning of the series) until 1999 in the 80 per cent effectiveness scenario, 2000 in the 60 per cent scenario and 2003 in the 40 per cent scenario. Thereafter, however, thefts fall quickly.

These results suggest that electronic immobilisers may have made an important contribution to the fall in vehicle thefts but that most of the impact would have been felt in the 2000s rather than around the crime turning point. One way to estimate the proportion of thefts prevented by electronic immobilisers is to use the 46 per cent net effectiveness figure generated by van Ours and Vollaard (2014) using data from the Netherlands and apply it to the model. The difference between estimated thefts prevented by electronic immobilisers and the actual reductions in thefts recorded can then be calculated. Using this method, it was estimated that around 43 per cent of the drop in vehicle thefts from 1992 to 2013 was due to electronic immobilisers. This amounts to around four million fewer offences over the 20-year period.

Caution is required. Models are not intended to capture all real-world effects; they are intended to deliver simplified, but helpful conclusions. Levels of effectiveness might have been higher or lower in England and Wales than they were in the Netherlands. And the modelling strips out other factors that might have influenced vehicle thefts. It is possible that electronic immobilisers could have caused larger reductions during the early years of the series if benefits from the small proportion of protected vehicles diffused to the rest of the fleet. For example, if thieves were unable to tell which vehicles were protected, even a small percentage of new cars with electronic immobilisers might act as a significant deterrent. Ayres and Levitt (1997) find effects of this kind when examining another vehicle security device, LoJack, see Appendix 2. But van Ours and Vollaard (2014) tested for this kind of 'diffusion of benefit' in relation to electronic immobilisers in the Netherlands and found no effect.

The modelling also does not take into account other types of vehicle security improvements (or interaction effects between electronic immobilisers and other security devices) or indeed other factors that might drive theft trends more generally, like changes in police activity, sentencing, drug use and so on. Even so, the model findings still suggest that if van Ours and Vollaard's estimate of electronic immobiliser effectiveness is translatable from the Netherlands to England and Wales, then electronic immobilisers probably had a marked crime-reduction effect. But it also suggests that – *on their own* – the devices were probably not the catalyst for the initial turning point in vehicle theft.

Conclusion

This section outlined the methodology and results for modelling the spread of immobilisers and their impact on car theft. The main conclusions are:

- Electronic immobilisers may have first appeared on new vehicles in Great Britain during the late 1980s but they were probably a negligible presence in the fleet as a whole before 1992. In 1993, when recorded vehicle crime peaked, both CSEW and CTI data suggest that only around one in 20 vehicles would have been likely to have an electronic immobiliser and thieves generally stole older vehicles anyway. Thereafter they probably increased gradually such that around half of all vehicles were likely to be protected by 2000.

- Analysis of Car Theft Index data shows that up to 1997 theft rates fell sharply on all cars, regardless of their age and security level. But after that point there is clear evidence of a change in theft patterns driven by improved security. Theft rates on new vehicles fell and *remained low,* while theft rates on much older vehicles increased. The timing of this transition

matches the introduction of electronic immobilisers though the displacement to older vehicles makes it unclear when national-level theft trends would have been most affected.

- Exploratory scenario modelling suggests that a major crime-reduction impact would have been unlikely before a majority of cars were protected by electronic immobilisers in the 2000s, but that after that point, drops in vehicle thefts due to electronic immobilisers might have been substantial, explaining around 43 per cent of the drop in total vehicle thefts through to 2013.

4: Analysis of vehicle theft trends and methods in Great Britain

Aims, data and methods

This chapter presents analysis of vehicle theft data in Great Britain (England and Wales and Scotland) in an attempt to examine some of the evidential gaps noted in Chapter 2. It also seeks to test the modelling from Chapter 3, which tentatively suggested that electronic immobilisers spread quite gradually through the vehicle fleet in Great Britain and may not have had a marked effect on numbers of thefts until around half the fleet was protected in 2000.

Two data sources were used: Police Recorded Crime (PRC) and the Crime Survey for England and Wales (CSEW). The former has data on numbers of thefts nationally and sub-nationally for 42 police force areas in England and Wales[35]. CSEW data are only available at national level but also include information on method and type of theft.[36]

The analysis focused on specific questions relating to the following.

The crime peak: The previous section looked at the crime turning point in relation to trends in electronic-immobiliser spread and suggested that the devices could not have caused the crime turning point without marked and rapid diffusion of benefits. In this section the analysis is extended to police force area level trends.

The shape of the crime decline: Modelling found that the introduction of electronic immobilisers would – in the absence of other factors – have caused a transition from a slowly rising trend in thefts to a slowly falling trend to a steeply falling trend. This is tested using national and sub-national figures.

The method of theft: If electronic immobilisers were effective, methods for stealing vehicles would be likely to change. When this occurred therefore provides a useful test of when the main immobiliser impact occurred.

The correlation and sequencing of falls in different crime types: If the crime-reducing benefits of electronic immobilisers diffused to other crime types via the keystone/debut-crime method, or via some other mechanism, trends in other crimes might be expected to correlate with vehicle theft or to follow it with a slight lag. Reductions in other crime types would not be expected to *precede* falls in vehicle theft, unless other effects were involved. This is tested using PRC data on burglary and theft from vehicles. These crimes were selected for three reasons: i) they are high volume offences – burglary and vehicle crime comprised more than half of all recorded offences at the peak; ii) they have reasonably high reporting rates (burglary rates are around 60

[35] There are currently 44 police forces in England and Wales but data were not available for British Transport Police through the 1980s and City of London was also excluded due to its vastly smaller geographical size.
[36] The sample size for the CSEW has varied and for some years, regional-level analysis is possible though confidence intervals are generally quite large.

to 70 per cent and theft from vehicles 30 to 55 per cent according to the CSEW[37]) and figures are also available on the CSEW so trends can be checked for reporting/recording biases; and iii) if benefits from electronic immobilisers were to diffuse to other crime types, these would seem likely candidates given the evidence that stolen cars are used to commit burglaries and that vehicles are often stolen for their contents rather than for the vehicle itself (Light *et al*., 1993).

Findings – National level

The national-level vehicle theft trends for England and Wales, and for Scotland, are shown in Figures 15 and 16.

Figure 15: Vehicle theft trends in England and Wales

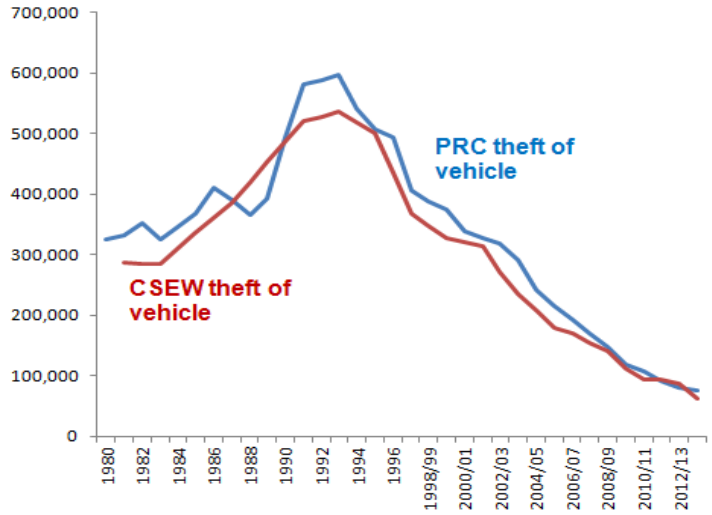
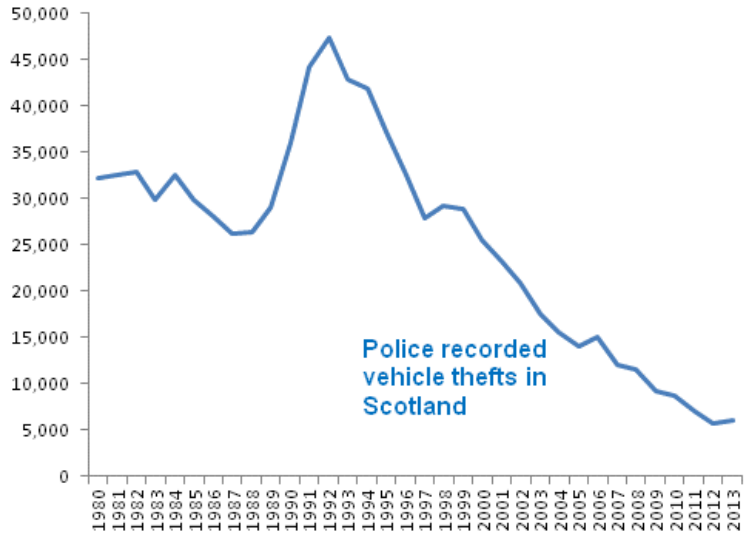


Figure 16: Vehicle theft trend in Scotland



Sources: ONS Crime Survey for England and Wales, ONS police recorded crime, Scottish Government statistics.

Figures 15 and 16 show that vehicle thefts in England and Wales peaked in 1993, and in

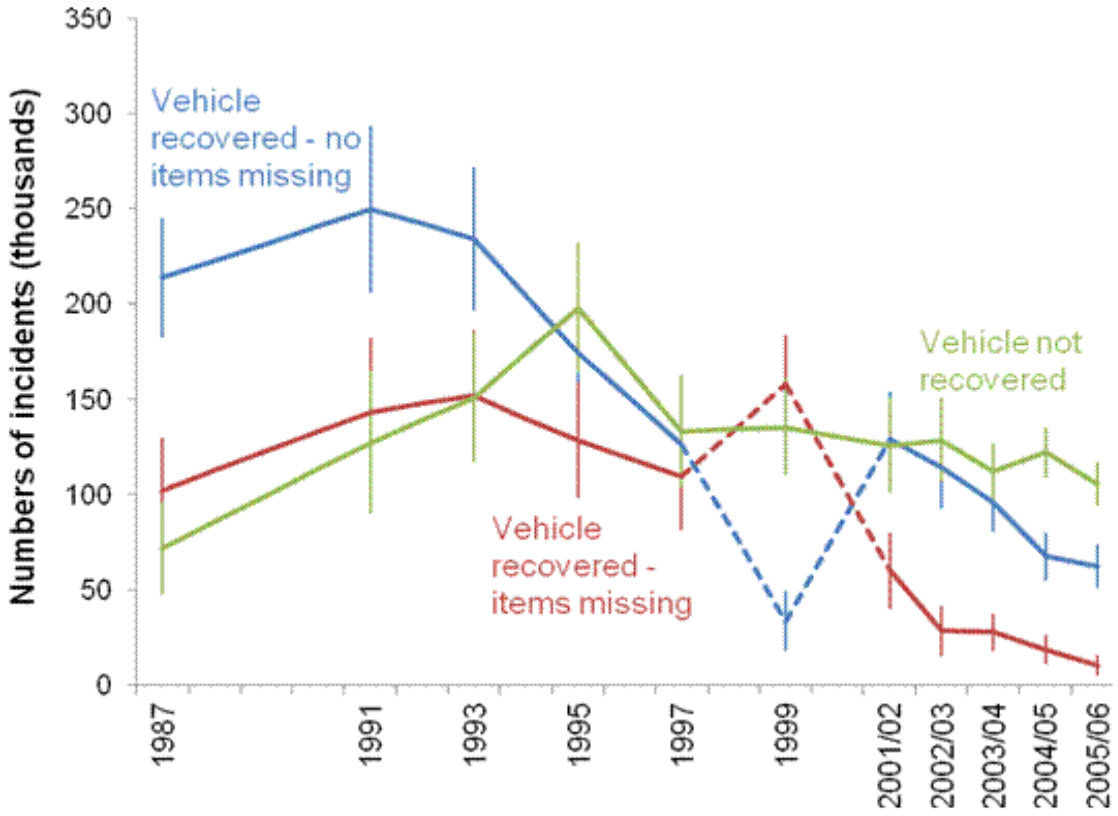
[37] Importantly, reporting rates for theft from vehicles peaked in the early 1990s at around 55 per cent. During the 2000s, rates were stable at between 40 per cent and 50 per cent, but for the last five years they have been between 35 per cent and 40 per cent. This implies that some of the decline in recorded theft from vehicles is due to fewer crimes being reported.

Scotland they peaked in 1992. The modelling in the previous section estimated that about five per cent and three per cent of all vehicles in Great Britain had electronic immobilisers in 1993 and 1992, respectively.

The peak is also relatively sharp in both cases, rather than the gradual transition predicted by the modelling. Though England and Wales had a rising trend in the 1980s and Scotland a falling trend (with some volatility in each case), both experienced a recorded crime rise of around 50 per cent in just two years at the start of the 1990s and a drop of almost exactly the same amount in the four years after that. There was a slight levelling-off period in the England and Wales CSEW series between 1991 and 1995, but after 1995 it also falls quickly.

The sharp early 1990s rise in crime does not correlate well with the gradually improving security for this period outlined in Chapter 2 (fewer vehicles left unlocked, more central locking), so other factors are likely to have been involved. Analysis of CSEW data shows that the rise in theft of vehicles from 1987[38] to 1993 was mainly (over 80%) due to thefts in which the vehicle was either not recovered or was recovered with items (like the stereo) missing, see Figure 17.

Figure 17: Vehicle thefts by recovery status



Note: Inspection of responses in 1999 show that a much higher proportion of victims reported that 'external fittings' were stolen, and were subsequently missing, than in other years. Given the abruptness of the break in trends for just those thefts where the vehicle was recovered (blue and red lines), it is possible that this anomalous year may be caused by slightly altered questioning of victims. Caution is therefore required for interpreting the trends for that year, which is why they have been shown with dotted lines.

Source: ONS, Crime Survey for England and Wales.

[38] From 1987 onwards the survey has asked victims of vehicle theft whether items, other than the vehicle, were recovered. It is not possible to know exactly what items were returned for a lot of incidents, as the victim is only asked whether none, some, or all other items were returned.

If it can be assumed that most recovered vehicle theft in which nothing went missing is joy-riding, then these results suggest that joy-riding was high but stable during the sharp rise in vehicle crime of the early 1990s. It was categories of economically motivated theft that largely drove the increase, which may help determine which other factors were pushing crime up at that time.[39] Increased heroin/crack use, rising unemployment or rising demand for stolen goods from Eastern Europe following the fall in the Berlin Wall may all have been involved (see Appendix 5 for more on these).

One further fact about the peak in crime is worth mentioning. In 1993, theft of vehicles made up 11 per cent of police recorded crime and three per cent of CSEW crime. Total vehicle crime made up 38 per cent and 23 per cent respectively. But they were not the only crimes to fall subsequently. In fact *total* CSEW crime fell 60 per cent, only a slightly smaller decline than the 78 per cent drop in vehicle crime.[40] For improvements in vehicle crime (especially those like electronic immobilisers which deterred thefts of vehicles more than thefts from vehicles) to have driven the overall fall in crime would therefore put quite a weight on the diffusion of benefits hypothesis.

Though both England and Wales, and Scotland, had a sharp four-year fall in vehicle thefts following the peak, trends differed slightly in the late 1990s. Offences in England and Wales continued to fall, while trends in Scotland stabilised from 1997–1999. From 2000, both series fall sharply with each reaching a level about an eighth as high as at the crime peak by 2013.

One implication of these trends is that vehicle thefts fell at a faster rate during the five years immediately after the crime peak than during the five years after that, when a far greater number of vehicles would have been likely to have had electronic immobilisers. This is shown in Table 4.

[39] One caveat to this conclusion is required. It is possible that joy-riding could still have been the primary motive in cases of 'theft of vehicle' in which an item was also stolen from the vehicle.
[40] Total police recorded crime fell too, but the exact figures are complicated by the recording practice changes in 1998 and 2002 that resulted in a considerable number of extra crimes being counted in the figures, mainly minor violence offences.

Table 4: Vehicle thefts in England and Wales and Scotland, annual percentage change and cumulative fall from peak

	England and Wales			Scotland		
	PRC vehicle thefts	% change on previous year	Cumulative fall from peak	PRC vehicle thefts	% change on previous year	Cumulative fall from peak
1990	494,209	25.6%		36,103	24.2%	
1991	581,901	17.7%		44,280	22.6%	
1992	587,856	1.0%		47,433	7.1%	
1993	597,519	1.6%		42,816	-9.7%	-4,617
1994	541,749	-9.3%	-55,770	41,962	-2.0%	-5,471
1995	508,450	-6.1%	-89,069	37,156	-11.5%	-10,277
1996	493,489	-2.9%	-104,030	32,504	-12.5%	-14,929
1997	407,239	-17.5%	-190,280	27,857	-14.3%	-19,576
1998	389,223	-4.4%	-208,296	29,290	5.1%	-18,143
1999	374,081	-3.9%	-223,438	28,881	-1.4%	-18,552
2000	338,135	-9.6%	-259,384	25,555	-11.5%	-21,878
2001	326,737	-3.4%	-270,782	23,146	-9.4%	-24,287
2002	318,507	-2.5%	-279,012	20,881	-9.8%	-26,552
2003	291,858	-8.4%	-305,661	17,604	-15.7%	-29,829
2004	242,732	-16.8%	-354,787	15,633	-11.2%	-31,800
2005	214,182	-11.8%	-383,337	14,041	-10.2%	-33,392
2006	193,384	-9.7%	-404,135	15,000	6.8%	-32,433
2007	170,038	-12.1%	-427,481	12,105	-19.3%	-35,328
2008	147,238	-13.4%	-450,281	11,551	-4.6%	-35,882
2009	117,684	-20.1%	-479,835	9,304	-19.5%	-38,129
2010	106,162	-9.8%	-491,357	8,716	-6.3%	-38,717
2011	92,056	-13.3%	-505,463	7,060	-19.0%	-40,373
2012	79,821	-13.3%	-517,698	5,731	-18.8%	-41,702
2013	75,330	-5.6%	-522,189	5,976	4.3%	-41,457

Sources: ONS, Scottish Government.

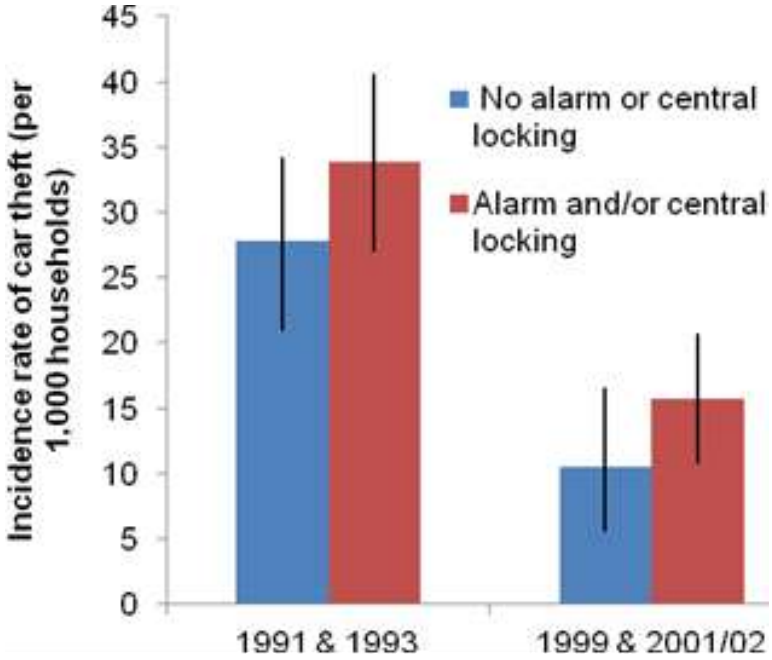
For England and Wales, thefts fell by 208,296 in the five years immediately after the peak (1994–1998) at an average rate of 8.1 per cent per year. In the five years after that (1999–2003), thefts fell a further 97,365 at an average rate of 5.6 per cent per year.[41] In Scotland, thefts fell by 19,576 in the first five years after the 1992 peak and by a further 6,976 thefts in the five years after that. For both series, just over half the entire drop in thefts is achieved by 2000, *before* the majority of vehicles on the road would have been likely to have had electronic immobilisers.

In the last chapter, data from the Car Theft Index suggested that during the initial fall in crime, rates of theft fell on all types of vehicle, regardless of security. This was further tested using the CSEW. Full details of the methodology are in the Technical Appendix (section 8), but essentially data were extracted for survey years between 1991 and 2001/02 in which a proportion of respondents were asked about the level of security on their main vehicle (if it was a car or light van). These were then cross-referenced with the question asking about whether the respondent

[41] The fall in the first five years post-peak compared to the five years subsequently is also greater in the CSEW data, whether looking at volumes or percentages. Vehicle thefts fell 35 per cent between 1993 and 1998/99 and by 32 per cent between 1998/99 and 2003/04. Given sampling error, it would be hard to say for certain that the trend was definitely steeper in the earlier period but even if the percentage drops are deemed to be the same, that would still imply a much larger volume decline in the earlier period.

had had a car/van stolen. This allowed for the calculation of 'theft of car/van' rates for households whose main car had car alarms and/or central locking and households whose main vehicle had neither. Figure 18 shows the difference in these theft rates between 1991/1993 (pooled together) and 1999/2001/02 (pooled together).

Figure 18: Household incidence rates of past motor vehicle theft by the security features of the current, main car/van used



Source: CSEW.

Notes: Ninety-five per cent confidence intervals around the incidence estimates are shown. The falls in theft rates for both types of households are statistically significant (p<.01) with the pooled years shown above. The falls are also statistically significant (p<.05) when individual years are compared – see Technical Appendix section 8.

There are two possible conclusions from Figure 18, though both require caution. The first conclusion is that rates of car/van theft fell during the 1990s, regardless of the vehicle's security level. Both households with and without security on their main vehicles experienced statistically significant declines in theft over the period. This is in line with the Car Theft Index evidence presented earlier. More surprising perhaps, is that Figure 18 also *appears* to show that rates of theft were actually higher for households whose main car/van had security than for households with no security. Importantly, this difference is not statistically significant in either period and in our judgement it is likely to be a spurious conclusion caused by the limitations in this analysis (see below).

The most obvious limitation is that the 'no security' category does not include electronic or mechanical immobilisers, so it possible that the lower rates of theft in this group may be driven by cars/vans with no central locking or alarms but *with* a mechanical or electronic immobiliser. However, this is unlikely to bias the results significantly because it would be unlikely for a vehicle to have had an electronic immobiliser and not to have had also an alarm or central locking. Farrell *et al*. (2011) found that all vehicles with electronic immobilisers had at least one other security device. In relation to mechanical immobilisers, these were not included in the 'no security' group because they were not asked about in all the years of the survey shown in Figure 18. However, analysis of the data in years for which mechanical immobilisers *could* be included still suggested that there was a significant fall in thefts of vehicles without any security (see Technical Appendix, section 8).

A far more important limitation of the analysis is that households' main vehicle may *not* have

been the vehicle that was actually stolen. It would have been preferable to compare the security profile of stolen cars with the security features in the total 'population' of cars, as Farrell *et al*. (2011) attempt to do. This is not possible, however, for years before 2001/02 as the survey only asked households about security features on their current main car/van, not on the vehicle that was stolen. It is quite possible therefore, that a household's second or third car may have been stolen, but it is not known what security features these secondary vehicles had (probably inferior to the primary car). Similarly, in some cases victims of vehicle theft may have obtained a replacement car with better security, or improved the security on the stolen vehicle if it was recovered. Additional analysis suggested these reasons may help to explain the counter-intuitive result that surveyed households with better vehicle security experienced higher (but not statistically significantly higher) rates of theft.

It is important to note, however, that these issues – thefts of secondary cars and changes to a car's security following a theft – should *not* affect the finding that theft rates fell during the 1990s for secure and non-secure vehicles alike. This is because it is unlikely that a household would have a second car with better security than its main car, and it seems even more unlikely that a household would get a car with inferior security after experiencing a vehicle theft. As such, we can reasonably assume that for households whose main, current car has no alarm/central locking, past thefts were also of cars with no alarm/central locking.

In general then, the data show a similar pattern to the Car Theft Index data. Both sources suggest that the decline in vehicle thefts had two phases: an initial one in which thefts rates fell on all vehicles, regardless of their level of security; and a second phase, beginning around 2000, in which improved security drove theft rates very low on new vehicles and caused some displacement to older, unprotected vehicles.

Another way to assess the extent of improved security's role in the pre-2000 declines in vehicle crime is by analysing data relating to the type and methods of vehicle theft. Bässman (2011) has suggested that comparing trends in successful vehicle crime and attempted vehicle crime can be one way of assessing the success of security. Figure 6 showed that the ratio of attempted thefts to successful thefts increased through the 1980s, suggesting improved security. But Bässman (2011) also hypothesised that if security, rather than any change in numbers of motivated offenders, were the catalyst for the vehicle crime fall then there would be a marked short-term rise in attempted thefts following the peak in actual thefts, as thieves who had previously committed vehicle crimes were deterred. He found evidence of such an effect in Germany. Figure 6 shows the relevant CSEW trends for England and Wales. The evidence is rather inconclusive. The graph appears to show a slight rise in attempted thefts and a fall in actual thefts between 1993 and 1995, but neither of these changes is reported as being statistically significant[42] and after 1995 both trends decline in unison until the early 2000s when attempted thefts drop faster. So on that measure there is little strong evidence to suggest a marked security impact in the early stages of the crime decline.[43]

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[42] See Table A2.1, note 3, in Mirrlees-Black et al, 1996.

[43] Mirrlees-Black et al (1996) do make reference to a 13% rise in attempted police recorded vehicle thefts between 1993 and 1995, when completed thefts had already begun falling. That could imply a security effect of the type Bässman suggests. Unfortunately though, it is not clear how this was calculated as police recorded vehicle theft attempts are generally included in the overall vehicle crime figures rather than being separated out, so it is hard to verify the 13% rise. It appears in Table 2.3 of Mirlees-Black et al (1996) but the number of attempted vehicle theft incidents in that table (150,000) represents only a 4% rise from the identical table for the 1993 survey, which shows 143,000 attempted incidents – see http://webarchive.nationalarchives.gov.uk/20110218135832/http://rds.homeoffice.gov.uk/rds/pdfs2/r14.pdf. The only other police series on attempted thefts that could be located was Table 5.01 in Simmons (2002). This does not include data from before 1996. From 1996 the trend shows a year-on-year fall in incidents of attempted theft of vehicles.

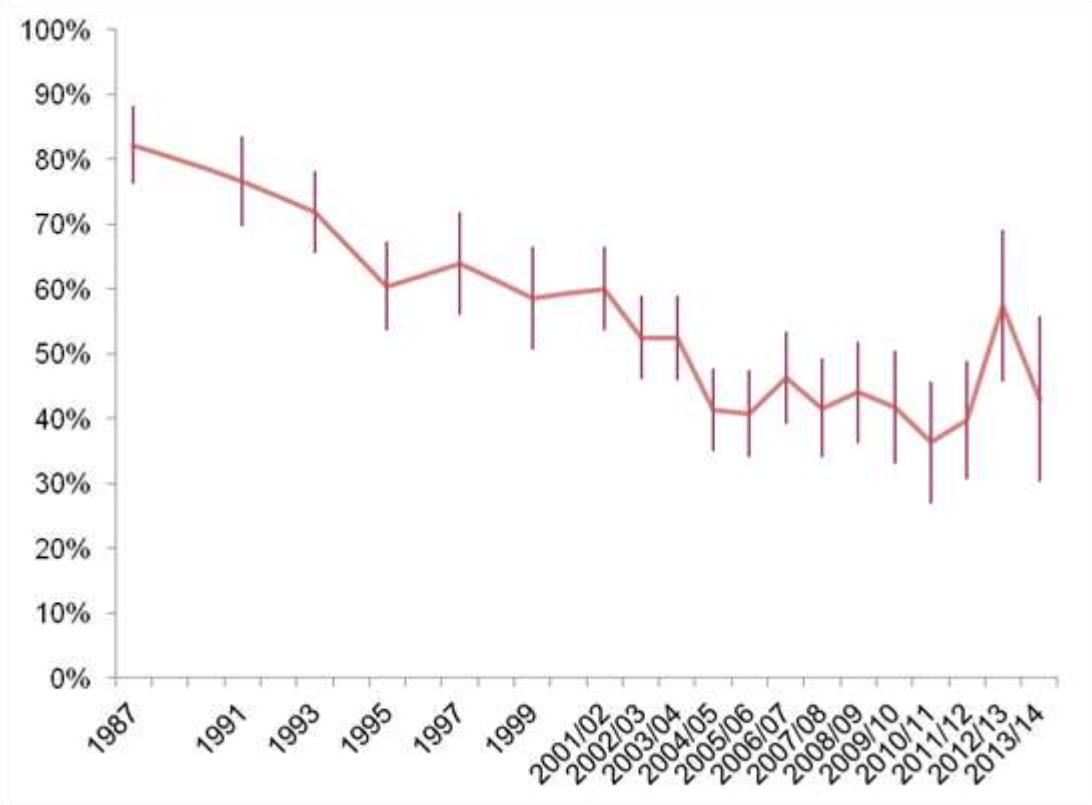
Data are also available from 1995 for England and Wales on the method of entry for vehicle theft and whether the vehicle was subsequently recovered. These are shown in Table 5 and Figure 19 below.

Table 5: Method of entry for theft of vehicles, CSEW

	Theft of vehicle																
	1995	1997	1999	2001 /02	2002 /03	2003 /04	2004 /05	2005 /06	2006 /07	2007 /08	2008 /09	2009 /10	2010 /11	2011 /12	2012 /13	2013 /14	Significant difference 2004/05 - 2013/14
Offender forced lock or tried to	65	66	66	61	62	53	55	50	51	36	40	48	35	22	25	18	*
Offender broke window or tried to	13	16	13	17	20	23	21	21	20	20	16	18	18	14	10	12	
Door was not locked	3	3	3	7	6	6	12	9	10	9	10	2	13	9	11	16	
Offender forced/broke/prised door	.	.	.	.	.	.	.	.	3	7	0	1	0	3	0	0	
Offender used a key	9	7	8	12	9	12	12	15	15	19	29	24	26	46	41	46	*
Window was left open	0	0	1	0	1	1	1	0	1	0	0	0	0	0	0	0	
Other	12	8	11	6	5	8	6	8	5	9	6	7	16	11	13	15	
Unweighted base	*239*	*156*	*183*	*215*	*222*	*204*	*203*	*164*	*155*	*179*	*117*	*74*	*62*	*75*	*44*	*43*	

Source: ONS, Crime Survey for England and Wales.

Figure 19: Percentage of stolen vehicles that were subsequently recovered, CSEW



Source: ONS, Crime Survey for England and Wales.

In Table 5 there are no statistically significant year-on-year changes from 1995 to 1999. From then on there is a general trend for vehicle thefts via forced locks to decline, slowly at first, and then steeply. The method: 'offender had a key' follows the opposite pattern. Over the last ten years, the change in these trends is statistically significant.

A number of studies have shown that some offenders reacted to electronic immobilisers by targeting car keys in other types of theft (van Ours and Vollaard, 2014). One example is 'car-key burglaries' in which houses are raided with the intention of taking the car keys and hence the vehicle outside. Data show a rise in car-key burglaries in England and Wales once most vehicles had electronic immobilisers. This implies that, regardless of any potential diffusion of benefits pushing crime like burglary down, electronic immobilisers also drove a limited amount

of displacement pushing burglary levels up.[44] Levesley *et al*., (2004), using data from Northumbria and Greater Manchester police, found that 85 per cent of stolen cars registered after 1997 (those that would definitely have had electronic immobilisers) were taken using keys and that burglary was the most common method. The CSEW shows that this shift to car-key burglary occurred from around 2000 which might therefore suggest – in line with the modelling – that electronic immobilisers were not present in enough vehicles to drive big changes in offender behaviour before that.[45] An alternative possibility would be that only more serious and committed offenders would make the switch to car-key burglaries and more casual, opportunistic thieves may have given up offending at even a low level of immobiliser penetration.

One way to further examine these possibilities is to look at recovery rates of stolen vehicles. Given that thefts in which the vehicle is recovered are more likely to indicate opportunistic offending (joy-riding or for-transport thefts) and unrecovered theft in which the vehicle is presumably either broken for parts or exported is more likely to indicate a higher degree of organisation or professionalism, some researchers have suggested that a downward shift in recovered thefts, relative to unrecovered thefts, might be a sign of improved security because devices would be more likely to deter opportunistic thieves than professional ones (Farrell *et al*., 2014; Brown, 2013).

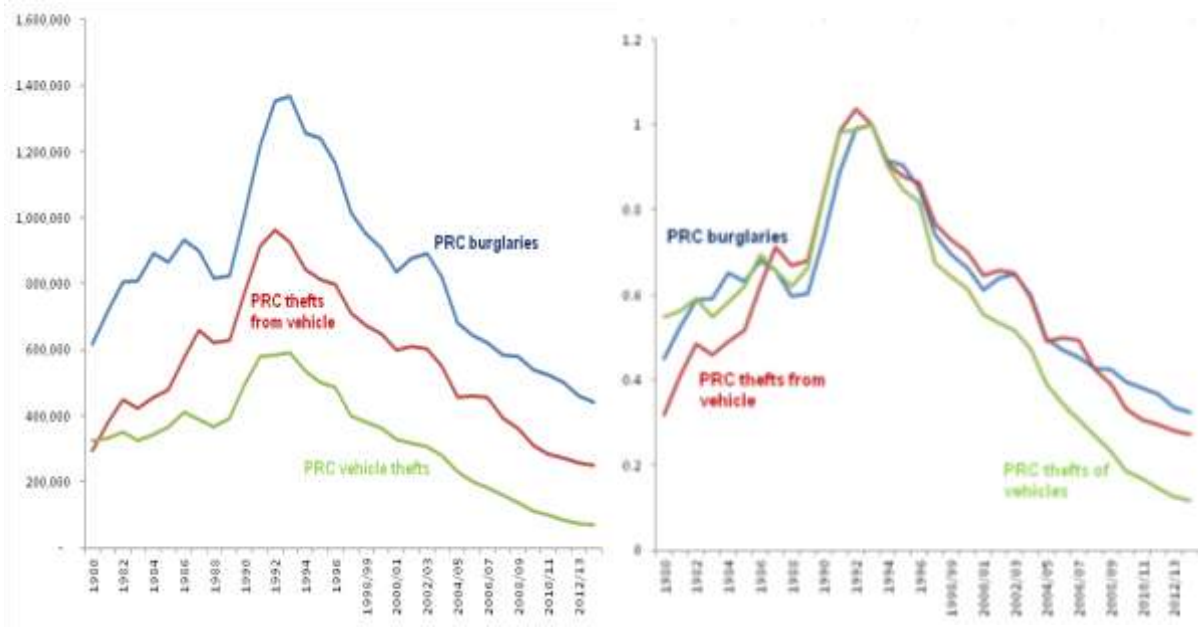
Figure 19 shows that, generally, there has been a shift from recovered thefts to unrecovered thefts over the last 25 years, a potential sign of overall improved security. But careful examination suggests that this happened in two distinct periods. From 1987 to 1995, as vehicle crime largely increased, there was a shift downwards in the proportion of recovered thefts. Figure 17 showed that this was due to a rise in unrecovered thefts rather than a fall in recovered thefts (i.e. a rise in profit-driven, more organised offending potentially). During the initial crime decline from 1995 to 2000/01, however, the proportion of recovered stolen vehicles did not change significantly. The declines in vehicle theft occurring during this period affected recovered and unrecovered vehicles alike. There is then a sharp second downward shift in the proportion of recovered vehicles from 2001/2 to 2003/4. It is possible that this represents the impact of electronic immobilisers reaching critical mass within the vehicle fleet, i.e. the downward shift could have been caused by falling numbers of opportunistic offenders relative to more professional offenders as a result of electronic immobilisers. Again though, any conclusion must be extremely tentative given that they rest on several assumptions about the links between types of theft and types of offenders that have not always been borne out in empirical studies. For example, van Ours and Vollaard (2014) found that electronic immobilisers were very effective in reducing unrecovered thefts as well as recovered ones.

Taken together though, the data on types of theft and method of entry are consistent with an electronic immobiliser effect, but one that was most prominent in the 2000s rather than the 1990s. What does this imply for the issue of displacement or diffusion to other crime types? Figure 20 shows the trends in vehicle thefts compared to those for burglary and for theft from vehicle.

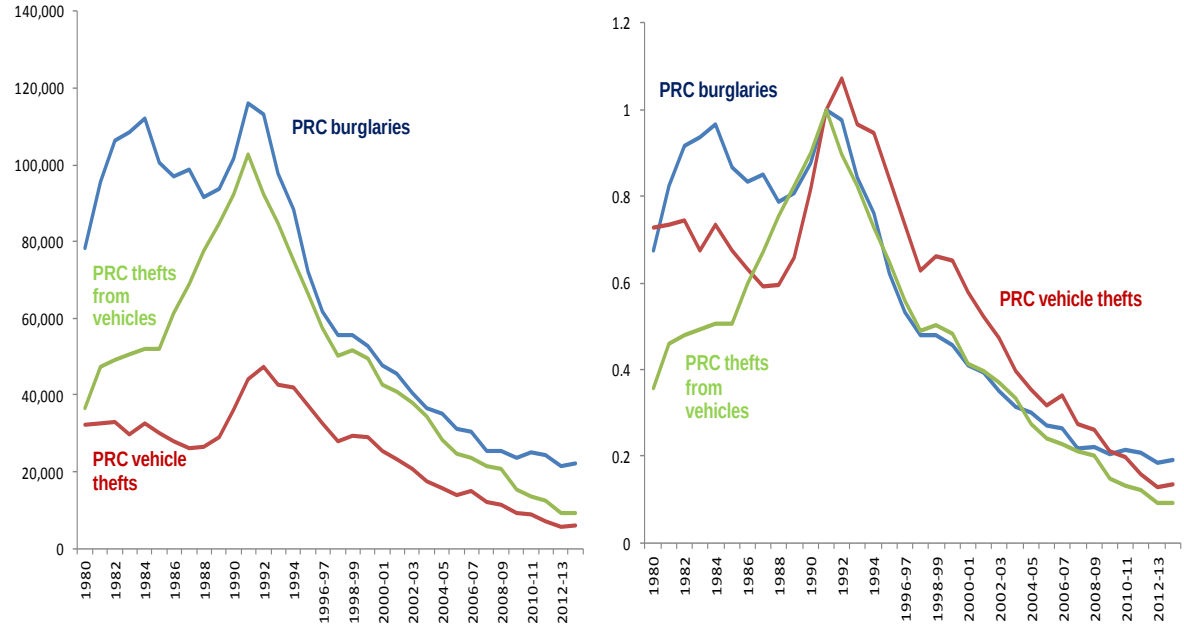
[44] Note that it is possible for the two to co-exist. Some offenders may have been driven to car-key burglaries by electronic immobilisers, while others may have given up crime entirely.
[45] This shift in offender patterns also suggests that house security was seen as *less* of a barrier generally than vehicle security at this point.

Figure 20: Police recorded burglary and vehicle crime by volume of offences (left chart) and indexed (peak year = 1) (right chart)

England and Wales[46]



Scotland



In England and Wales there is a very high degree of correlation between the three crimes, particularly from 1989 onwards, as Table 6 shows. In Scotland the correlation is less strong in the 1980s but becomes stronger through the crime-drop period of the 1990s and 2000s.

[46] The trends for England and Wales have a 'bump' in around 2002. This may be caused by the introduction of the National Crime Recording Standard that year, which increased recording of crime generally. It affected violence mostly, but may have boosted the recording of burglary and vehicle crime slightly too. See Technical Appendix for more on this.

Table 6: Correlations between crime types in England and Wales, and Scotland

England and Wales

	PRC burglary and theft of vehicle	PRC burglary and theft from vehicle	PRC theft of vehicle and theft from vehicle
1980-2013/14	0.96	0.96	0.92
1990-2013/14	0.99	0.99	1.00

Scotland

	PRC burglary and theft of vehicle	PRC burglary and theft from vehicle	PRC theft of vehicle and theft from vehicle
1980-2013/14	0.87	0.85	0.90
1990-2013/14	0.96	0.97	0.96

Note: All the above correlations are significant at the one per cent level

These high correlation coefficients certainly support the hypothesis that whatever was driving vehicle theft trends at this point was driving trends in other types of theft too. However, there are complexities. The indexed chart for England and Wales demonstrates that through the period of the crime 'spike' of the 1990s, all three offence types rose and fell at a very similar rate, but that through the 2000s vehicle thefts fell faster. Table 7 shows that in Scotland vehicle thefts fell more slowly than the other crimes in the 1990s but about as fast or faster in the 2000s.

Table 7: Average annual change in burglary and vehicle crime levels, by decade

England and Wales

	PRC burglary	PRC theft from vehicle	PRC theft of vehicle
1980-89	4%	9%	2%
1990-92	18%	8%	9%
1993-99	-5%	-5%	-6%
2000-09	-5%	-7%	-11%

Scotland

	PRC burglary	PRC theft from vehicle	PRC theft of vehicle
1980-89	2%	10%	-2%
1990-91	11%	10%	23%
1992-99	-9%	-9%	-5%
2000-2009	-6%	-11%	-10%

Methodological note: The 1990s is broken into two in both cases to show the different trends either side of the crime turning point.

Arguably, Table 7 and Figure 20 suggest two possible narratives, one that supports an almost perfect diffusion of benefits and one that moderately contradicts the notion that benefits from immobilisers spread to other crimes. In the first narrative, electronic immobilisers had an

immediate impact from the moment they appeared in the vehicle fleet in the 1990s, reversing an upward trend in vehicle thefts and reversing similar trends in related theft types.[47] In the second narrative, another factor or factors drove all types of theft up and then down sharply in the 1990s and then electronic immobilisers had an *additional* effect during the 2000s, causing vehicle thefts to fall at a faster rate than most other crimes.

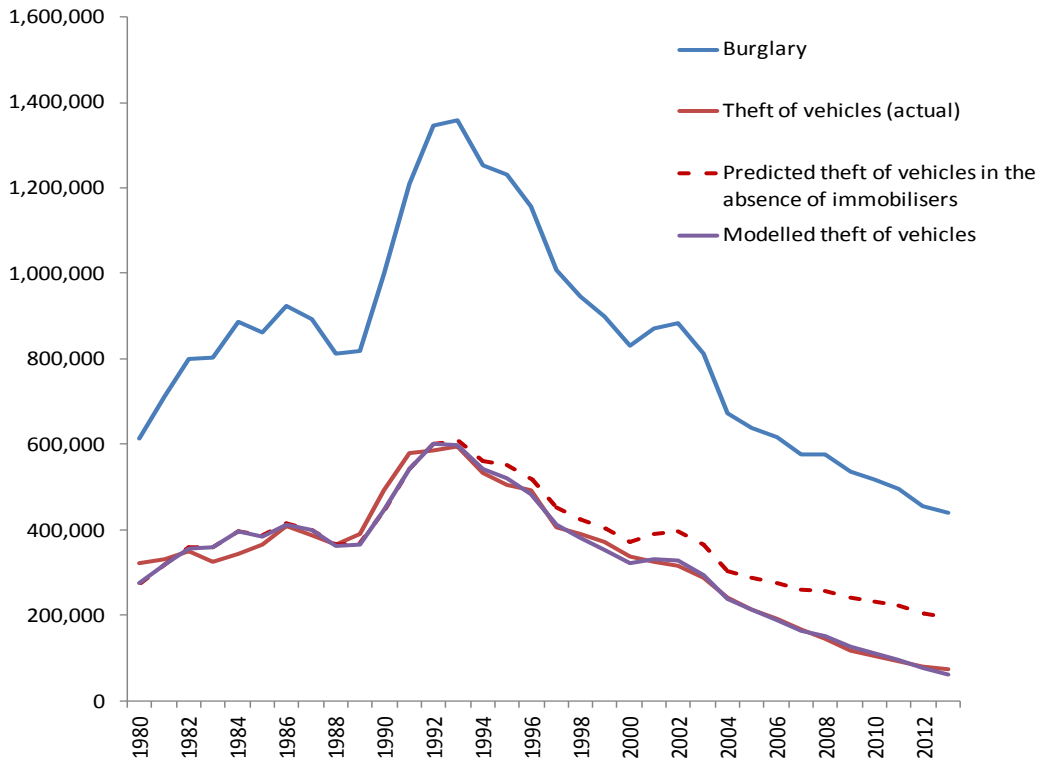
The sequencing of crime peaks offers some support for both possibilities. The CSEW has all three crime types in England and Wales peaking in 1993, in line with potential diffusion of benefits. But police recorded crime trends generally run counter to the hypothesis. In England and Wales theft *from* vehicles peaked first in 1992, followed by burglary and theft of vehicles in 1993. In Scotland, PRC burglary and theft from vehicles peaked in 1991 followed by theft of vehicles in 1992. It is difficult to be certain which measure offers the more trustworthy picture of sequencing.[48] CSEW trends will be unaffected by any reporting or recording influences but rely on the accurate recall of interviewees making the determination of precise turning points somewhat problematic.

Another way to analyse the likely effect of electronic immobilisers is via time series modelling. Full details of the methodology and results are in Appendix 6. But in brief, an initial model confirmed that trends in burglary and theft from vehicles were strongly significant predictors of the trend in thefts of vehicles in England and Wales from 1980 through to 2013. This suggests the possible presence of a common factor linked to general propensity for theft, which drove all three crime types up initially and then down from 1992–3. However, the model also showed that these relationships were not constant over time. Using maximum likelihood estimation, it was possible to determine the presence of two statistically significant 'break-points' in the relationship between burglary and thefts of vehicles, suggesting the presence of another influence on vehicle thefts over and above any 'common factor'. The first break-point occurred in 1992 in line with the introduction of electronic immobilisers. At this point, thefts of vehicles began decreasing at a slightly faster rate than burglary, but this accelerated considerably at the second break-point in around 2004 when a majority of vehicles would have been protected by the devices. From this point onwards, thefts of vehicles began falling much faster.

Using this method, it is possible to estimate a trend in thefts of vehicles for a hypothetical scenario in which electronic immobilisers had not been introduced. This is shown in Figure 21. By calculating the difference between the fall in thefts in this hypothetical scenario and the actual fall, it is possible to generate an estimate for the contribution of electronic immobilisers. Using this approach suggests that 23 per cent of the fall in vehicle thefts can be attributed to electronic immobilisers.

[47] Note that in Scotland, the diffusion of benefits goes beyond 100 per cent, as vehicle thefts actually fell by less than burglaries and thefts from vehicles during the 1990s.
[48] It is worth bearing in mind too that – to a certain extent – the national PRC peaks are illusory given that there is a degree of variation in the peaks at force level.

Figure 21: Police recorded burglary and theft of vehicles, modelled theft of vehicles and estimated trend in theft of vehicles in the absence of electronic immobilisers



Source: ONS, police recorded crime.

Like the modelling from the previous section, caution needs to be applied to these results due to the lack of experimental conditions and the assumptions being made. The assumptions are mostly the same as in Chapter 3, i.e. no attempt is made to model the additional benefits of other types of vehicle security or any interaction between those and electronic immobilisers. But there is also one important additional assumption central to this modelling approach: electronic immobilisers were assumed to have no effect on burglary. These findings implicitly assume that there was no displacement or diffusion of benefits. For that reason, it is perhaps not surprising that this exercise produced a lower estimate than the method employed in Chapter 3. As such, 23 per cent can probably be viewed as a lower bound on the proportion of the fall in thefts of vehicles that can be attributed to electronic immobilisers.

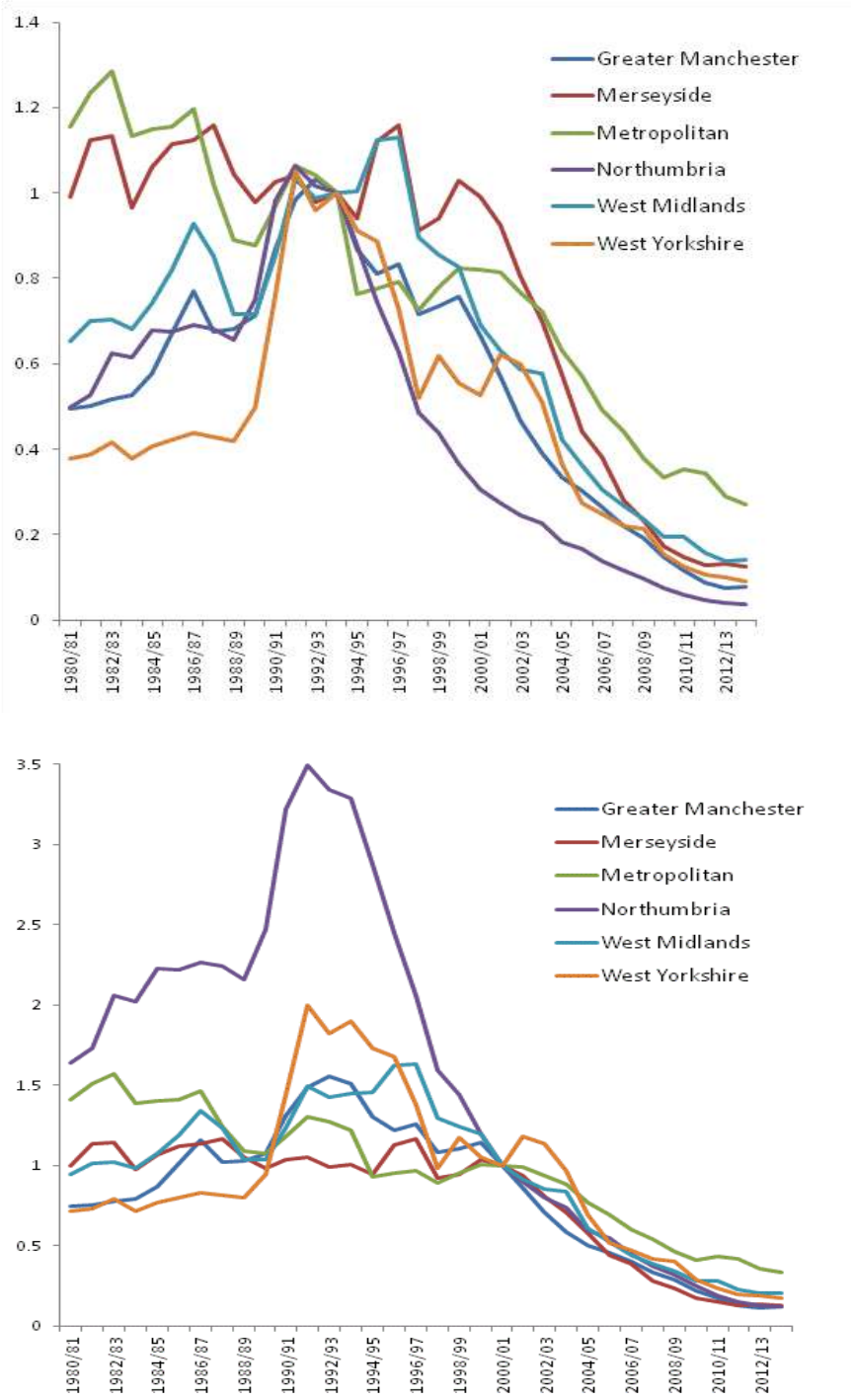
Findings – Police force area level

Moving from the national to the local level, 15 of 42 police forces in England and Wales (36%) show sequencing that supports a diffusion of benefits hypothesis (i.e. their trend in vehicle thefts peaks in line with or before their trends in burglary, other theft or theft from vehicles). See Table A7.3 in the Technical Appendix.

Breaking trends down to police force area level allows another examination of electronic immobiliser impact. For the most part their introduction can probably be thought of as a 'national' effect. That is, their spread would be likely to have been fairly uniform across areas given that legislation mandating them on all new vehicles applied to all police force areas at the same time. There will have been some variation, as some areas are likely to have had a higher percentage of new vehicles than others, but generally it might be expected that electronic immobilisers would have caused a downward trend in vehicle thefts across all areas at more or less the same time.

To test the two possible narratives, Figure 22 takes the six police forces with the largest average annual volume of vehicle thefts and shows their trends, indexed first to the national vehicle crime peak in 1993 and then to the point at which the modelling suggested a that a majority of vehicles would have electronic immobilisers, in around 2000/01.

Figure 22: Vehicle theft trends in the six highest-volume police force areas, indexed to 1993/94 (top chart) and 2000/01 (bottom chart)



Source: ONS, police recorded crime.

The top chart shows a great deal of variation in vehicle theft trends both before and after the indexation point (1993). For example, vehicle thefts in Merseyside[49] and West Midlands

[49] Trends in Merseyside arguably offer a particularly interesting case study as they differ from the national trends in several

continue to rise for a period after 1993 and in West Yorkshire there is a large increase in thefts in the early 1990s followed immediately by a large decrease, but then thefts stabilise until the early 2000s at which point they fall sharply again. So 1993 does not appear to mark a uniform downward shift in police-force-area vehicle theft trends. By contrast, the bottom chart shows that from around 2000 on (West Yorkshire arguably see a slightly later effect) the six police forces had relatively uniform declines of sizeable magnitude.

Broadening the analysis to all areas using a similar approach, Table 8 shows the number of police forces areas with rises or falls in vehicle thefts for each five-year period from 1981 to 2010. There is some variation up to 2000 after which every police force in England and Wales has a decade of consistent decline.

Table 8: Number of police forces showing rises/falls in vehicle thefts, by five-year periods

	1981-85	1986-1990	1991-1995	1996-2000	2001-2005	2006-2010
Number of forces seeing rises	36	40	23	3	0	0
Number of forces seeing falls	6	2	19	39	42	42

Conclusion

This chapter examines available data from England and Wales and Scotland on trends and methods of vehicle theft. All three nations had a sharp rise and then fall in vehicle thefts during the 1990s, with numbers of thefts falling fastest in the years immediately after the crime turning point, when data suggest that fewer than five per cent of vehicles on the road would have had electronic immobilisers.

The analysis also adds further evidence that, whilst joy-riding was still a common motive for vehicle theft, the bulk of the early 1990s rise in crime was due to a surge in economically motivated offending.

Analysis of data on household vehicle security through the crime turning point revealed evidence to suggest that devices like central locking and car alarms were limited in their effectiveness up to 1993 and that the initial fall in crime saw theft rates decrease sharply on all vehicles, regardless of their security levels. This, along with the low numbers of vehicles with electronic immobilisers at the crime turning point and the sharp falls in other types of acquisitive crime, suggest perhaps that other factors were likely to be driving crime down at that time.

This was further supported by an examination of data on vehicle theft methods, an analysis of vehicle thefts by police force area and time series modelling. The latter showed that electronic immobilisers were pushing down on vehicle thefts from their introduction in 1992, but that the effect was small until a majority of vehicles were protected in 2000.

Ultimately these analyses suggest that although other factors may have been more important around the crime turning point and immediately afterwards, electronic immobilisers had an additional and substantial impact on vehicle crime during the 2000s. This was consistent across police force areas and has persisted at least to 2013/14. They changed the security 'arms race' in a way that other devices like steering locks, central locking and car alarms were unable to do, driving at least a quarter of the total fall in thefts of vehicles to that point and perhaps up to a half.[50]

important ways. This is examined in more detail in Appendix 4.

[50] This range – between a quarter and a half – combines the quantitative estimates from the last two chapters to produce an

5: Evidence from other nations

The aim of the analysis in this section is to test the conclusions reached so far using data from other nations. Given the trends in electronic immobiliser spread, vehicle thefts and other types of crime in Great Britain, two specific hypotheses were developed.

i) The 'immediate impact' hypothesis: That electronic immobilisers had a marked impact on vehicle crime and possibly other types of offence from the point at which they *first* started appearing on new vehicles.

ii) The 'delayed impact' hypothesis: That the impact from electronic immobilisers was small until a significant portion of the fleet was protected at which point the devices drove a marked fall in vehicle thefts largely irrespective of trends in other crimes.

These hypotheses were tested, against the possibility that immobilisers did *not* have an impact, on national-level trends using data from a panel of seven nations: England and Wales, Scotland, the US, Canada, Australia, the Netherlands and Sweden. These nations were selected for data reasons. They were the only nations for which complete datasets could be located for the relevant police recorded crime types going back to 1980.

Cross-national crime comparison has numerous pitfalls. Crime categories that sound similar often have subtle differences that can affect levels and/or trends markedly. However, the primary crime of interest here was theft of vehicles, which is subject to less variation in interpretation than other offences like violence.

Police recorded crime statistics were used throughout. For the panel of seven nations, these were collected from the country-specific statistical or governmental authority. These sources are fully referenced in the Technical Appendix.

To test the hypotheses, trend analysis similar to that from the previous section was employed. As in that section, the analysis was necessarily retrospective meaning it can really only suggest conclusions, rather than prove them. However, as the speed of electronic immobiliser spread was examined across nations it became clear that a 'natural experiment' of sorts could be used to strengthen the analysis. The evidence suggests that electronic immobilisers first appeared in all nations at more or less the same time in the early 1990s but that their spread was faster in Australia and Europe than in the US and Canada. This provided an opportunity to check more robustly the 'delayed impact' hypothesis, by examining whether the marked impact visible in

approximate range.

England and Wales occurred later in the US and Canada, in line with the slower spread of electronic immobilisers in those nations.

The spread of immobilisers internationally

This section briefly examines available evidence on the introduction and spread of immobilisers in the seven nations used for the main analysis, though England, Wales and Scotland have already been covered.

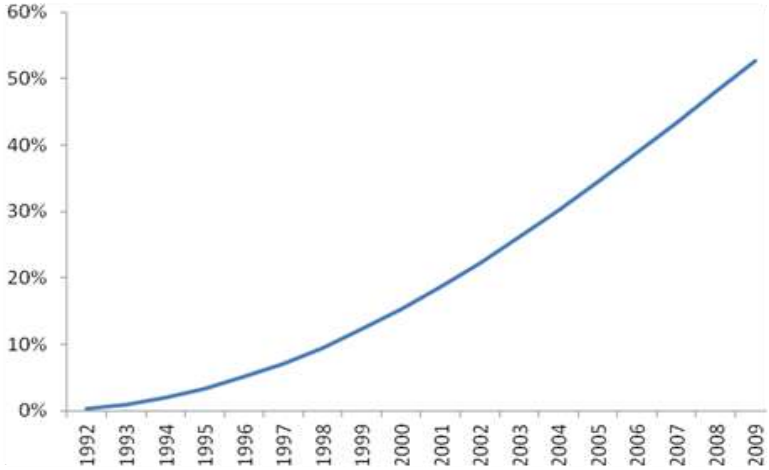
The US

In the US, most researchers agree that electronic immobilisers began to be fitted on new vehicles at around the same time as in Europe – i.e. from the late 1980s and early 1990s – but that the spread was slower. Brown (2013) and Fujita and Maxfield (2012) both cite a 1998 National Highway Traffic Safety Administration report stating that certain anti-theft devices were fitted on some new models of car in the US from the late 1980s. It is hard to be certain whether these were actually electronic immobilisers or simply 'electrical systems' which were easier for thieves to overcome (Bässman, 2011). More certain is that the first mass-market cars to be fitted with electronic immobilisers in the US were BMWs in 1995 (Fujita and Maxfield, 2012).

Unlike Europe, the US did not have legislation making electronic immobilisers mandatory in new vehicles which meant some manufacturers took longer to introduce them. Two sets of researchers have attempted to estimate the spread of immobilisers in the US: Fujita and Maxfield (2012) and van Ours and Vollaard (2014). Both suggest that electronic immobilisers were a negligible presence in the early 1990s and that the spread was gradual such that by 2010 only around 30 per cent of all cars on the road had electronic immobilisers. These estimates may under-estimate the speed of spread slightly. Separate analysis by Fujita (2011) examining samples of parked vehicles in New Jersey between 2005 and 2009 found that almost half had electronic immobilisers at that time[51]. The National Institute for Highway Safety suggested that 86 per cent of new vehicles were fitted with electronic immobilisers by 2009 (van Ours and Vollaard, 2014). Using this and data on average age of vehicles on the road in the US[52], an estimate of immobiliser spread was produced, see Figure 23.

[51] This may be due to the fact that New Jersey is one of the wealthiest states, as measured by median income – see: http://www.census.gov/statab/ranks/rank29.html
[52] See http://www.epa.gov/oms/models/mobile6/r01047.pdf

Figure 23: Estimated penetration of electronic immobilisers within the US vehicle fleet



Sources: National Institute for Highway Safety estimates, EPA vehicle data.

According to this estimate, it was not until the late 2000s that around half of all vehicles became protected, though some uncertainty around the precise trend exists.

Canada

As with all other nations studied, the first reports of electronic immobilisers in Canada appeared in the late 1980s and early 1990s. But available evidence suggests that spread of the devices was more similar to the gradual progression in the US rather than the swifter adoption seen in Europe.

Unlike the US, Canada did introduce legislation mandating installation of electronic immobilisers on new vehicles, but not until 2007. However, the Canadian Theft Deterrent Standard was published in 1998, which began a programme aimed at encouraging manufacturers to voluntarily introduce electronic immobilisers on new vehicles. Wallace (2003) shows that the late 1990s saw a shift to thefts of older vehicles just as in England and Wales and Australia (see below), and that around 50 per cent of *new* vehicles had electronic immobilisers in 2000. The Insurance Bureau of Canada reported that this had increased to 60 per cent by 2003 (IBC, 2003).

Assuming roughly linear increases in the introduction of electronic immobilisers on new vehicles from the early 1990s to the early 2000s would imply that adoption of electronic immobilisers in Canada was slower than in England and Wales but followed a similar trajectory to that in the US. In other words, while the 2007 legislation may have speeded up the end of the process, with the proportion of new vehicles with electronic immobilisers going to 100 per cent in 2007, most of the spread was dictated by the date of introduction and the gradual increase of new vehicles with the devices during the 1990s and 2000s.

Australia

Evidence suggests immobiliser spread in Australia resembled Europe more than the US or Canada. In fact, improved security may have affected the mass market in Australia even before it did in Europe. Geason and Wilson (1990) say that “an electronically operated deadlock

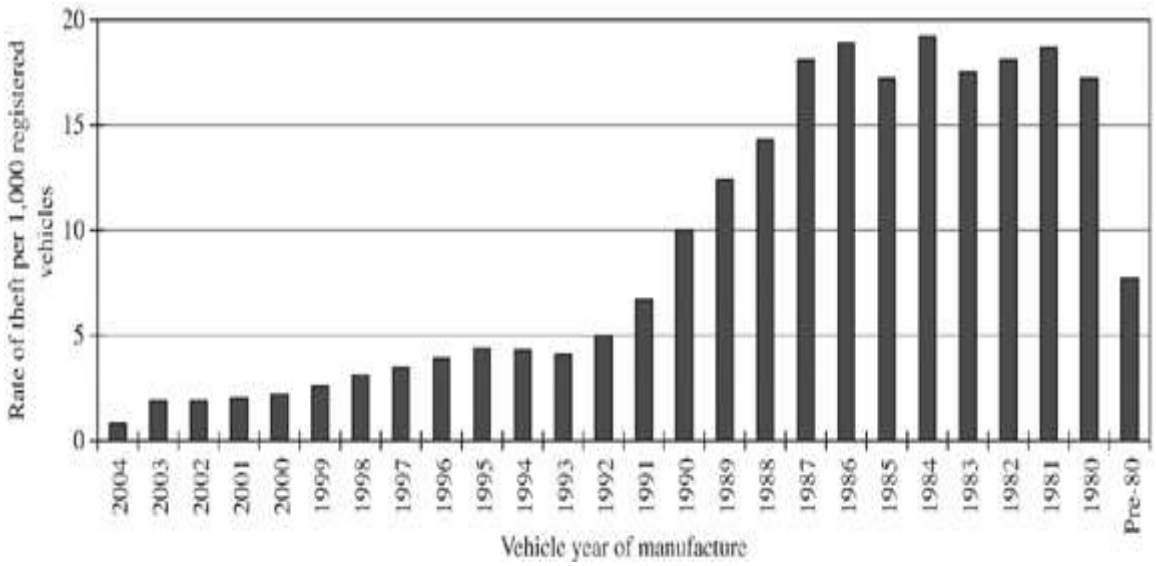
system" was fitted on the top-line Commodore (Australia's top-selling brand of car in the early 1980s) in 1989. Potter and Thomas (2001) note that Ford and Holden began incorporating electronic immobilisers in their biggest selling models as early as 1992.[53]

Electronic immobilisers were made mandatory on all new vehicles in Western Australia in 1999, following two years of a voluntary scheme that encouraged the retrofitting of immobilisers to older vehicles. National legislation enforcing immobiliser installation on new vehicles was introduced in 2001. The earlier legislation in Western Australia therefore constitutes something of its own natural experiment, which is examined in Appendix 4. Here the focus remains on the national trends.

Whilst the national legislation in 2001 almost certainly increased the speed of spread, evidence suggests electronic immobilisers were already well established in Australia by this point. Kriven and Ziersch (2007) find that almost half (47%) of cars already had immobilisers in 2000 with the majority of those being of the approved 'Australian standard' variety. This statistic would put Australia on an almost identical trajectory to Great Britain and the Netherlands (see below). In each case, about half of the fleet became protected in around 2000.

This is further supported by data on thefts by age of vehicle, which is available from the CARS data analyser (see https://ncars.on.net/statistics.html). Figure 24 shows the age distribution of vehicles stolen in 2004.

Figure 24: Cars stolen in 2004 in Australia, by age



Source: Kriven and Ziersch (2007).

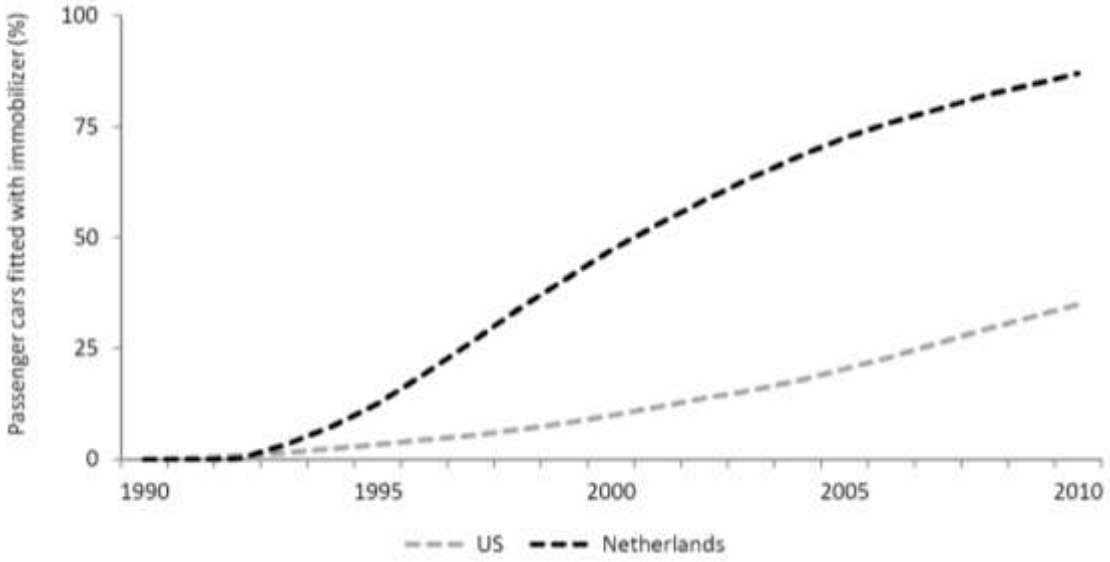
This distribution is similar to those produced for Great Britain earlier in the report (Figure 9). If it was primarily electronic immobilisers that caused lower theft rates on newer vehicles, then the chart suggests that the introduction of the devices on new vehicles probably occurred from about 1989 to 1992. If that is true, then the majority of vehicles were probably already protected by the time legislation was introduced in 2001.

[53] Kriven and Ziersch (2007) say that these early immobilisers were not as effective as later models and were "easily defeated." However, the Australian theft figures by age of vehicle (Figure 24) suggest otherwise. Rates are very low for vehicles registered from around 1992 onwards. As such, Potter and Thomas (2001) note that the initial devices did appear to "reduce theft rates significantly" with only minor additional gains coming from the later models.

The Netherlands

Spread of electronic immobilisers in the Netherlands has been estimated by van Ours and Vollaard (2014), see Figure 25 below. This trajectory is almost identical to the estimates presented earlier for Great Britain, with a low percentage of vehicles having the devices before 1995 and a majority being protected from 2000 on. Figure 25 also shows an estimated trend for the US, which suggests a slower take-up than that proposed in this report, as explained above.

Figure 25: Estimated spread of electronic immobilisers in the Netherlands and the US



Source: van Ours and Vollaard, 2014.

Sweden

Very little evidence relating to electronic immobilisers was identified for Sweden. However, being subject to the same EU legislation as Great Britain and the Netherlands it seems reasonable to assume that the spread of the devices would have been similar to that in England and Wales provided the age profile of the vehicle fleets were similar. Eurostat data suggest that the average age of passenger cars in Sweden increased from about seven to nine years during the 1990s, whereas it was constantly around six years old for the UK and the Netherlands. So Sweden had a slightly older age profile and hence the spread of electronic immobilisers may have been fractionally slower in Sweden than in the UK or the Netherlands. However, modelling work showed this effect to be small.[54]

Analysis of theft trends

To analyse the effects of electronic immobilisers, data were gathered on police recorded theft of vehicles and burglary for the period from 1980 to 2013 for seven nations.[55] These were: England and Wales, Scotland, the US, Canada, Australia, the Netherlands and Sweden. Full information on data sourcing is contained in the Technical Appendix.

Table 9 shows changes in vehicle theft levels for each of the nations by decade, along with dates related to electronic immobiliser spread from each nation.

[54] To try and capture the degree to which immobiliser spread in Sweden may have lagged that in England and Wales and the Netherlands, modelling was carried out on two imaginary vehicle fleets, one with an average age of vehicle of 6.5 years and one with an average age of eight years. In the younger vehicle fleet, spread of immobilisers reached 50 per cent in the tenth year. In the older fleet it took 11 years.

[55] Burglary data were collected as well as vehicle theft data in an attempt to test for offence-level displacement or diffusion of benefit.

Table 9: Changes in vehicle theft levels, by decade

	Eng + Wales	Scotland	Netherlands	Sweden	Australia	US	Canada
Dates of electronic immobiliser spread							
Estimated first appearance of electronic immobilisers in mass market vehicles	1991-92	1991-92	1991-92	1991-92	1989-1990	1988-1992	1988-1992
Year in which electronic immobilisers mandated on new vehicles	1998	1998	1998	1998	2001	None	2007
Estimated year in which 50% of all vehicles have electronic immobilisers (threshold)	2000	2000	2000	2000	2000	2006	2006
Changes in numbers of police-recorded vehicle thefts							
1980-90	52%	12%	89%	120%	94%	45%	18%
1990-00	-32%	-29%	43%	-16%	1%	-29%	40%
2000-10	-69%	-66%	-53%	-66%	-61%	-36%	-42%

Sources: Police figures for each nation, see Technical Appendix for details.

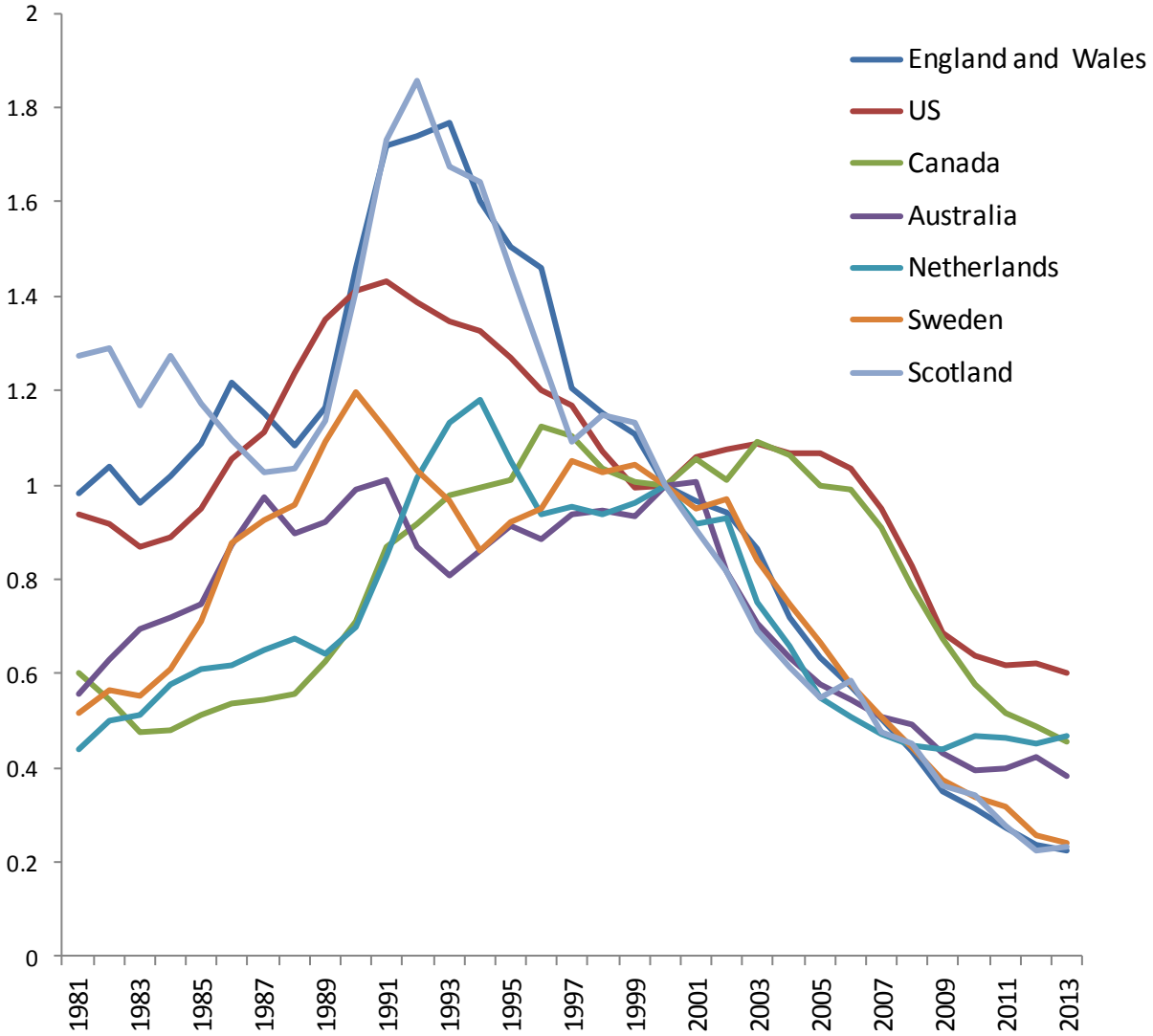
Table 9 shows that all nations had rising trends in vehicle thefts during the 1980s, though with variation of magnitude. During the 1990s trends are mixed with four nations seeing overall falls and three seeing rises (though the rise in Australia is just one per cent). In the 2000s, all the European nations had a decline of more than 50 per cent, while levels in the US and Canada fell around 40 per cent.[56]

The data in Table 9 offer support for an immobiliser effect, given the size of the declines in the 2000s. There is stronger support for the 'delayed impact' hypothesis than for the 'immediate effect' hypothesis. The Netherlands, Canada and Australia all have higher levels of vehicle thefts in 2000 than in 1990 even though a far greater number of vehicles would have had electronic immobilisers by the end of that decade. But the fact that the falls during the 2000s are similar in the European nations and smaller in Canada and the US would be in line with a substantial effect at or around the point when the majority of vehicles became protected.

To further investigate this, trends for each nation were plotted and indexed to 2000, the year in which it was estimated that Australia and the European nations would have a majority of vehicles protected.

[56] Canada's vehicle theft trend is particularly interesting because it does not follow trends in other types of recorded acquisitive crime. While most types of recorded theft (and violence) began falling around 1991 in Canada, thefts of vehicles peaked in 1996 and did not fall sharply until around 2007. Dauvergne (2008) shows that there was variation at the state level within Canada. For the period 1997–2007, for example, most Canadian states saw drops in vehicle thefts in line with other types of recorded acquisitive crime, but Manitoba and Alberta saw large volume increases, which kept the overall Canadian level of thefts high. This could be due to different trajectories of security adoption, but in Manitoba at least, it seems to be connected instead to a surge in joy-riding amongst 15- to18-year-old offenders (ibid.). In other words, available evidence suggests Canada may share some similarities with Australia in that during the period in which penetration of electronic immobilisers was partial, other upward pressures on crime caused displacement to older vehicles and theft trends continued to rise until greater penetration was achieved.

Figure 26: Trends in vehicle thefts in seven nations, indexed to 2000



Sources: police figures for each nation, see Technical Appendix for details.

Figure 26 shows that prior to 2000, trends across the nations were highly variable. But after 2000, the trends become uniform and cluster into two groups. The European nations and Australia have substantial declines from 2000, whereas the US and Canada have declines of a similar magnitude beginning several years later in about 2006/07.

The results of the 'natural experiment' are highly supportive of a marked crime-reduction effect for electronic immobilisers. But they also demonstrate the benefits of government legislation because nations that mandated the installation of electronic immobilisers earlier had earlier drops in crime. Even so, it is worth considering how things might have gone even better. Vehicle thefts dropped even more quickly several decades earlier in FRG following the mandatory introduction of steering locks on *all* vehicles rather than just new ones. Had any country adopted a similar policy for electronic immobilisers in the 1990s, the evidence in this report suggests it would have been highly effective.

A question for future policy-making is the role that consumer choice played in these declines in vehicle thefts. The aim of the original Car Theft Index in 1992 was to encourage manufacturers to install better security by highlighting to consumers each vehicle's relative vulnerability to theft. If security became part of the consumer choice process when buying a vehicle – the logic went – then manufacturers would be forced to up their game and install the latest security devices. It

is hard to gauge how effective this process was. Thefts certainly fell in England and Wales shortly after the Car Theft Index first appeared, but the findings above suggest that the speed at which the majority of the fleet was protected was the crucial factor and this was achieved just as quickly in other nations that did not produce theft indices (to our knowledge). Furthermore, the US, which did have a series of theft indices beginning in the 1980s, had a much slower improvement in security. Taken together this perhaps suggests that consumers paid relatively little attention to security indices, or not enough to affect manufacturers' decision-making process markedly. In a study using data obtained from *Motoring Which*'s annual review of new and used vehicles, Shaw and Pease (2010) attempted to test the degree to which security was used in the decision-making process to recommend vehicles. Their results were somewhat equivocal. They tested two separate years and price was the only factor that was consistently significant as part of the decision to recommend vehicles in both years (with more expensive vehicles being more likely to be recommended). Security was significant in one of the two years, along with several other factors.

In addition, the results shown in Figure 26 demonstrate that the spread of electronic immobilisers through the vehicle fleet, and the crime reduction benefits this brought, was ultimately brought about for the most part by the natural churn of vehicle purchasing. Countries had to wait for enough new vehicles with electronic immobilisers to be bought before their national-level crime trends benefitted from their effectiveness. Outside of Western Australia there was little evidence of significant numbers of individuals retrofitting the devices to older vehicles despite their success; and even in Western Australia the limited success of retrofitting required significant subsidies (see Appendix 4).

Yet it would probably be a mistake to write off consumer-driven theft-reduction policies entirely. Shaw and Pease's result suggests that security levels may play some role in vehicle selection, and even if legislation rather than the Car Theft Index was ultimately the most important factor in driving down crime, the move to create an Index may have spurred the legislative process on and brought manufacturers to the table. Also, the lack of retrofitting may have been a failure of communication rather than consumer willingness. Table 2 showed that a significant number of consumers were willing to spend their own money on security devices like mechanical immobilisers, so perhaps if the benefits of electronic immobilisers had been detected and communicated more widely and more quickly a larger amount of retrofitting may have taken place. It also seems possible that a more tangible device like a mechanical immobiliser might have been more popular with consumers than the invisible – but actually more effective – electronic immobiliser.

A further question about the results shown in Figure 26 concerns whether the security benefits, so evident in relation to vehicle thefts, also diffused to other crimes. As such, burglary trends were analysed to see whether the correlation and sequencing of trends supported a diffusion-of-benefits hypothesis. The main results are shown in Table 10.

Table 10: Statistics on burglary and vehicle theft trends for seven nations

	Eng + Wales	US	Canada	Australia	Netherlands	Sweden	Scotland
1980-2013 correlation	0.96	0.37	0.19	0.86	0.55	0.76	0.87
Vehicle theft peak	1993	1991	1996	1991	1994	1990	1992
Burglary peak	1993	1980	1991	2000	1994	1992	1991
Sequencing	Simultaneous	Burglary first	Burglary first	VT first	Simultaneous	VT first	Burglary first
Five years pre-threshold (VT)	-33%	-2%	-6%	9%	-5%	9%	-31%
Five years pre-threshold (B)	-33%	4%	-10%	13%	-23%	-8%	-34%
Five years post- threshold (VT)	-41%	-34%	-46%	-46%	-44%	-39%	-35%
Five years post-threshold (B)	-29%	-4%	-24%	-40%	5%	-16%	-33%

Sources: Police figures for each nation, see Technical Appendix for details.

Note: Correlation coefficients (top line) are significant at the one per cent level for all nations except the US, which is significant at the five per cent level and Canada, which is not statistically significant.

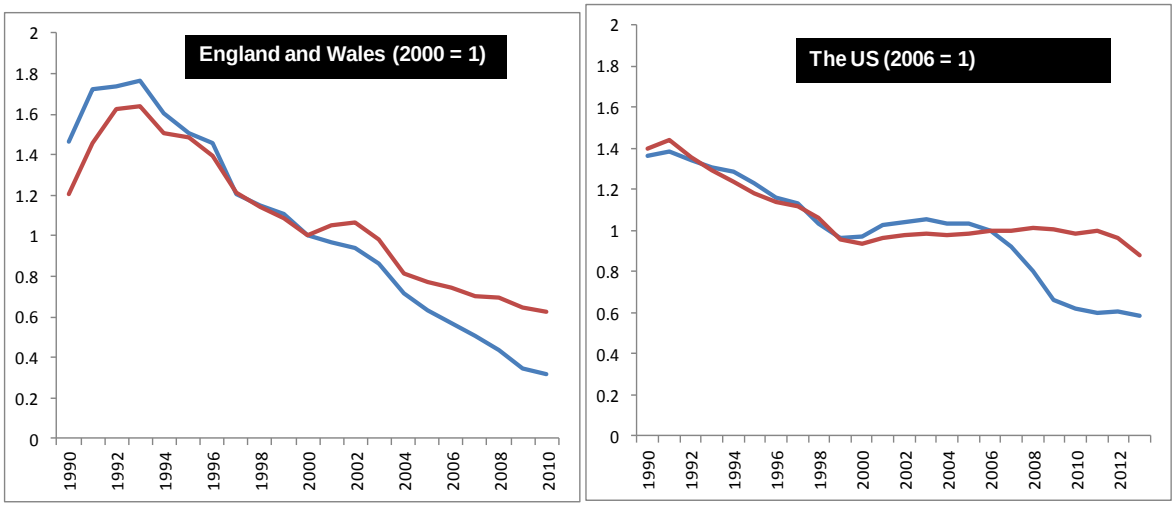
The first row of Table 10 shows the correlation coefficients between burglary and vehicle theft in each nation from 1980 to 2013. There is generally a high correlation in the European nations and in Australia, but much lower correlation coefficients for the US and Canada.

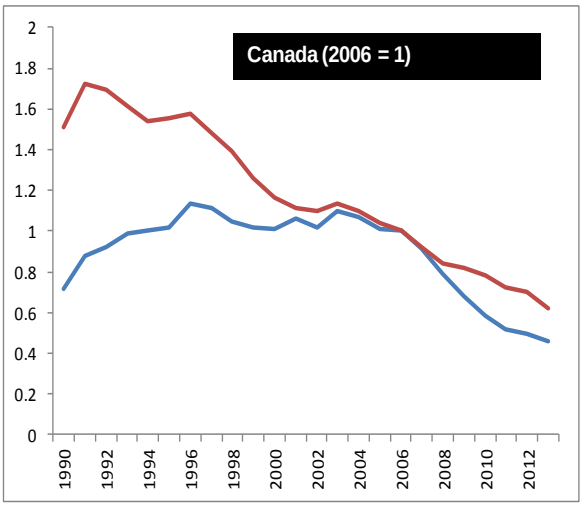
The next three rows look at the timing and sequencing of the peaks. This reveals a mixed picture with three nations having peaks simultaneously or with burglary following vehicle theft with a short lag (Sweden) or long lag (Australia). Broadly speaking, these would support a diffusion-of-benefits hypothesis. But in three other nations the sequencing is reversed and in the US in particular, burglary peaks more than a decade earlier than vehicle theft.

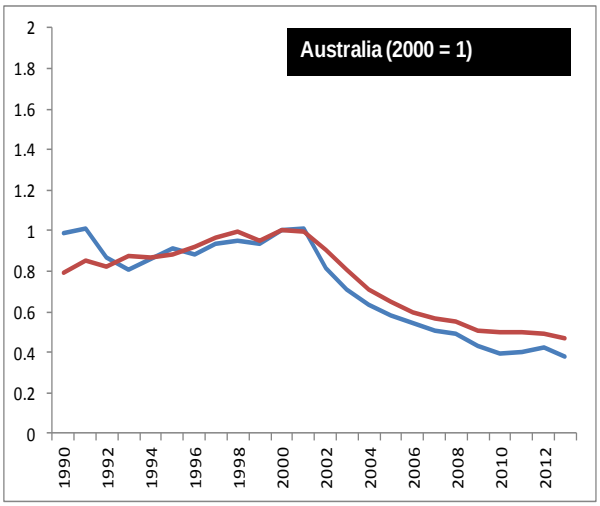
The final four rows are an attempt to look at displacement and/or diffusion to burglary at the point at which most evidence suggests electronic immobilisers had their greatest impact. This is referred to as a notional 'threshold' in Table 10 and is set at 2000 for the European nations and Australia and 2006 for Canada and the US in line with the evidence presented above. The table shows the percentage change in levels of the two crime types for the five years before and after the threshold. Pre-threshold, trends in both crime types are variable, with falling trends of differing magnitude in five countries and rising trends in two countries. After the threshold, trends become uniform for vehicle theft with all nations seeing falls of between 34 per cent and 46 per cent. Burglary figures after the threshold remain quite varied, though all countries apart from the Netherlands experience falls of between four per cent and 40 per cent.

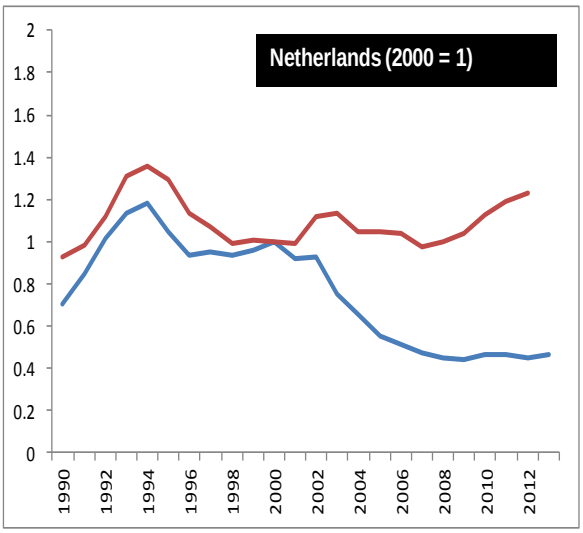
Another way to analyse diffusion and/or displacement impacts would be to look for deviations in trend at the point of maximum immobiliser impact. Figure 27 shows a panel of charts with burglary and vehicle theft trends for each nation.

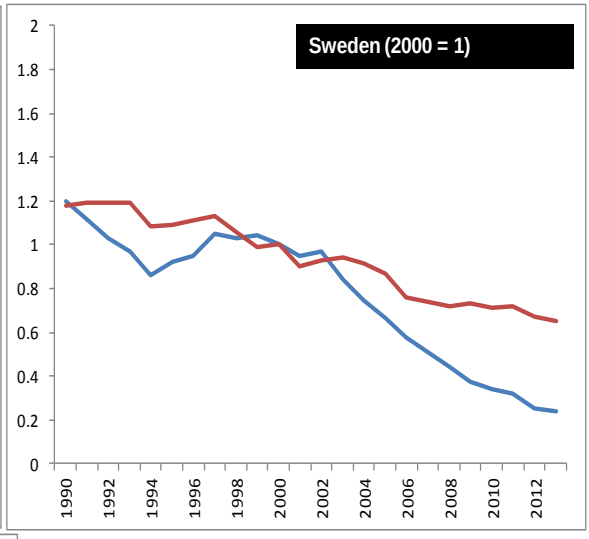
Figure 27: Indexed trends in burglary (red line) and vehicle theft (blue line)

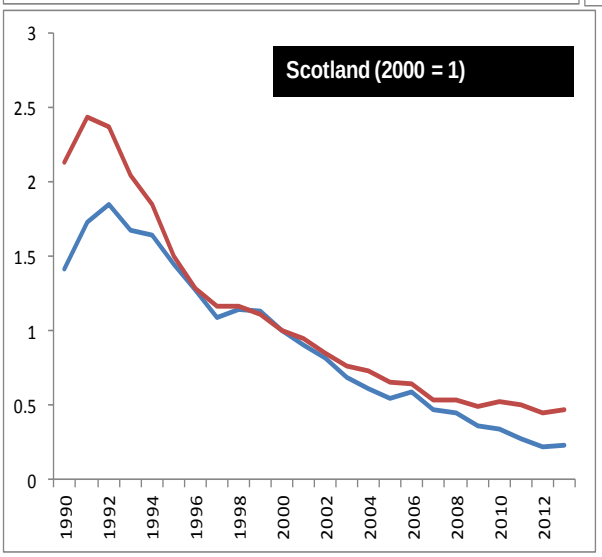












For most nations, burglary trends do not seem to deviate markedly at the 'threshold' point, when electronic immobilisers were installed in more than half the vehicles on the road. If anything the two trends often separate at this point, suggesting that immobilisers affected one but not the other. In other words, there does not appear to be significant evidence of either displacement or diffusion. Australia is an exception. In Australia, the trend in burglary does deviate sharply at the threshold point, falling more or less in line with vehicle theft. Australia is also the only country in which the estimated threshold point is in line with the turning point for overall recorded crime.

An attempt was made to repeat this analysis for trends in theft from vehicles, to see whether there was evidence of diffusion of benefits. However, data could not be sourced for all nations

and the results – shown in full in the Technical Appendix – were somewhat inconclusive. For the US and Canada, trends in theft from vehicles show little if any deviation when theft of vehicles starts falling in 2006. But for most other nations, theft from vehicles does show signs of deviation from 2000 on, falling at the same rate, or slightly slower than, vehicle thefts. There is partial support, then, for the theory that benefits from electronic immobilisers diffused to theft *from* vehicles, once a majority of vehicles on the road had the devices.

Conclusion

Available evidence suggests that electronic immobilisers *first* appeared in new vehicles in the late 1980s or early 1990s for all the seven developed nations studied. However, due to differences in legislation, the speed of spread was different in different countries. In particular, it was slower in the US and Canada than elsewhere.

Analysis shows that trends in thefts of vehicles were varied across nations, with different peaks at different times. But at the point where electronic immobilisers were installed in around half of all vehicles, which occurred in around 2000/2001 for most nations but later for the US and Canada, thefts fell sharply and uniformly by around 40 per cent. This suggests that electronic immobilisers were effective but that they were not necessarily the catalyst for the falls in vehicle thefts in all nations.

These results also imply that government legislation was an important factor in bringing down theft, but that had the legislation applied to all vehicles rather than just new ones, crime reductions could have occurred even more rapidly.

Tests were also conducted to check for diffusion of benefits to burglary at the time when electronic immobilisers appeared to have their greatest crime reduction impact. For the most part little evidence of diffusion was found, although there was some tentative evidence in relation to theft from vehicles.

6: The current vehicle crime landscape

This section examines current data on vehicle crime, with the aim of drawing out policy conclusions in relation to whether security remains a deterrent for thieves.

In 2014 in England and Wales, there were 75,000 recorded vehicle thefts and 246,000 recorded thefts from vehicles (the corresponding figures for the CSEW were 58,000 and 668,000).[57] This represents a fall of more than 75 per cent in total vehicle crime since the mid 1990s on both sources. Despite this large fall in offences, rates at which offenders are charged for vehicle offences remain low. In 2014/15, 86 per cent of the outcomes assigned to vehicle thefts were: "Investigation complete – no suspect identified" and only five per cent resulted in an offender being charged.[58] It is hard to determine precise trends over time as recording practice has shifted several times, but examination of historical reports suggests that detection rates for vehicle crime shifted little during the 1990s, through the rise and then fall in crime. So there is little evidence to suggest that the fall has been due to an increased number of offenders being caught.

Evidence presented in the rest of this report suggests instead that other factors are likely to have been responsible for the fall in vehicle crime, including the spread of electronic immobilisers, which deterred offenders rather than causing more to be apprehended.

However, two separate strands of recent evidence have been cited to suggest that security effectiveness may now be waning. These are:

1) **The effect of technological change**: Evidence shows that tools are available (and easy to buy via the internet[59]) which allow thieves to bypass current car security. A number of recent research studies have examined this phenomenon and concluded that "electronic immobilisers are now prone to getting hacked". (Choudhuri et *al*., 2014; Mason, 2012).

2) **Current trend data**: Though vehicle crime remains at a historically low level in virtually every nation studied in this report, there are signs that the downward trend may be slowing. The latest Police Recorded Crime statistics for England and Wales showed a three per cent rise in 'theft of vehicles' for the year to June 2015 and the trend for vehicle thefts in Western Australia has also turned upwards.

To examine the current situation, data were sourced from the Metropolitan Police Service (which has also seen its first annual rise in vehicle thefts for around 20 years) on vehicle thefts

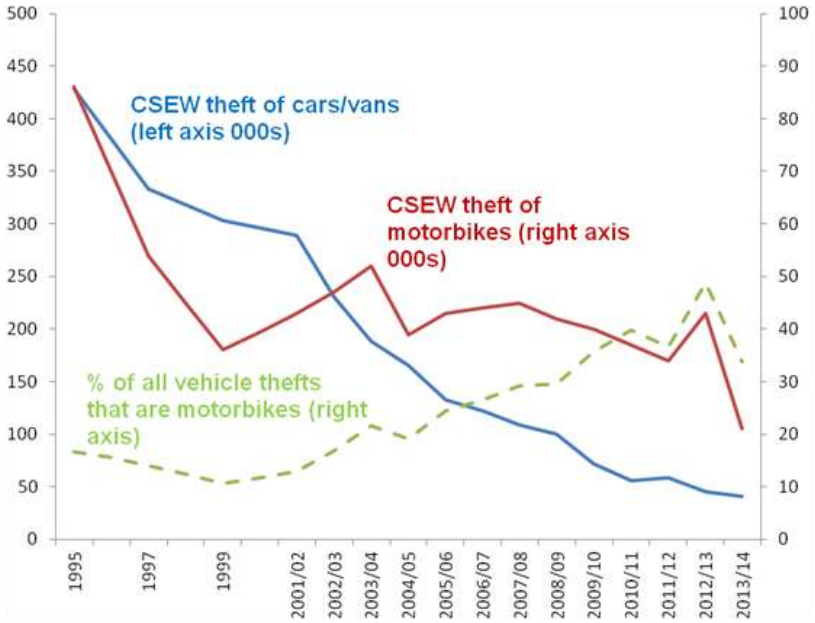
[57] Note that the actual number of stolen vehicles is likely to be higher than 75,000. Recorded crime figures use the 'principle offence rule' which counts a crime involving multiple offences within the category of the most serious of those offences. So a burglary in which a thief steals car keys and takes the vehicle from outside the house is recorded as a burglary rather than vehicle theft.
[58] It is likely that ultimately around 90 per cent of the 2014/15 offences will result in no suspect being identified as the latest figures show that four per cent of cases are still pending.
[59] Research demonstrates a range of products available on the internet with a wide price range. Some products are expensive and may therefore be unavailable to low-level thieves for that reason, but even low prices imply the need to plan, and commit to, the crime in advance, which may not be compatible with opportunist offenders (Gottfredson and Hirschi, 1990).

in London for 2012[60] and 2014, broken down by age and type of vehicle. These data have slightly higher annual totals than are captured in PRC because they include vehicles stolen in burglaries (which are recorded as burglaries, rather than thefts of vehicles in police figures). This small discrepancy aside, comparing the two years of data showed that the slight rise in vehicle thefts in London is due to an increase in the theft of motorbikes. Whereas car thefts in 2014 were down by 15 per cent compared with 2012 (equating to around 2,800 fewer offences), motorbike thefts had increased by 44 per cent (around 2,900 extra offences). Separate but unpublished analysis by the Retail Motor Industry Federation (RMIF) using data from the Police National Computer, which looked at the whole of England and Wales, also suggests a rise in motorcycle thefts during 2014.[61]

It is not clear why motorbike theft appears to be increasing. The rise is not simply a reflection of increased motorbikes on the road, as Department for Transport statistics show that whereas numbers of registered cars are rising again following a lull after the 2008 recession, numbers of motorbikes have been largely flat for the last five years. It is possible that there is some displacement from car theft as a result of security deterrence (though no direct evidence of this could be located). Media reports have also suggested that stolen motorbikes are being used to commit other crimes: data released by the MPS showed that there were 1,240 recorded crimes in London in which suspects rode mopeds or motorbikes during the 12 months to February 2015.

The Crime Survey shows that, due to the drop in car thefts, motorbike thefts have gradually made up a bigger proportion of all vehicle thefts (grouping together the years since 2010, this proportion currently stands at about 40 per cent). That means fluctuations in the trend for motorbike thefts can now affect the trend in all vehicle thefts, see Figure 28.

Figure 28: Thefts of cars/vans and motorbikes from 1995 to 2013/14



Source: ONS, Crime Survey of England and Wales

[60] The 2012 data actually covered the 12-month period from November 2011 to October 2012.
[61] Police recorded crime data obtained from 17 forces for 2014/15 also showed an overall rise in motorbike/scooter theft. Additionally, there were some rises in recorded *car* theft in a few of the police forces with the largest crime volumes, but overall, theft of cars was down up to the end of 2014.

The thefts data from the MPS was also broken down by age of vehicle to see whether the pattern for lower theft rates among newer vehicles – visible in Figure 9 – has been maintained through to 2014. Figures 29 and 30 demonstrate that it has.

Figure 29: Cars stolen in London in 2014, by age of registration

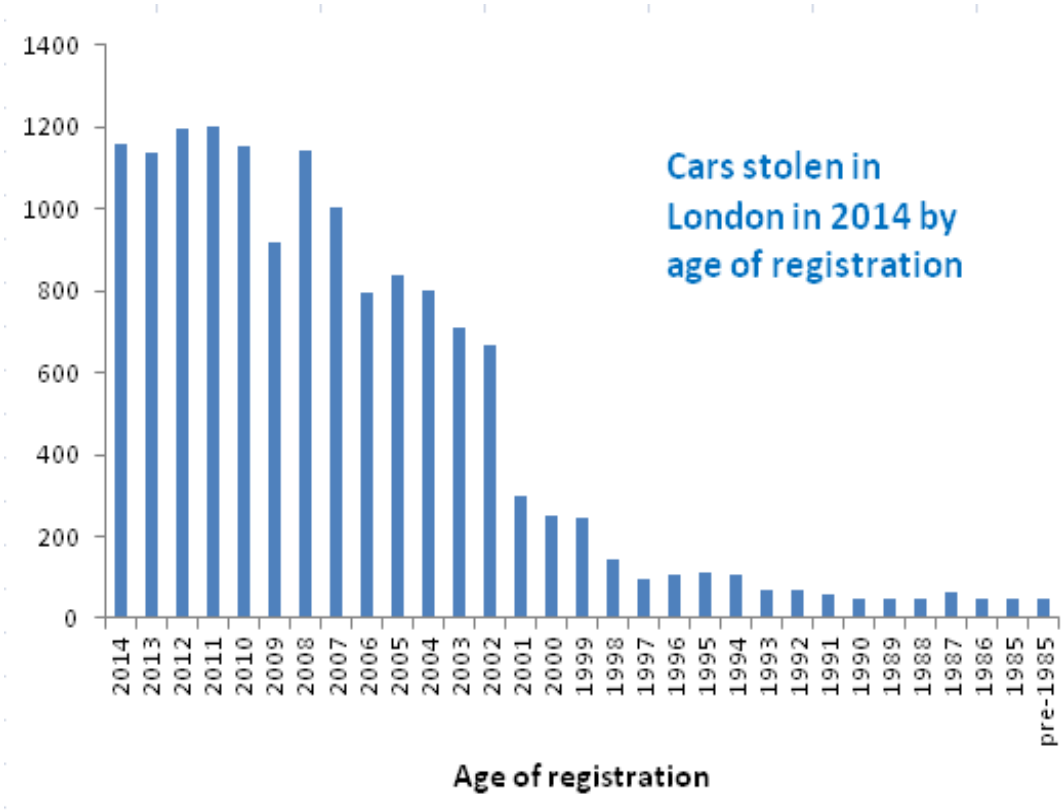
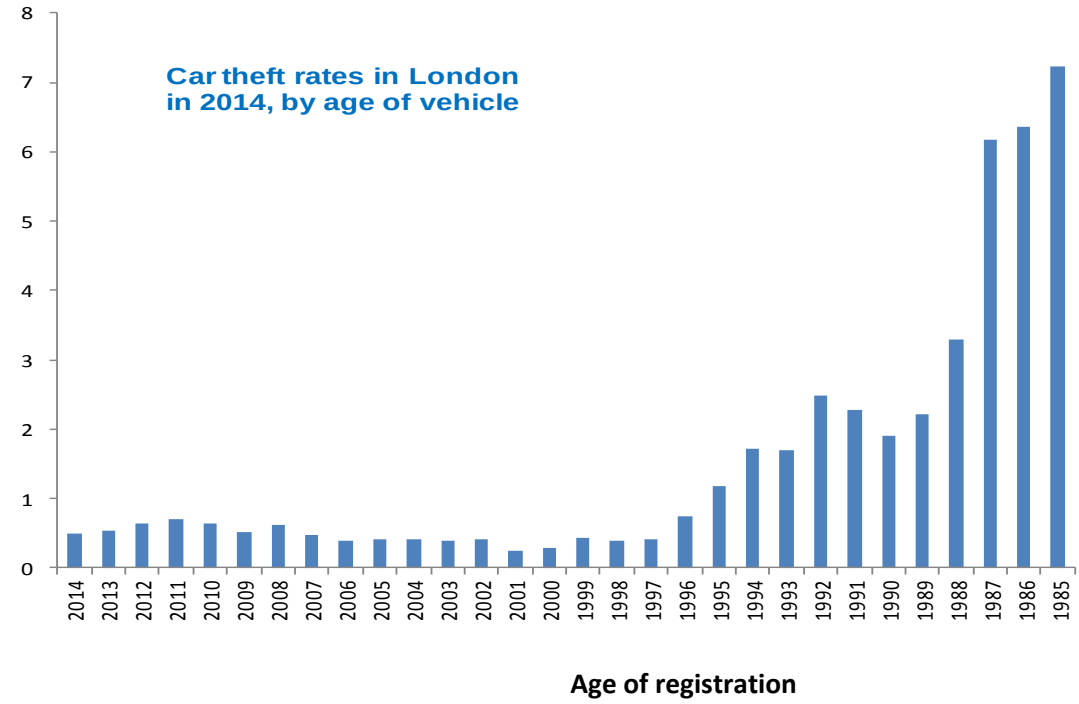


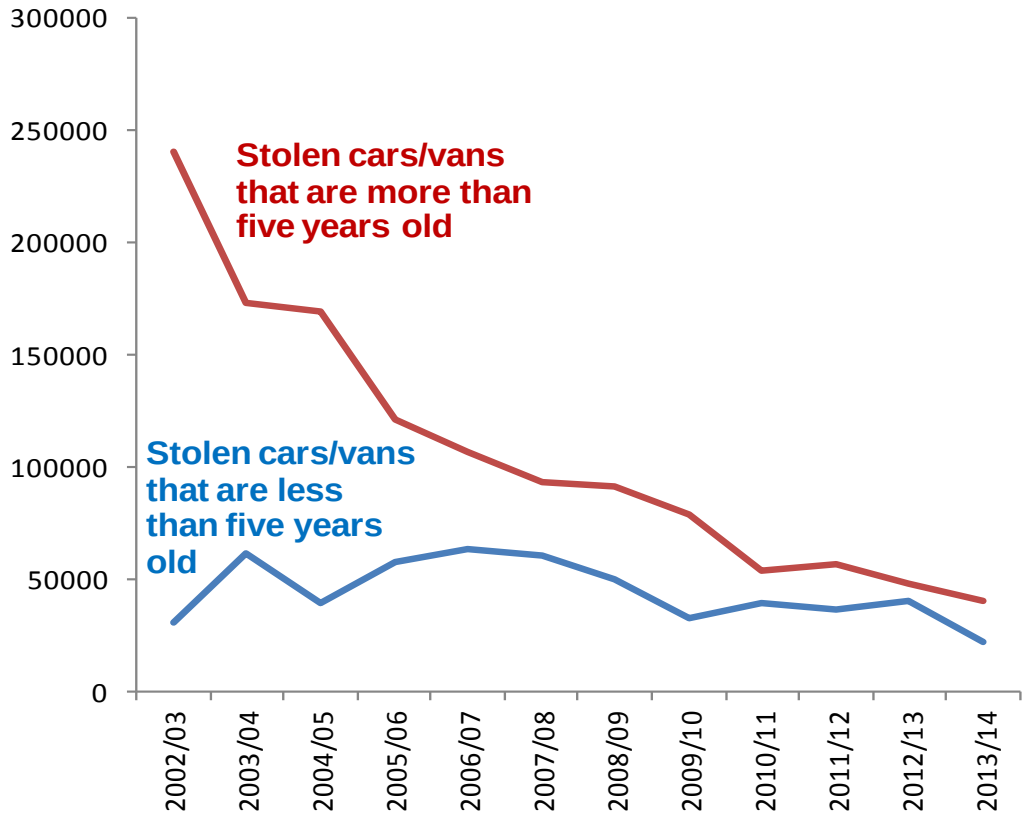
Figure 30: Car theft rates in London, per 1,000 vehicles on the road, by age of registration



Source: MPS data.

Figure 29 shows that in volume terms, newer cars make up a far higher proportion of stolen vehicles than older cars, but that once this is adjusted for numbers of cars on the road, those vehicles that were made in the 1980s (before the second wave of vehicle security began) are still more likely to be stolen even though they collectively make up less than two per cent of vehicles on the road. In other words, it appears as though vehicle security may still be keeping theft rates down, with only a few offenders bypassing the security to steal newer vehicles, and some thieves *still* seeking out older cars with weaker security. Similar trends from the CSEW also support this. Figure 31 suggests the fall in thefts of vehicles through the 2000s has been wholly driven by the gradually reducing pool of older, more vulnerable cars on the road.

Figure 31: CSEW car/van thefts, broken down by age of vehicle



Source, ONS, Crime Survey for England and Wales.

These trends are consistent with the conclusion that most vehicle theft offenders operating today are more organised criminals capable of bypassing current security levels. Hence new security devices may be required. The results from Farrell *et al*., (2011) suggest that tracking devices may be highly effective but that they are only installed on a minority of vehicles currently. Anecdotal evidence from officers working on vehicle crime in the Metropolitan Police Service suggests that some offenders routinely park a vehicle in a safe location for a few days immediately after stealing it to check it is not being tracked. This would suggest that boosting the number of vehicles with tracking devices might reduce the 'rump' of more organised vehicle theft that remains. However, trackers may also have limitations. Jamming devices which prevent stolen vehicles being tracked are also available online (Choudhuri *et al*., 2014; Mason, 2012).

A further point to make in relation to Figure 31 is that it is slightly at odds with the new research suggesting that current electronic vehicle security can be easily compromised and that newer

cars are therefore easy to steal again, despite the presence of electronic immobilisers and other security devices. Two possibilities suggest themselves:

i) the degree to which security has been compromised has been somewhat exaggerated; and/or

ii) security is easier to overcome, and hence the *opportunity* for committing car theft has increased markedly, but thefts remain low for another reason.

It is hard to determine which of these two positions is closest to the truth. But given the potential threat for electronic compromise of security, there is a clear priority for policy-makers to try and better understand the degree to which new technology does or does not make cars easier to steal. The other main conclusion from this section is that security on motorbikes does not seem to be as effective at preventing thefts as security on cars, hence looking at methods for better protecting motorbikes should also be a priority if the long-standing decline in vehicle crime is to continue.

7: Conclusion

The Home Office published a discussion paper on opportunity/security as a driver of crime in line with the Home Office hosted crime and policing conference in January 2015. The paper provoked much debate on this issue. This analytical report has attempted to clarify some points and add further to the discussion.

The idea that opportunity and security might cause crime and hence drive crime trends has come a long way in the last 40 years (Clarke, 2012). Before that, crime causation theories focused mainly on the development of criminality within individuals and assumed that changes to this process drove aggregate trends. The research of Clarke and others challenged this view, giving rise to situational crime prevention, which showed that altering the crime environment by improving security or lowering opportunity *could* reduce numbers of crimes committed. This is now reasonably well accepted and has become an important plank of policy-making.

Neither the discussion paper, nor this research report, sought to challenge the importance of that journey. Opportunity/security is an important driver of crime; but not the *only* driver of crime.

The main aims of this report were to examine long-term trends in vehicle security; to draw out policy lessons and to examine a new strand of opportunity-based research: 'the security hypothesis'. The hypothesis suggests that better security, particularly on cars and houses may be the main reason why crime has declined (Farrell *et al*., 2014). The most studied example has been the electronic immobiliser and numerous reports have demonstrated its effectiveness in preventing vehicle theft.

The analysis presented here has added to that evidence base. Unlike earlier advances in vehicle security – which may have deterred thieves for a while – but which clearly provided limited deterrence by the end of the 1980s, electronic immobilisers seem to have been one of the main reasons why vehicle thefts have fallen further than just about any type of crime in many of the nations studied in this report, and why they have continued to decline through to 2014.

But were electronic immobilisers the catalyst for the vehicle crime turning point? On balance, the evidence presented in this report suggests not. Rather, the main impact of electronic immobilisers appears to have been delayed until they reached critical mass within the vehicle fleet. In many nations, the crime decline was well under way by then.

In England and Wales for example, all types of theft – vehicle crime, burglary and personal theft (as measured by the CSEW) – fell sharply from the mid 1990s. For immobilisers to have caused that, they would not only have had to reverse a steeply rising trend in stolen vehicles *and* in other types of theft, but they would need to have done this at a time when fewer than one in ten cars on the road had the devices. This is not impossible, but it places a heavy burden on the power of the debut crime/keystone crime hypotheses to transmit benefits to other crimes. Furthermore, thefts of vehicles made up just three per cent of crime in England and Wales at the crime peak according to the Crime Survey (total vehicle crime made up 22 per cent), so it

seems unlikely that ‘diffusion’ from electronic immobilisers can fully explain the fact that overall crime fell 62 per cent between 1995 and 2013/14.

Alternatively, strong evidence may emerge that other types of vehicle security, like central locking, may have had an earlier impact. Or that housing security improved markedly at the same point in time, negating the need for diffusion of benefits from immobilisers to burglary. But even then, further explanations would be required. In the US, and in certain parts of the UK (Merseyside and Edinburgh), burglary peaked far earlier than it did elsewhere, which would suggest two-speed trends in housing security levels. And if central locking was important, why did vehicle thefts rise so sharply in the early 1990s when this technology was first spreading?

Arguably more plausible is that better security is just one of several factors that explain the decline in crime, and some of these are explored in Appendix 5. Whatever the driving force, one fact about crime trends that emerges from the analysis in this report, from the local to the national, and whether they relate to violence or property crime, is the sharpness of many of the crime turning points (see Figures 20, A2.1, A2.2, A3.3). Crime generally did not gradually switch from a rising to a falling trend; it spiked. Whilst it was not the purpose of this paper to try and explain this phenomenon, some thoughts are offered in Appendix 3.

It should be acknowledged that there are limitations to the analysis in this report as well as several bits of missing data that could strengthen or disprove the conclusions. Trying to explain a change that has already happened is a complex exercise that is subject to bias given that no prospectively generated control groups are available. This report has attempted to use systematically gathered trends at different geographical levels and employed some natural experiments to generate findings, but ultimately the exercise involves looking for patterns in historic data and triangulating where possible. As such, it is difficult to be conclusive about any findings. All that can really be said is that the findings represent a plausible explanation of the data available. And further data would help. It would be useful, for example, to have more information about immobiliser spread in the US and Canada. It would also be helpful to see Australian theft rates by age of car from the early 1990s to check that the low rates on vehicles up to ten years old was a phenomenon that emerged through that decade, in keeping with improved security, or was always the case.

Where does this evidence leave the security hypothesis? This paper has provided some challenges, particularly in relation to claims that security may have been the catalyst for the initial turn-around in crime. But it has also provided further evidence that better security did play an important role in the drop in vehicle thefts and probably also contributed to the decline in thefts from vehicles. Further analysis may yet add more evidence in relation to security improvements to houses and shops and possibly even in relation to violent crime. Certainly, the example of electronic immobilisers clearly suggests that changes to security levels can change *national* levels of crime, and hence that situational crime prevention must remain a crucial pillar of any crime reduction programme, even if other factors also played a role in the crime drop.

Indeed, from an opportunity perspective, the scope and reach of cyberspace has arguably created the greatest ever challenge for crime and policing policy-makers. As well as providing the opportunity for potential victims and offenders to come together in ways that were unimaginable a few decades ago, it also means that methods for overcoming security can be disseminated quickly and universally. Instruction manuals for how to bypass electronic immobilisers and steal cars quickly are now available on the internet. At the timing of writing,

however, there is limited evidence that this is having an effect on levels of vehicle theft, which remain at historic lows.

It is hard to know whether to interpret this as evidence of the long-lasting impact of security or as an indication that the number of people who would even think to look online or elsewhere for methods of stealing cars has decreased since the 1980s and 1990s. Certainly there is ample evidence that crime is only one type of risky behaviour that has fallen over the last two decades, which would suggest that there has been a general shift in young people's attitudes that has accompanied improved security and the fall in crime (Mishra *et al*., 2009; HM Government Horizon Scanning Programme, 2014). The roots of these attitudinal changes remain to be fully explained, but *something* appears to have worked and it would be helpful to identify more precisely what that is. So whilst the evidence in this paper suggests that reducing opportunity and improving security remain important crime reduction tools in the new (cyber) crime landscape – and the equivalent of the electronic immobiliser for cyberspace would certainly be welcome – it perhaps also suggests that proven interventions aimed at preventing criminal careers and reducing long-term propensity for crime should remain part of the policy-makers' toolkit.

Appendix 1: Diffusion, displacement and switching

As the above discussion has emphasised, it is impossible to analyse the degree to which opportunity and security have affected aggregate-level crime trends without understanding the concepts of displacement and diffusion (of benefits). Hence this brief section will seek to explain these terms as well as to distinguish them from 'switching', which – as it is defined below – is a separate but equally important phenomenon in this context. A brief summary of the evidence in relation to these effects is also attempted.

- **Displacement and diffusion** (of benefits), in this context, are effects that may or may not occur in reaction to some kind of crime-reduction intervention. For example, if CCTV is introduced in a car park with the intention of reducing the number of offences, it may be the case that offences reduce in that car park but increase in a neighbouring one, as thieves simply switch locations. That is displacement. But it is also possible that the neighbouring car park *also* experiences reduced offences. This phenomenon – which is called diffusion of benefits – could occur if offenders are put off crime entirely by the introduction of CCTV. As Felson and Clarke (1998) point out, there are at least five ways in which displacement/diffusion might occur (their list below relates to displacement but theoretically diffusion might operate through similar channels):
    - *geographic displacement* (crime moves from one location to another);
    - *temporal displacement* (crime moves from one time to another);
    - *target displacement* (crime moves from one target to another);
    - *tactical displacement* (one method of committing crime can be substituted for another);
    - *crime-type displacement* (one type of crime can be substituted for another).

  Measuring all these different types of displacement/diffusion is not easy and requires very carefully constructed control groups to be done properly. For example, in an environment in which crime is falling generally, it is very easy to mistake a general trend for diffusion of benefit from an intervention and vice versa.

- **Switching,** in this context, refers to a change in criminal behaviour that is not caused by a crime-reduction intervention but for some other reason. This may relate to conditions related to opportunity and security. For example, mobile phone thefts increased sharply in the late 1990s while theft of other goods (like car stereos) decreased. This suggests the possibility that thieves switched target as a result of the increased opportunity to steal phones. Mobile phones were rare in the early 1990s but ubiquitous by the end of the decade. However, switching might also occur for reasons unrelated to opportunity, like a change in the relative value of the two goods or simply a change in fashion.

A great deal of research has examined displacement and diffusion. A review by the Dutch Ministry of Justice (Hesseling, 1994) examined 55 studies that measured displacement/diffusion effects following a situational intervention. In six of the 55 studies, no evidence of displacement was found but there was evidence of diffusion of benefits. In 16 studies there was no evidence of either displacement or diffusion and in the remaining 33 studies, displacement occurred but not to the extent that the original crime reduction benefit was completely offset. In other words, there was always a benefit to the intervention.

This finding has been reinforced by more recent studies. A systematic review of 102 situational crime interventions by Guerette and Bowers (2009) found evidence of displacement in 26 per cent of the studies and diffusion of benefit in 27 per cent. Another systematic review by Grove *et al*. (2012) also found that a diffusion of benefit was about as likely to be observed as displacement. As Felson and Clarke (1998) have pointed out, this is powerful evidence that changing the crime environment can have important crime reduction effects, and that crime does not simply move elsewhere.

In the current context though, it is important briefly to note some limitations of this evidence. Firstly, quality of research design is slightly variable amongst the studies and very few measured all types of possible displacement. Of particular relevance to this paper is that in both the Hesseling (1994) and Guerette and Bowers (2009) reviews very few studies examined displacement/diffusion effects in relation to other crime types (Johnson *et al*., 2014) and fewer than ten per cent measured temporal displacement. Most studies looked at local, spatial displacement/diffusion only (ibid.).

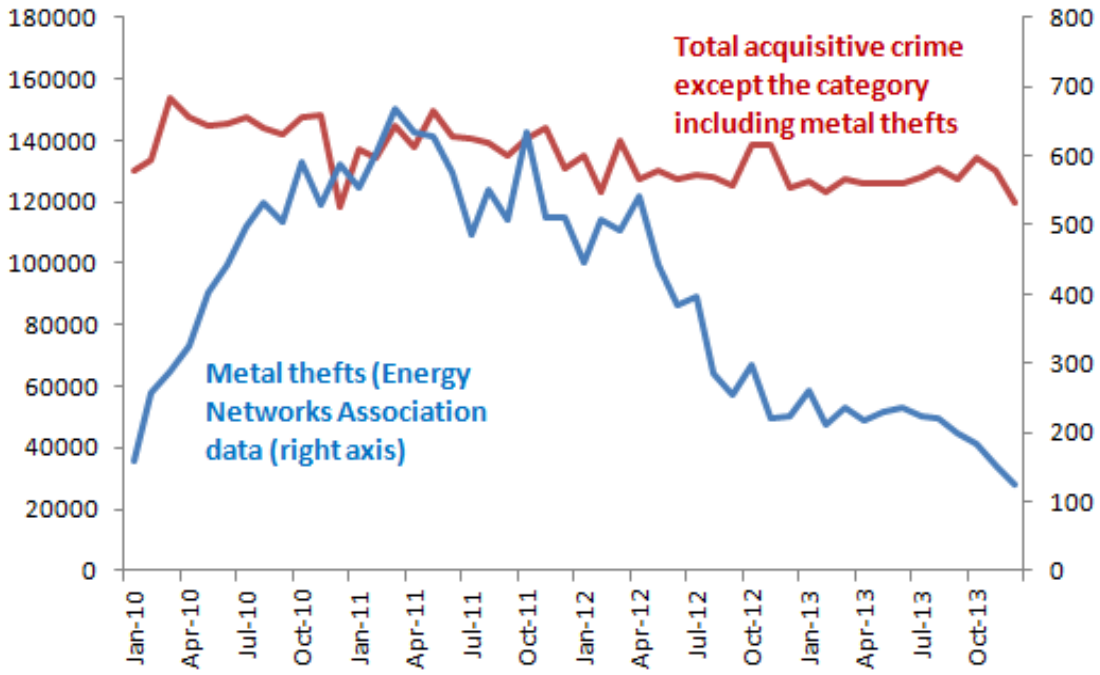
Secondly, the results – powerful though they are in demonstrating the effectiveness of individual situational interventions – do not really tell us much about the extent to which situational crime prevention as a whole has driven *aggregate* level crime trends. To determine that, it would be necessary to estimate a trend in situational crime prevention over time. For example, many of the reviews highlighted above demonstrate that problem-solving policing is an effective tactic that reduces crime without displacement. Yet it is still difficult to say how much this has contributed to the crime drop as we do not know how the amount of problem-solving policing has changed over time.

This is not to say that situational crime approaches have not affected national-level trends. In some cases, like those relating to immobilisers and vehicle crime examined in this paper, the evidence is compelling. Another example is the study by Mayhew *et al*. (1989) showing that legislation requiring motorcyclists to wear helmets triggered a fall of around 100,000 motorbike thefts within six years. Given the absence of any other potential explanation and the fact that a similar drop occurred when the same legislation was introduced in England and Wales, the authors concluded that the fall was caused by an opportunity effect: offenders wanting to steal a motorbike now had to go equipped with a helmet (Mayhew *et al*., 1989). Furthermore, although there was some evidence in Germany of displacement to thefts of cars, and possibly also bicycles, it did not offset the drop in motorbike thefts, in volume terms at least (ibid.). Again, this is good evidence that making criminal opportunity harder is a very valid way of reducing crime, even at the national level. But like most of the vehicle-crime examples above, the motorcycle legislation produced a national-level effect on motorbike theft only. It did not, in Germany or in England and Wales, cause a crime turning point in several different crime types at the same time.

This is important for the analysis in this paper because it identifies instances in which crime types have risen and fallen simultaneously at the national level but also instances when a single crime type moves in a quite unique way. Generally, the available evidence on displacement seems to suggest that the latter instances are more likely to be driven by opportunity/security changes. Or to put it another way – when the opportunity to commit a particular type of offence is reduced through improved security or some other method, the most common result seems to be a reduction *in that type of offence only.* Sometimes there may be a little displacement to other crimes, but this generally does not offset the benefits of the intervention entirely, but almost never – to our knowledge – is there an obvious example in which diffusion of benefits has occurred to alternate crime types at the national level. The motorbike example drove a drop in motorbike thefts, but not a drop in car or bike thefts. When an earlier vehicle crime security device was introduced, it had a large crime-reduction effect on car theft, but there was some possible displacement to motorbike theft and no discernible effect at all on theft from vehicles (Webb, 1994).

Two more recent examples have similar results. Metal thefts increased in England and Wales from 2009 to 2011, as they did in many other nations, due in all likelihood to the rise in global metal prices during that period (Sidebottom *et al*., 2014). Yet the rest of acquisitive crime continued to fall. And when a combination of enforcement and legislation (beginning in early 2012) reduced the opportunity to dispose of stolen metal profitably by restricting and then banning cashless trading at scrap metal yards, metal thefts reduced markedly. But again, there was no obvious deviation in the trajectory of other acquisitive crime trends, see Figure A1.1.

Figure A1.1: Metal thefts and other acquisitive crime, 2010–2013



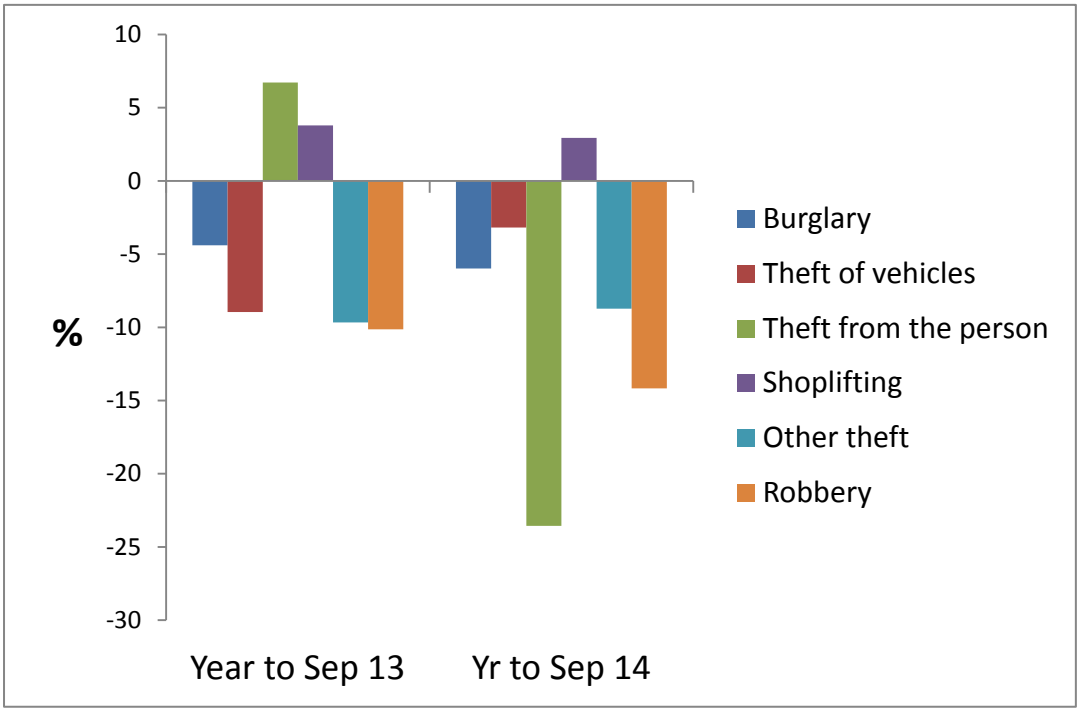
Sources: Energy Networks Association data for metal thefts; ONS, police recorded crime for total acquisitive offences.

One final example is important here. Another recent security success appears to have been the introduction of activation locks on mobile phones. Initial analysis has suggested these had an instant impact on mobile phone thefts in London (BIT and Home Office, 2014). In the 12 months to September 2013, recorded thefts from the person were up by seven per cent in England and Wales with i-phone thefts particularly prominent. Then Apple introduced its activation lock via the operating system ios7, which was incorporated on almost 80 per cent of i-phones within

three months. This quick rate of penetration (far faster than that for vehicle security during the 1990s[62]) seemed to have an instant effect. Data for the 12 months after ios7 was launched showed that theft from the person was down by 24 per cent.

In this instance benefits probably *did* cut across crime types. But this is because phone theft is not a crime category on its own. Phones may be stolen in thefts from the person, but also in robberies or in 'other thefts'. They'd be less likely to be stolen in burglaries, thefts of vehicles or incidents of shoplifting. This makes detection of displacement and/or diffusion of benefits more difficult. Figure A1.2 shows an apparently big crime-reduction effect for theft from the person, and possibly a smaller effect for robbery and other theft. But the year-on-year trends in other crime types seem largely unaffected.[63] In other words, it does not seem to be the case that the benefits from the activation locks on phones diffused to theft generally.

Figure A1.2: Percentage change in theft levels compared to the previous year



Source: Police recorded crime, ONS.

Overall then, there are many persuasive examples of security bringing down levels of the crime against which the security is targeted. But there is no strong evidence from these examples that the benefits diffuse from one type of crime to another.

A separate point needs to be made in relation to switching. Farrell *et al*., (2014) has used the fact that mobile phone thefts increased while thefts of other items fell in the late 1990s as a test for crime-drop hypotheses. The argument being:

"Phone theft ... is a street crime which increased when others were decreasing (Mayhew and Harrington, 2001), and at the time of writing in 2013 is experiencing a resurgence due to expensive smart phones. More generally, theft of valuable electronic goods such as laptops and

[62] For the speed of ios7 adoption see: http://www.macnn.com/articles/14/07/14/figure.based.on.visits.to.the.app.store.growing.at.one.percent.a.month/

[63] A fascinating question for future research is whether activation locks on phones drove diffusion or displacement within the items targeted. i.e. within theft from the person did the improved security on phones cause an increase in thefts of other types of items even as overall thefts declined?

GPS-Satnavs have increased. Any explanation of the decline in other crime types must not contradict these facts. Most hypotheses fail this test because they suggest that all types of crime should have decreased. This is because their focus is the number or the motivation of offenders."

Farrell *et al*., 2014.

The logic of this test is not clear to the current authors. The type of goods stolen will change over time as fashions, values and opportunities shift, but it seems perfectly possible for this to co-exist with a rising or falling offender population and for that to be the key factor in driving crime. Put differently, if there were 10,000 active offenders in the 1980s and just 100 in the 2000s, the latter would still commit more mobile phone theft and internet-related offences because mobile phones and the internet did not (effectively) exist in the 1980s. But overall crime would still be down, due to the vast fall in numbers of offenders.

Appendix 2: The effect of LoJack on car thefts in the US

The analysis in the main report suggests that the fall in vehicle crime in the US from 1991 would be unlikely to be caused by electronic immobilisers given that such a small proportion of vehicles would have had them installed at that time. However, it is possible that another security device was responsible: LoJack tracking equipment.

Its effectiveness was examined by Ayres and Levitt (1997), who concluded that LoJack reduced vehicle thefts, though more so in some parts of the US than others, and that benefits diffused to other crime types. A subsequent study (Gonzalez-Navarro, 2013), found that LoJack also proved to be effective in Mexico when it was introduced, very publicly, on a specific model of car that was previously much stolen. However, LoJack also appeared to cause some displacement. Gonzalez-Navarro (2013) found that in the state in which LoJack was introduced on a specific car, the theft rate of that car was much reduced and theft rates on other cars were largely unaffected; however, in neighbouring states theft rates for the same model of car (which in those states did *not* have LoJack fitted) increased. In other words, there was displacement to the same type of car in a different state (where LoJack was not used), rather than to other cars in the same state.

In this brief appendix, the effectiveness of LoJack is analysed in a different way. The concern here is not simply whether LoJack was effective in reducing theft rates; overall the evidence suggests that it was (with qualifications). Instead this analysis looks at whether the penetration of LoJack correlates with the turning point in crime at the state level within the US and hence whether it can be seen as a catalyst for the decline.

LoJack was introduced at different times in different states. Ayres and Levitt (1998) write that: "*LoJack was first introduced in Massachusetts in 1986, and Massachusetts remains LoJack's strongest market today. LoJack was subsequently introduced in South Florida in 1988 and three additional markets in 1990. As of December 1994, LoJack served 12 markets*." Other evidence (IDCH, 2003) agrees that LoJack was first introduced in Massachusetts in 1986. It came to Florida in December 1988 and to Los Angeles, Michigan, Illinois and New Jersey in 1989. Georgia, Rhode Island and Virginia became LoJack markets in the early 1990s and the devices first appeared in New York in 1994 (ibid.). The IDCH (2003) reports states that: "*By year-end 1989, LoJack had "installed 35,000 systems in Massachusetts and south Florida ... and recovered over 900 cars for clients*." Given that around 50,000 vehicles per year were stolen in Massachusetts at that time and around 80,000 in Florida that suggests LoJack's influence may have been small at first. Indeed Ayres and Levitt note that because installation occurred almost exclusively on new vehicles, initial penetration into markets tended to be quite slow, as was the case with electronic immobilisers. Using data obtained from LoJack, they estimated that after five years in a market, LoJack's typical coverage was less than 2% of total registered vehicles. The company estimated that by late May 1997, LoJack was installed in about 15 per cent of all new cars in Massachusetts and about ten per cent of new vehicles in Florida, New York and

California. Given these relatively low percentages, and the fact that new cars make up only a fraction of cars on the road, it seems initially unlikely that LoJack was the catalyst for the nationwide fall in vehicle thefts from 1991.

However, Ayres and Levitt find that LoJack was effective even at very low penetration levels. They argue that this could be due to the fact that many vehicle-theft offenders are prolific offenders, stealing perhaps hundreds of cars per year. In that scenario, even if LoJack is present on just 2 in 100 cars, it could raise their risk of apprehension in any given year considerably. In addition, the IDCH report (2003) lists research suggesting that many car thefts at the time were committed by drug addicts who took the vehicles to chop-shops for selling of parts. Ayres and Levitt (1998) note that chop-shops would therefore encounter hundreds of stolen cars each month, hence even a low percentage of LoJack devices could significantly increase their chances of being detected by enforcement services.

To test the possibility that LoJack may have markedly driven down vehicle theft rates from the outset, this appendix attempts some simple analysis looking at trends in the states affected by LoJack to see whether the security device appears to be a credible reason for the turning point in overall vehicle thefts. From the evidence above, a table of states was constructed containing the year in which LoJack was introduced. It was assumed that the other states did not have any LoJack penetration before 1995, as suggested by both Ayres and Levitt (1998) and the IDCH report (2003).

Table A2.1: Year of LoJack introduction and vehicle theft peak, by US state

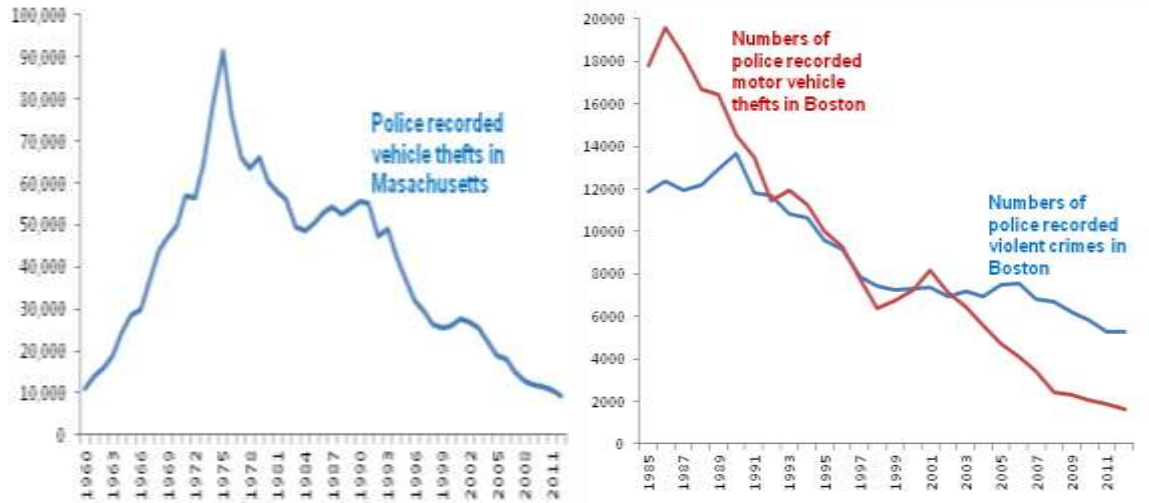
	Year LoJack introduced	Vehicle theft peak
Massachusetts	1986	1975
Florida	1988	1994
California	1989	1992
Michigan	1989	1984
Illinois	1989	1979
New Jersey	1989	1990
Georgia	1990–94	1996
Rhode Island	1990–94	1990
Virginia	1990–94	1991
New York	1994	1990
Other States	**n/a**	**1991**

Source: Uniform crime reports, FBI.

At first glance, the table does not demonstrate much support for LoJack being a central factor in the reversal of vehicle theft trends within states. Of the ten LoJack states, four had vehicle theft peaks *before* LoJack was introduced. And the average peak for the non-LoJack states was in 1991, which must also have been before LoJack was a presence in these markets. These facts clearly suggest that other factors must have been involved.

However, looking in more detail at the trends in each state reveals a slightly more mixed picture. All evidence suggests that Massachusetts achieved the highest initial LoJack penetration and that this was initially focused in the state's major city, Boston. Trends for both the state of Massachusetts and Boston are shown in Figure A2.1. The FBI's uniform crime-recording data tool has data at the state level from 1960 and at the city level from 1985.

Figure A2.1: Vehicle theft trends in Massachusetts and Boston



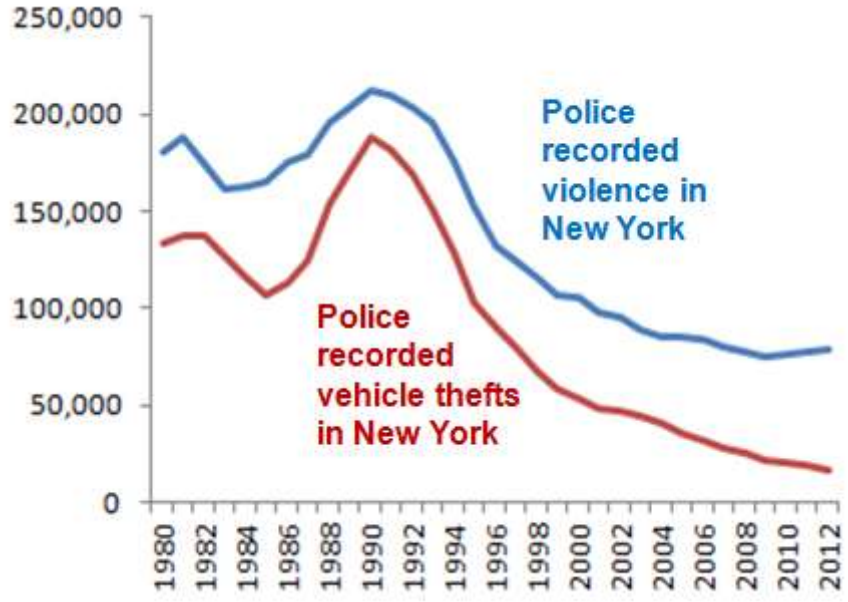
Source: Uniform crime reports, FBI.

Figure A2.1 shows that vehicle thefts at the state level rose from 1980 to 1990 while remaining at a lower level than in the 1970s 'spike' in thefts. However, in Boston, thefts fell from 1986, the year LoJack appeared in the city. Furthermore, Figure A2.1 also shows that violence continued to rise in Boston through to 1991 in line with other parts of the US and with the city's crack epidemic (Braga, 2003). Given that violence and vehicle theft correlate strongly at the national level in the US (Farrell *et al*., 2014), possibly due to the link between drug markets, stolen cars and violence (Blumstein and Rosenfeld, 2008)[64], it seems possible that in Boston, LoJack broke that link. That is, the earlier penetration of LoJack may have driven down vehicle theft even as other crimes continued to rise.

Similarly, as Ayres and Levitt (1997) show, other cities within LoJack states like Chicago (the major city in Illinois) also start to see falling trends in vehicle thefts more or less in line with the introduction of LoJack. However, Miami in Florida continued to see a rising trend for several years after LoJack's introduction while New York experienced sharp falls in motor vehicle thefts and violence for three years *before* LoJack appeared in 1994, see Figure A2.2.

[64] Blumstein and Rosenfeld write that: "The trend in motor vehicle theft, with a turning point in the early 1990s, is more similar to those for robbery and homicide than to the burglary trend, and it is consistent with qualitative accounts of stolen cars traded for drugs during the crack era (Jacobs, 1999) or for use by drug dealers to avoid having their own cars confiscated as forfeited assets. A clear need exists for research on the divergence between burglary and motor vehicle theft trends over the past 25 years." On the latter, one possible explanation is that burglary and general theft were more associated with the heroin epidemic of the 1970s in the US in which users stole to fund their use, while the crack epidemic gave rise to a new generation of drugs sellers (some of whom were also users) but who tended to be more associated with violence, robbery and car theft (see Morgan, 2014, for more on this).

Figure A2.2: Police recorded violence and vehicle theft trends in Chicago and New York



Source: Uniform crime reports, FBI.

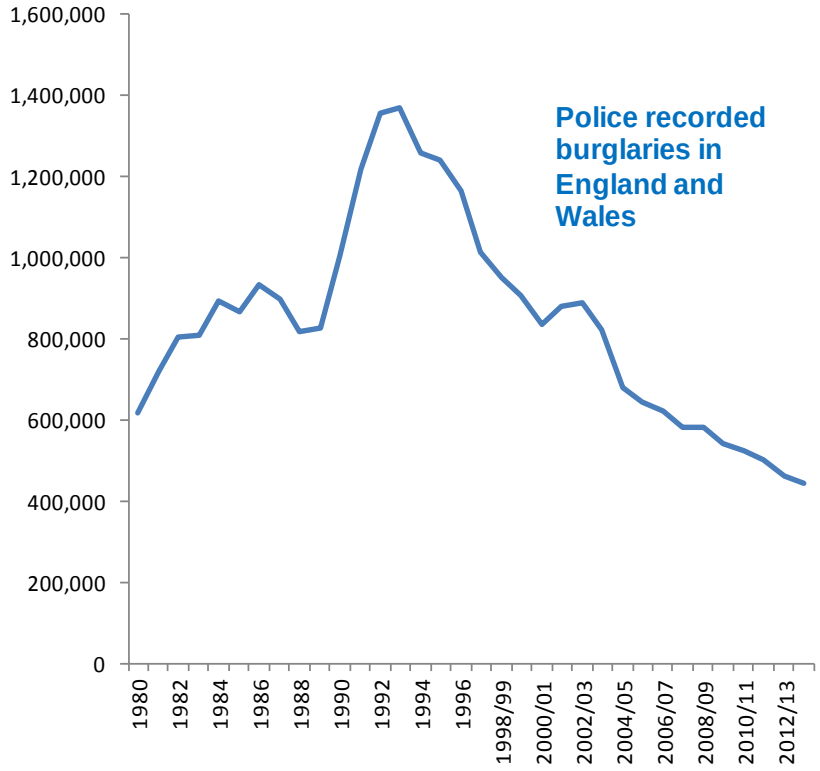
Overall then, this analysis suggests that LoJack may have been a contributor to the turnaround in vehicle crime in some areas, particularly in Boston. However, it was certainly not the only factor involved and it appears to have affected vehicle thefts only, rather than crime more generally.

Appendix 3: Why does crime spike?

A central finding from the examination of crime trends presented in this report is that numbers of offences do not, in general, gradually switch from rising to falling trends or vice versa. Instead these reversals often happen very sharply, with periods of steeply rising crime followed by periods of steep falls. This brief section offers some tentative thoughts on this issue.

The first reason for this phenomenon that often comes to mind is that the cause is some sort of blip or shift in the way the data are recorded, i.e. that the trend is not real but an artefact of the data collection process. In some cases, this may be what has occurred. The trend in police recorded burglary offences in England and Wales is shown in Figure A3.1.

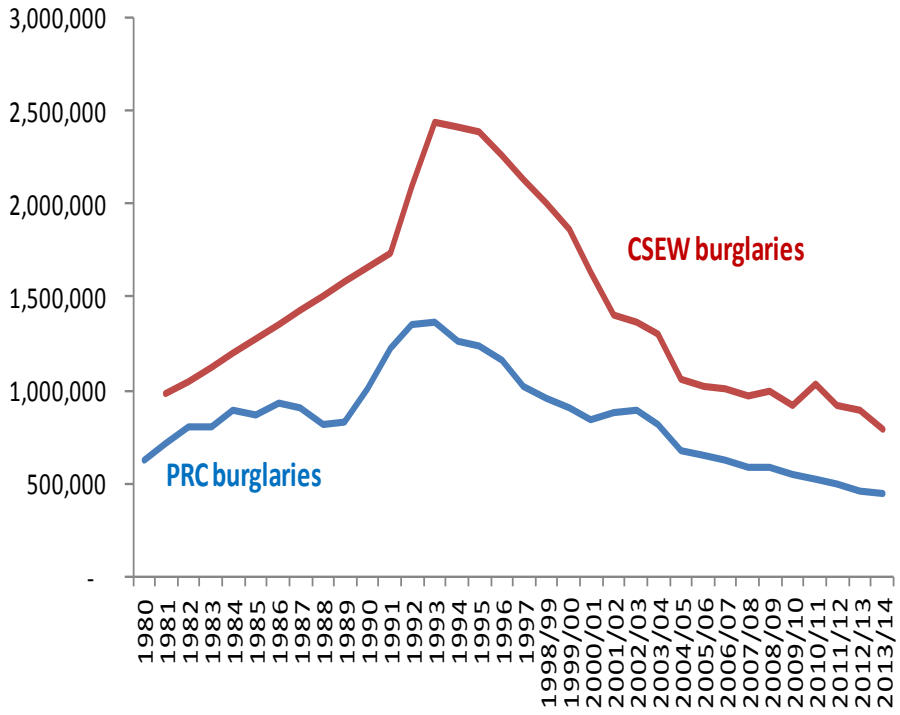
Figure A3.1: Police recorded burglaries in England and Wales



Source: Police recorded crime, ONS.

Clearly this has one very large 'spike' in the middle of the series but also another rise and then fall (admittedly more of a bump than a spike) occurred in about 2002. The latter may well have been driven by recording practice changes. The National Crime Recording Standard came into effect in 2002 and this had the effect of increasing the number of recorded burglaries by around three per cent according to a Home Office report (Simmons *et al.*, 2003). It is possible that this initial rise in recording eroded, either correctly or incorrectly, in subsequent years to give rise to the trend above. Overlaying the trend with the Crime Survey for England and Wales (CSEW) equivalent suggests that this small spike may have been artificial.

Figure A3.2: Burglaries in England and Wales



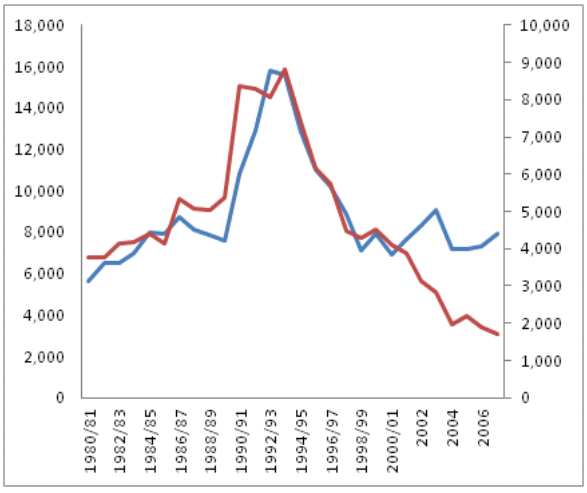
Source: Police recorded crime, ONS; Crime Survey of England and Wales, ONS.

Clearly though, the main spike in the middle of the series does not seem to be an artefact of any data collection process for the simple reason that it is present in both series, despite the fact that their data collection processes are quite different.

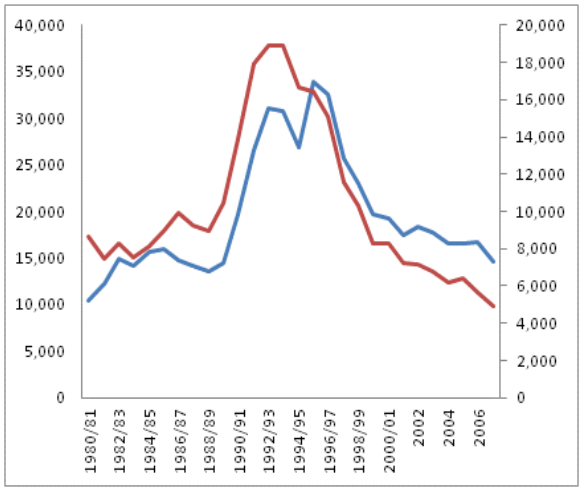
This, and the fact that spikes seem to crop up with incredible regularity, particularly in local-area data (see Figure A3.3), suggests that there is more to the phenomenon than simply data recording issues.

Figure A3.3: Burglary and vehicle theft trends in four police forces in England and Wales

Bedfordshire

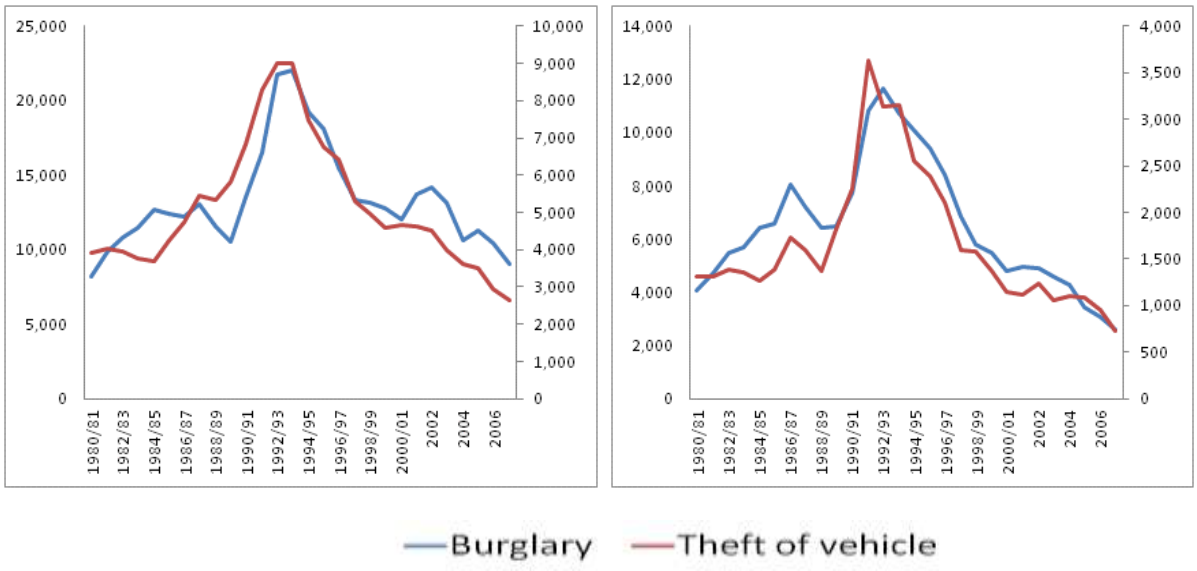


Kent



Cheshire

Cumbria



Source: Police recorded crime, ONS

One explanation is that changes to the crime environment create sudden 'breaches' that drive up offending until they are spotted at which point the breach is closed and crime falls again. Killias (2006) has documented a number of instances of this kind including the "mass production and consumption of spirits" which coincided with crime increases in the early 19th century and the fall of the Berlin Wall in 1989 which opened up a new market for stolen goods in Eastern Europe. The latter is a good example of a 'breach' that is in line with opportunity theory. A new market for goods does not directly affect the number of potential offenders or their propensity for crime, it just increases the potential reward and hence the temptation to indulge in crime. But Killias (2006) also talks of breaches that more directly affect numbers of potential offenders, like drug epidemics, where numbers of new users have a tendency to rise and fall sharply irrespective of precautionary activity (Morgan, 2014).

Another explanation has been offered by Paul Ormerod (2011) in his book 'Butterfly Economics'. In the chapter on crime trends, Ormerod notes the large number of sharp fluctuations present in crime data. For him, the explanation is that human behaviour is not simply the result of an individual's own preferences, but that human behaviour is instead *profoundly influenced by the behaviour of others*. Ormerod shows that this effect can be modelled and that it gives rise to the kind of sharp spikes seen in the data. For example, when modelling crime he divides the population into three groups: those who are unlikely to commit crime regardless of the behaviour of others (he includes most women and all pensioners in this group), those who are active criminals, and those who are *susceptible* to criminality. Crucially the number of offences committed by this last group depends on the size of the active offender population. So when the number of active criminals increases, this drags an ever-increasing number of those susceptible into crime, and vice versa.

Though a proper examination of the validity of Ormerod's approach is beyond the scope of this report, it is worth noting that there is very strong evidence that one type of behaviour frequently linked to crime – heroin/crack-cocaine use – does operate in a way that seems to fit with Ormerod's model. Numerous studies have shown that heroin use, for example, spreads through networks of friends and relatives rather than via drug dealers and pushers. An ethnographic study of heroin users in the Wirral in Merseyside, found that nine out of every ten users said that they had first received heroin from a friend or relative, rather than from a dealer (Parker *et*

al., 1988). In their seminal book on the spread of heroin epidemics Hunt and Chambers (1976) describe the process as follows:

> *Heroin use.... spreads within groups of closely associated youths by a process of peer emulation and influence. Exactly why one person should copy the behaviour of another, and voluntarily adopt his attitudes and practices, is no clearer for heroin use than for religious conversions, but both are empirical facts. … Though the idea of peer-influenced spread was well established, at least in the scientific literature, its implications seem to have been mostly overlooked. If heroin use is transmitted among friends, being as often sought by the non-user as offered by the initiator, then it is contagious ...* (underline added).

Source: Hunt and Chambers, 1976.

And of course, if there is a relationship between heroin use and crime, as other research has suggested (Morgan, 2014) then it follows that crime too is contagious to some degree.

The London riots offer another example from a completely different context. Many of the explanations offered by the rioters for their actions suggest that they were influenced by the behaviour of others and that criminality bred further criminality. For example:

> "*All right then, well, everyone's getting free stuff, I'm joining in, like, coz it's fucking my areas*."
>
> "*After it all kicked off and everyone was doing it, you just joined in and it felt fine*."

Source: Lewis *et al*., 2011.

If there is any truth at all in this approach, it has some quite important implications both for crime research and crime policy. The obvious research implication is that the standard economic models of crime need to be revised. These are based on the notion that an individual rationally makes up his or her mind whether to commit crime based on the relative costs and benefits of the situation. These models therefore assume that the number of other people committing crime in the vicinity is irrelevant to the individual (except via indirect ways[65]). If Ormerod is correct, these models will never accurately capture crime trends and the explanatory variables that drive them. Instead, different models that incorporate the way in which human behaviour is influenced by, and influences, the behaviour of others, need to be employed.

For crime policy, the most obvious implication is that 'tipping points' are likely to exist and that once reached, sharp changes could occur that may be impossible for policy action to prevent. Crime is currently falling, which, following Ormerod's logic, means that – other things equal – crime is likely to go on falling as fewer and fewer criminals influence fewer and fewer susceptibles. But if something should cause the number of criminals to increase, even slightly, history suggests this could tip the trend into a sharp reverse.

[65] Economic models typically include the likelihood of being caught as an important variable, weighing this and the potential punishment if caught, against the potential gain. Arguably the likelihood of being caught may be affected by the number of other offenders in the vicinity via the diversion of police resources, so it is possible that an element of the 'contagion' model enters standard economic models. But this does not really capture the essence of Ormerod's argument: that individual behaviour is influenced by the behaviour of others *irrespective* of how it affects their own costs and benefits.

There are, indeed, parallels between the current situation and that in 1960. Then, as now, homicide rates, and crime rates generally, were at historic lows. Yet within a decade the number of murders had increased by nearly 75 per cent[66] and the number of recorded robberies rose more than three-fold. It is still not clear exactly why this happened, which means it is hard to be certain that something similar will not occur in the next decade. In other words, though crime has been falling for 20 years in England and Wales, without a fuller understanding of the mechanisms that have driven this decline, we cannot be absolutely sure it will continue.

[66] In 1961 there were 265 police recorded homicides. By 1971 there were 459, and by 1991 there were 725.

Appendix 4: Two local-area cases studies: Western Australia and Merseyside

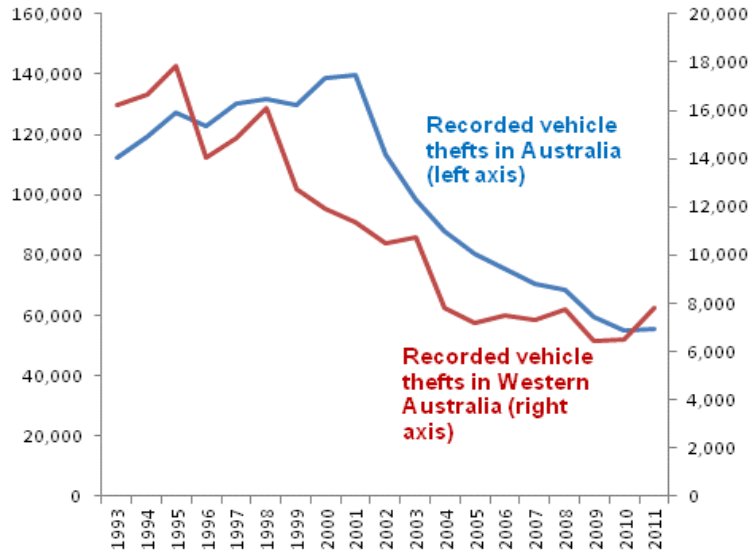
This appendix analyses trends from the state of Western Australia and the police force area of Merseyside in England. These areas show important differences from their respective national-level crime trends and may therefore shed light on the underlying causal mechanisms.

Western Australia

The state of Western Australia has been cited by many as a 'natural experiment' for testing the effectiveness of electronic immobilisers because it introduced legislation promoting the devices earlier than the rest of Australia. Electronic immobilisers were made mandatory in new vehicles in Australia in 2001, but in Western Australia a scheme commenced in 1997 in which subsidies were provided to encourage retrofitting of electronic immobilisers. Due to the limited take-up, this was followed in 1999 by legislation mandating the installation of electronic immobilisers on all new vehicles, two years earlier than the same legislation was passed at the national level. Importantly though, the Western Australia legislation had an additional component. It also mandated the installation of an electronic immobiliser on any car that was transferred (i.e. bought and sold) as long as it was less than 25 years old. In other words, anyone wanting to buy a second-hand car in Western Australia after 1999 had to first ensure it was fitted with an electronic immobiliser.

An obvious question then, is whether the earlier action taken by Western Australia in relation to electronic immobilisers caused an earlier fall in vehicle thefts compared with Australia generally. Figure A4.1 shows trends in police recorded vehicle thefts in Western Australia compared with the national trend.

Figure A4.1: Vehicle theft trends in Australia and Western Australia

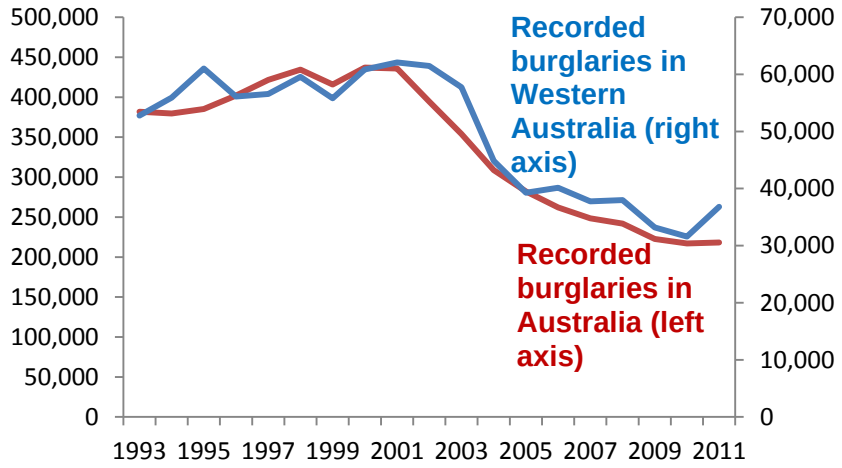


Source: Australian Bureau of Statistics.

Figure A4.1 shows that vehicle thefts did fall earlier in Western Australia than in Australia generally. The evidence is not totally conclusive, because Western Australia had a different trend from the rest of the country prior to the introduction of the voluntary scheme in 1997 and, arguably, numbers of thefts began falling from around 1995. But certainly the state experienced a sustained fall in thefts that commenced shortly after the scheme came into effect and which occurred before a similar fall was observed in the rest of the country.

In line with the analysis in the main report, the Western Australia example provides little support for the hypothesis that the benefits from electronic immobilisers diffused immediately to other acquisitive crime types. Figure A4.2 shows that, unlike vehicle thefts, recorded burglaries did not start falling earlier in Western Australia. Like burglaries nationally, they continued to rise until the early 2000s and actually peaked a year later (in 2002) than for Australia overall.

Figure A4.2: Burglary trends in Western Australia and Australia

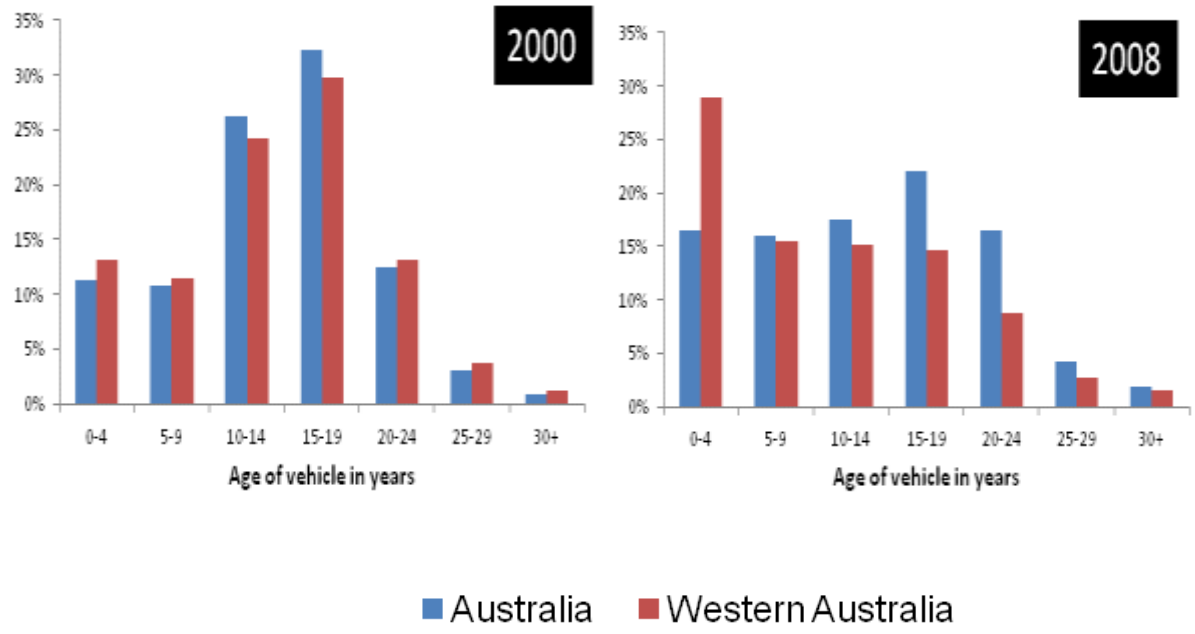


Source: Australian bureau of statistics.

The pattern in Figure A4.2 is also reflected in the trend for 'other theft.' Numbers of these incidents continued to rise in Western Australia until 2002, after which they fell 22 per cent in four years. This again is very similar to the national picture and perhaps suggests that another factor, affecting Australia more generally, also contributed to the fall in acquisitive crime during the early 2000s. One candidate is the reduction in numbers of heroin users that occurred at this time. Other evidence suggests that trends in heroin use correlated with general acquisitive crime trends in a number of countries through the crime turning point (Morgan, 2014). For Australia, available prevalence estimates suggest that numbers of heroin users rose for at least two decades up the late 1990s but then abruptly halved in the early 2000s (Hall et *al*., 2000a; Degenhardt et *al*., 2004).

To further examine the effect of the electronic immobiliser legislation in Western Australia, analysis was conducted to look at the breakdown of car thefts by the age of the vehicle stolen. Figure A4.3 shows this breakdown, in comparison to Australia as a whole, for thefts in 2000 and 2008.

Figure A4.3: Total thefts broken down by age of car, Western Australia and Australia



Source: CARS data analyser.

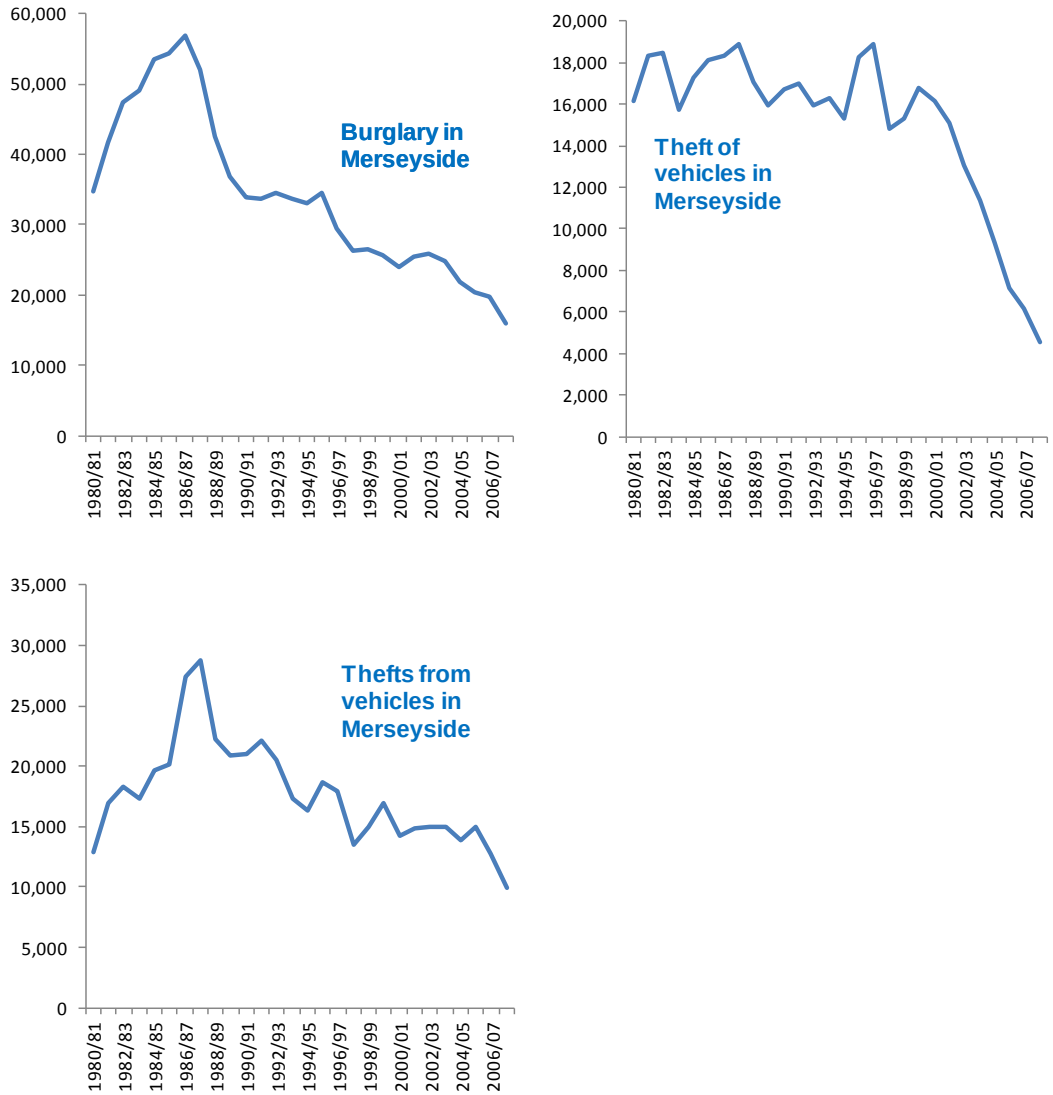
In 2000, the distribution of car thefts in Western Australia was very similar to that of Australia as a whole, with thieves displaying a clear preference for cars that were between 10 and 20 years old. This is further evidence that the introduction of the early electronic immobilisers from around 1990 had an important impact on criminal behaviour. From this date, there is clear displacement of thefts to older vehicles, though total thefts continued to rise initially. So although Western Australia had earlier legislation, the initial spread of immobilisers was probably quite similar to that seen nationally. By 2008 though, Western Australia shows a distribution that is quite different from the national picture. Nationally, thefts are still skewed towards older vehicles with the mode group being those aged 15–19 years, which is the youngest group of cars that will contain some vehicles without electronic immobilisers. In Western Australia though, the retrofitting scheme (and the compulsion for buyers of older cars to have an electronic immobiliser fitted) appears to have had a clear effect. In Western Australia, the most stolen group in 2008 is the group of vehicles aged 0–4 years.

Overall then, whether the earlier legislation in Western Australia drove an earlier fall in vehicle thefts in that state is debatable, given the trend was heading downwards anyway and up until 2000, there is little evidence that theft patterns were that different from the national picture. But what this evidence does suggest is that by mandating retrofitting as well as installation on new vehicles, Western Australia may have driven a greater fall in thefts in a shorter space of time because the pool of vehicles to which thieves could turn shrunk far more quickly due to the legislation. In Western Australia the peak-to-trough fall in vehicle thefts was 64 per cent and this was achieved by 2009. Nationally, the fall reached 62 per cent by 2013. In this light, Western Australia may also provide a glimpse of what the ‘post-immobiliser’ landscape may look like, once only a negligible number of cars on the road do not have the devices. If Western Australia is representative, it might be expected from the evidence in Figure A4.3 that new cars will be targeted more than older vehicles and that there may be renewed upward pressure on total thefts, given that car thefts in Western Australia increased about 15 per cent between 2008 and 2013.

Merseyside

Merseyside provides an illuminating example of a different sort because it is one of the few areas in England and Wales in which vehicle thefts show a different trend from the other high-volume acquisitive crime types: burglary and theft from vehicles. Table A7.3 shows that 41 of the 44 police force areas had peaks in all these acquisitive crimes more or less simultaneously between 1990/91 and 1996/7. The Metropolitan Police Service, West Midlands and South Yorkshire each have one crime type that peaks at a different time, but Merseyside is the major exception. None of its crime types peaks in the early 1990s. As Figure A4.4 shows, burglary and thefts from vehicles peaked in the mid-1980s, while theft of vehicles was largely flat (with some volatility) through till 2000 when it began to fall sharply.

Figure A4.4: Acquisitive crime trends in Merseyside, England



Source: Police recorded crime, ONS

Previous Home Office research has suggested that a possible explanation for the different trends in Merseyside is that it had a different trajectory of heroin use compared to most of the rest of the British Isles (Morgan, 2014). Merseyside had a steep increase in the number of heroin users in the early 1980s in line with several other parts of the UK, including Manchester and Glasgow (Parker, 1998). But Addicts Index data suggest that by the 1990s, Merseyside was the only area in England and Wales in which the heroin problem was in decline (Morgan,

2014). By contrast, most other areas experienced their sharpest increase in heroin users during the late 1980s/early 1990s (ibid.).

In this context, however, the Merseyside example is interesting because, *regardless of its different trends up to that point*, Merseyside still has a substantial fall in vehicle thefts from 2000, at the point in which the modelling in this report suggests that the main effect of electronic immobilisers would be likely to occur.

Appendix 5: Other reasons for the rise and fall in vehicle crime

This appendix explores other factors that may have been important drivers of vehicle crime trends in England and Wales. It is broken up into six sections: opportunity, economics, drugs, policing, prison and other factors.

Opportunity

Figure 5 showed that between 1975 and 1990 the trend in vehicle thefts tracked the increasing trend in cars on the road to a reasonable degree. This does not, of course, prove that there was any relationship, but it is perhaps suggestive that an increasing number of targets, and hence opportunity for criminality, probably played some role in that long-term increase. Similarly, for thefts from vehicles, the data presented in this report suggest that when victims and manufacturers increased the opportunity for criminality by putting reasonably valuable and easily-stolen stereos into vehicles during the 1970s and 1980s, thefts increased at an even faster rate than numbers of vehicles on the roads.

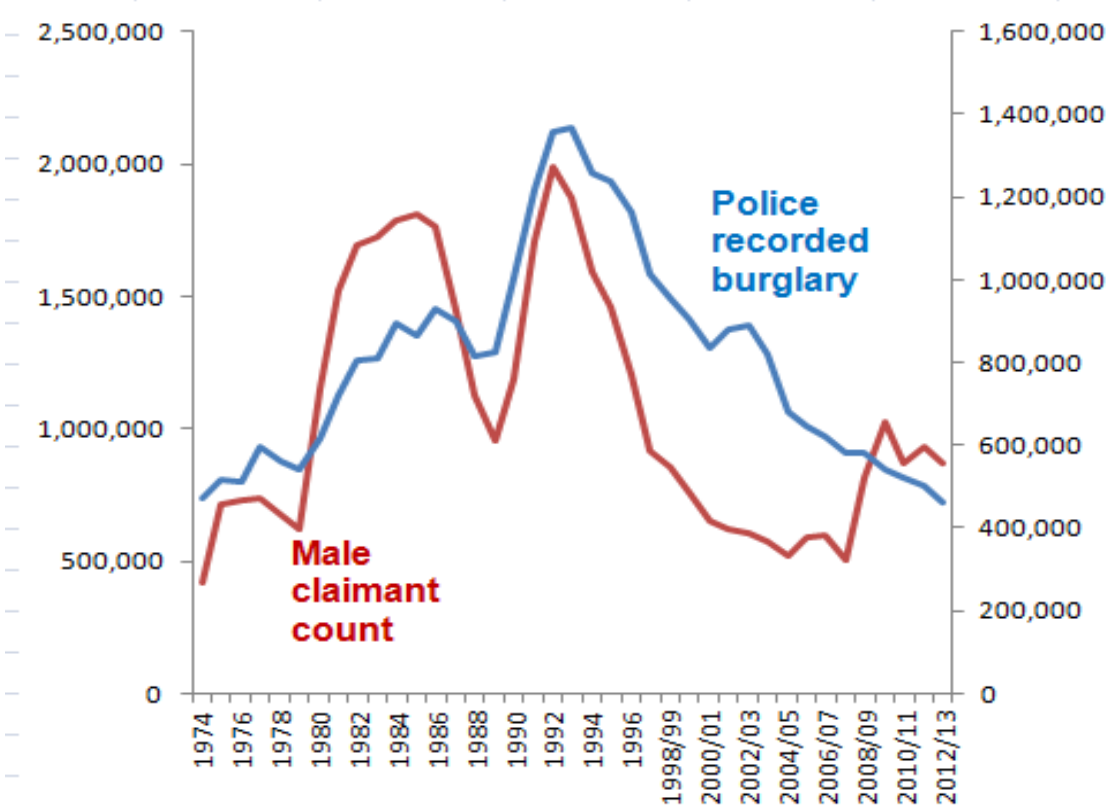
However, there is less evidence to suggest that opportunity played an important role in the sharp rise and then fall in vehicle crime that occurred in the majority of police force areas during the 1990s. Department for Transport statistics show that, having risen every year from the end of World War 2, the number of licensed vehicles on the road in Great Britain actually fell from 1990 to 1992, during the period when both thefts of and from vehicles saw their sharpest increases. This fact, which was almost certainly due to the recession of the time, does not suggest that opportunity – in its simplest sense – was driving the vehicle crime trend. The rising trend in licensed vehicles resumed in 1993. Between 1993 and 2014, around 8 million more cars have been registered, so the decline in thefts is nothing to do with the number of vehicles on the road. It must have been due to security and/or other factors.

Economics

There is a huge literature on the relationship between economic factors and crime. The results remain inconclusive and much debated.

Much of the debate reflects the fact that economic conditions correlated strongly with the rise in crime in the early 1990s, the sharp turning point and then the long fall in crime through to 2008. The correlation ended at that point, however. This is demonstrated by Figure A5.1, which shows unemployment in England and Wales (proxied by male claimant count) and numbers of recorded burglaries.

Figure A5.1 Recorded burglaries and male claimant count in England and Wales



Source: ONS, Police Recorded crime; NOMIS.

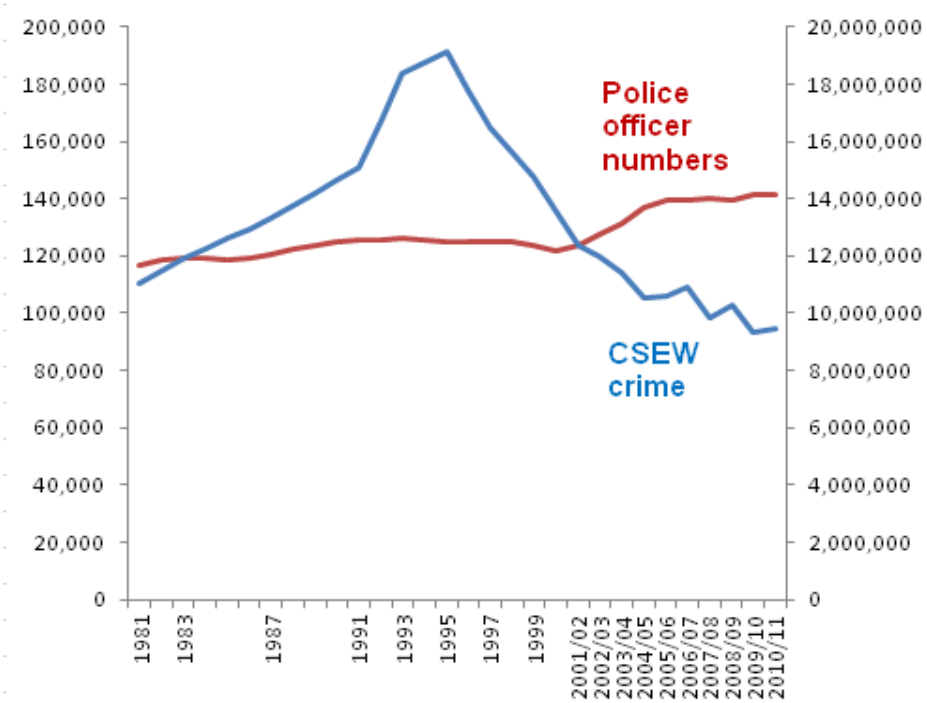
The two series show a strong correlation for most of the period, and especially during the early 1990s. But there was no rise in crime during the 2008 recession. This suggests either that the earlier correlation was spurious or that by the time of the later recession, the relationship had either ended or changed in some way. For example, there is some evidence that the 2008 recession was different from previous recessions. Unemployment rose in 2008, but not by nearly as much as in the early 1990s; and though cuts to household consumption were actually worse than in previous recessions, the type of reductions were different, with a greater reliance on cutting back on nondurable expenditure and less of an effect on durable items (Crossley *et al*., 2013). This could suggest that people were not finding it as hard to purchase essential items like food. Also, as US criminologist Richard Rosenfeld has argued, the economy entered the 2008 recession with historically low levels of inflation (Rosenfeld, 2014). This was the opposite of earlier downturns, which had shown stronger links with crime. Perhaps even more importantly, as the Institute of Fiscal Studies has shown, income inequality actually decreased from 2008 to 2012 (in sharp contrast to earlier recessions) as real earnings for those in work fell, while benefits and tax credit incomes remained robust (Cribb *et al*., 2013). So if income inequality or bottom-decile incomes are important factors (as suggested by Machin and Meghir in a 2004 paper), then it may not be surprising that there was no obvious crime rise during the 2008 downturn.

Regardless of what happened in 2008 though, unemployment is one of the few data series that offers compelling correlation with vehicle crime (and other types of theft) during the sharp rise and fall in numbers of offences during the early 1990s. Given that this report has found little correlation with security or opportunity trends during that period (though both are clearly important at other times), the early 1990s recession and swift recovery must remain potentially important factors in explaining the vehicle crime turning point.

Policing

If changes in policing have been important in driving vehicle crime trends, there are probably two ways in which this could have happened. Firstly, there could be a relationship with police resources. This is a fairly obvious formulation: if police resources increase, crime might be expected to fall and if resources decrease they might be expected to rise. Many studies have attempted to test this hypothesis with mixed results (see for example: Klick and Tabarrok, 2005 Evans and Owens, 2007). But whatever the specific relationship between crime and police resources, it seems unlikely that it played an important part in the vehicle crime turning point in England and Wales, for the simple reason that there was no marked change in police officer numbers at this point, see Figure A5.2.

Figure A5.2: Crime and police officer numbers in England and Wales



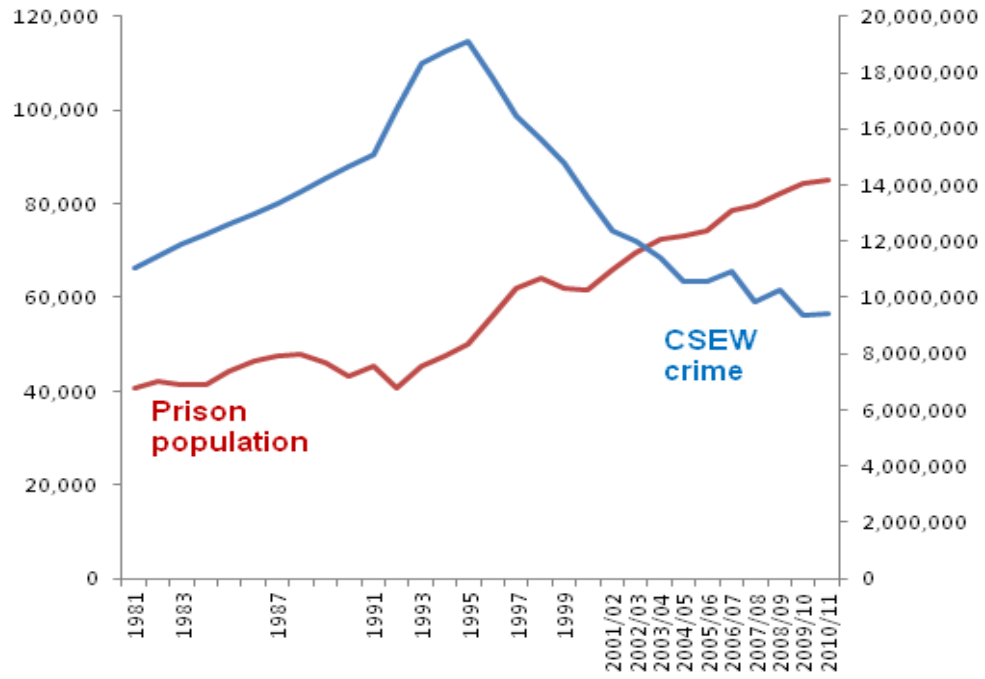
Sources: CSEW, Home Office Police Statistics.

The other way in which policing might affect crime levels is through improved tactics and techniques. This has been cited as a major reason for the crime decline in the US, particularly in New York City (Zimring, 2001; 2012). In England and Wales too, some have linked falling crime to improvements in policing, either via raised detection rates (Bandyopadhyay *et al*., 2012), or through the increased adoption of problem-solving policing (Economist, 2013). It is beyond the scope of this paper to test these claims, due in part to the fact that it is very difficult to obtain data at the aggregate level on the degree to which police practices (like the adoption of problem-solving policing) have changed. So it remains a possibility that changes to policing played an important part in the overall crime decline. But policing is perhaps unlikely to have been the main cause of the sharp spikes in crime visible at the local-level in the mid 1990s, because that would imply police tactics got markedly worse and then markedly better in a short space of time.

Prison

For the most part, studies that have looked at the relationship between incarceration and crime levels have yielded significant but small effects. Overall, they suggest that increases in the prison population have probably played some role in the crime decline but that they are unlikely to be the main driver of trends. The mid 1990s turn-around in crime in England and Wales did coincide with an increase in the prison population and the prison population has continued to rise as crime has continued to fall, see Figure A5.3.

Figure A5.3: Crime and the prison population in England and Wales



Sources: CSEW, MOJ Prison Population Statistics.

Other nations (notably Canada) saw crime turn downwards during the 1990s without raising their prison populations, which suggests the possibility that the correlation in England and Wales is spurious. However, the number of prisoners increased by around 50 per cent between 1993 and 1998, meaning that around 24,000 more individuals were in prison in 1998 than at the crime peak in 1993 (Ministry of Justice, 2013). Table A5.1 shows a breakdown of the sentenced prison population (it does not include prisoners on remand) from 1990 to 2013. It shows that violent and sexual offenders made the biggest contribution to the prison population increases over the whole period. But during the 1990s – when crime turned around – many more offenders of all types were incarcerated. It therefore seems possible that at least some of the most prolific vehicle crime offenders went to prison at this time and that this contributed to the sharply falling vehicle crime rate.

Table A5.1: Sentenced prison population by offence groups, 1990 to 2013, England and Wales

	1990	1995	2000	2005	2010	2013	Increase 1990-2000	Increase 1990-2013
Violence against the person	7,477	8,781	11,217	15,178	20,247	19,473	50%	160%
Sexual offences	3,018	3,668	5,090	6,185	9,304	10,540	69%	249%
Robbery	4,052	5,372	6,353	8,378	8,834	8,873	57%	119%
Burglary	5,885	5,953	8,982	8,082	6,857	7,073	53%	20%
Theft and handling	3,042	3,729	5,044	4,126	3,850	4,500	66%	48%
Fraud and forgery	795	1,167	1,016	1,454	1,544	1,320	28%	66%
Drug offences	2,829	4,256	8,473	10,661	11,064	10,175	200%	260%
Motoring offences	na	1,678	2,328	2,163	931	723	na	na
Other offences	3,280	2,628	3,723	5,289	7,353	7,625	14%	132%
Offence not recorded	3,148	1,631	866	664	887	479	-72%	-85%
All offences	**33,526**	**38,863**	**53,092**	**62,180**	**70,871**	**70,781**	**58%**	**111%**

Sources: Data for 1990 to 1993: Prison Statistics England and Wales (1999), Table 1.7 (motoring offences were included in 'other offences'). Data for 1994 to 2004: Offender management caseload statistics England and Wales 2004, Table 8.2. Data for 2005 to 2013: Annual prison population (2013), Table A1.3b.

Drugs

Heroin and crack-cocaine use has been linked to the rise and fall in vehicle crime in both England and Wales (Morgan, 2014) and in the US (Blumstein and Rosenfeld, 2008). Certainly, available surveys of heroin/crack-cocaine users show a high self-reported volume of thefts of and from vehicles. Table A5.2 shows the total self-reported offending by a cohort of 1,699 heroin and/or crack-using arrestees in England and Wales during a 12-month period from the mid 2000s.

Table A5.2: Self-reported annual offending by regular heroin/crack-using arrestees in England and Wales

	Total offences	Offences per individual
Domestic Burglary	2,352	1.4
Commercial Burglary	4,396	2.6
Theft of Vehicle	2,662	1.6
Theft from Vehicle	5,931	3.5
Theft from Person	2,528	1.5
Robbery	719	0.4
Shoplifting	300,952	177.1
Other Theft	43,335	25.5
Violence	2,212	1.3
Criminal Damage	13,443	7.9
Total	**378,530**	**223**

Source: Home Office Arrestee Survey, 2006.

Similar results have been found in other studies (see Morgan, 2014 for a review) and certainly suggest that any changes in the number of heroin/crack users may have had an important effect on the rise and fall of vehicle crime, given that numbers of heroin/crack users increased from the low thousands to the hundreds of thousands in both the UK and the US. Blumstein and Rosenfeld (2008) noted that the high correlation between violence and theft of vehicles in the US may have been due to declining crack markets and the fact that stolen vehicles were often traded for drugs (see Jacobs, 1999). Morgan (2014) has suggested that the heroin epidemic may have contributed to the rise and fall in acquisitive crime (including vehicle crime) in England and Wales, noting that peaks in heroin use tended to coincide with peaks in theft both locally and internationally, which could explain some of the variations in trend, notably the fact that Merseyside peaks earlier than the rest of England and Wales (see Appendix 4) and the earlier peak in theft in the US and the later peak in Australia.

However, data difficulties mean it is hard to track the progress of drug epidemics precisely. Epidemic models suggest numbers of users can both increase and decrease very quickly at the local level, which would fit with the 'spikes' in crime shown in Figure A3.3, but it is hard to measure the national peak in heroin/crack use precisely. In that light, the changes to both unemployment and the prison population may be important. Evidence suggests a link between job markets and heroin spread (Parker *et al*., 1987; Pearson, 1987), so the vastly improved unemployment situation from 1993 may have helped to curtail numbers of new users; and given the highly prolific level of offending by some heroin/crack users (Table A5.2), if even a proportion were incarcerated during the rise in the prison population from 1993, this could have had a marked effect on crime levels.

One objection to the hypothesis that heroin/crack use may have played a role in driving vehicle crime trends is that drug use is not particularly compatible with joy-riding, and so if joy-riding was the major component of vehicle thefts it is unlikely that drug use would play a role.

The evidence shows, however, that thefts of vehicles typically made up about 10–15 per cent of all vehicle crime on the CSEW, hence joy-riding is far from the main component of all vehicle crime. Indeed, the proportion of thefts committed purely for joy-riding (or for reasons other than financial gain) is hard to quantify, but Figure 17 shows that the sharp rise in crime was more do to with economically motivated offending than joy-riding. In interviews with car thieves from the early 1990s, Light *et al*., (1993) found that although excitement and relief from boredom were the main reasons for first stealing a car, the main reason for continuing in car crime was listed as "money". Arguably the latter would probably account for the majority of offences, given that crime is generally skewed to a few highly prolific offenders.

In the US, evidence suggests joy-riding had reduced markedly by the time vehicle thefts peaked. At the height of the vehicle crime peak in New York in the early 1990s, a hearing that convened a series of experts to discuss the problem, concluded that joy-riding typified the vehicle crime problem "25 years earlier" and that it accounted for only five per cent of vehicle thefts by 1990. "Profit-making" was seen instead as the main motive (Committee on the Judiciary, 1992).

It is probably fair to say though, that while the evidence is stronger for a security effect on theft of vehicles, due to the research on electronic immobilisers particularly, the evidence regarding heroin/crack use is probably stronger for theft from vehicles. There is considerable evidence to suggest heroin/crack users committed large amounts of stereo thefts from cars (Ball and Wikngaart, 1994; Akhtar and South, 2000). And areas like Merseyside and the US, that had a

heroin epidemic peak before 1990, often had peaks in burglary and theft (including thefts from vehicles) at the same time. But their peaks in thefts of vehicles did not correlate with trends in heroin use and instead peaked far later (though in line with the peak in the crack-cocaine epidemic in the case of the US). For those areas that had heroin peaks after 1990, however – like most parts of England and Wales and Australia – the drug trends seem to correlate well with all types of theft, including thefts of vehicles. It is not totally clear why this should be the case, but one possibility is that when heroin use peaked in the 1970s in the US and in the early 1980s in Merseyside, theft of vehicles was still dominated by joy-riding and hence was less affected by the epidemic. But after that point, as rates of joy-riding declined and financial motivations increased, vehicle theft trends became more aligned with heroin/crack trends. Part of this story may also involve the development of a new market for stolen cars from 1989 when the Berlin Wall came down and opened up a new source of illegal demand from Eastern Europe.

Other

This appendix has summarised some of the other factors that have been suggested as possible causes of the fall in vehicle crime (and other types of crime) in developed nations around the world. But there are many more and it is beyond the scope of this report to examine them all in great detail. This final section will simply note therefore that many of the other theories for crime's decline involve long-term or generational impacts, which are generally not consistent with the sharp crime spikes seen in Figures 5 and A3.3.

One of these is demographic change. There is some evidence that the number of young males in the population shifted downwards shortly before crime fell in England and Wales and certainly the ratio of old to young increased through the crime drop. This may therefore have contributed to the overall shift from rising to falling crime, but arguably it cannot have happened quickly enough to offer a compelling explanation for the sharp reversal in vehicle crime that occurred in the 1990s.

The same can be said of theories relating that operate on a generational basis like the lead hypothesis offered by Nevin in a 2007 paper or the abortion hypothesis put forward by Donuhue and Levitt (2001). These approaches argue that a significant change occurred a generation before the crime drop (a marked drop in atmospheric lead levels in the case of the first hypothesis and the legalisation of abortion in the case of the second), which would have lowered the crime propensity of later generations and caused falling crime.

It should be acknowledged that there is considerable evidence to support the notion of a generational change in relation to the crime drop in England and Wales. Certainly the decline has occurred in line with falls in risky behaviours of all kinds (speeding, traffic accidents, alcohol use, smoking, etc.) which suggests a general attitudinal change amongst young people may have occurred (Mishra *et al*., 2009; HM Government Horizon Scanning Programme, 2014). But again, whilst this may be a hugely important part of the story of the crime decline overall, it does not offer a compelling explanation for the sharp shifts in trends that occurred around the crime turning point. Generational change, almost by definition, has to be gradual.

Appendix 6: Time series modelling (written by Christos Byron)

1. Initial analysis

Looking at the national police recorded crime dataset for 'theft of motor vehicle' (TOMV), 'theft from motor vehicle' (TFMV) and burglary, with 41 forces aggregated[67], an initial model[68] was formulated as follows:

(A) Y = a + b*U + c*V + d*T

where,

- Y = TOMV
- U = TFMV
- V = Burglary
- T = time (in calendar years)

Table A6.1: Initial model results

Parameter Estimates

Dependent Variable:sum_TOMV

Parameter					95% Confidence Interval		Partial Eta
	B	Std. Error	t	Sig.	Lower Bound	Upper Bound	Squared
Intercept	43740.413	18231.374	2.399	.023	6506.980	80973.845	.161
sum_Burglary	.240	.045	5.306	.000	.148	.333	.484
sum_TFMV	.310	.053	5.809	.000	.201	.419	.529
Time	-5169.181	410.025	-12.607	.000	-6006.564	-4331.797	.841

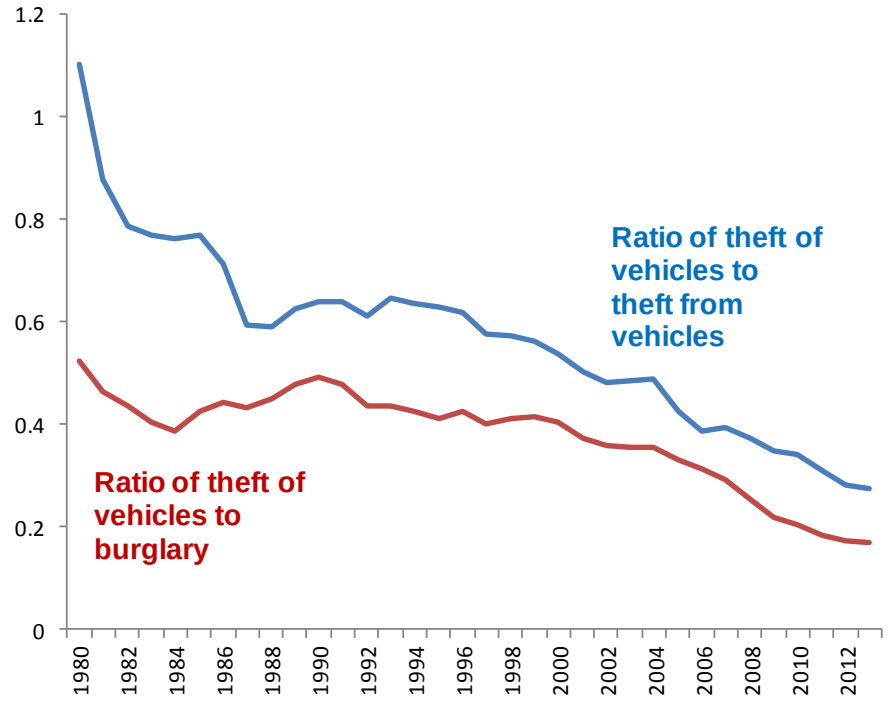
The findings in Table A6.1 show that burglary and TFMV are significant predictors of TOMV. The coefficient on the 'Time' variable indicates that over the whole time period there was a decline in Y (TOMV) after taking account of U (TFMV) and V (Burglary). It implies that for every year the number of vehicles stolen above what U and V predict decreases by 5,169 (CI=4,332 and 6,007), i.e. at T=1 there were 5,169 fewer vehicles stolen than U and V alone would predict, at T=2 there were 2 x 5169 fewer, etc.

However, further inspection of the data revealed a problem with this approach. This is illustrated in Figure A6.1, which shows the ratio of Y/U and Y/V by time across all forces.

[67] The aggregated force-level dataset used in this analysis comprised of PRC crime totals for 41 forces. City of London, British Transport Police and Wiltshire were excluded for reasons of missing data or small geographical size.

[68] As a general rule (except for multi-level models), the models were run as General Linear Models (GLM) rather than as (traditional) linear regression, to take advantage of the robustness of the GLM procedure when it comes to model definition.

Figure A6.1: The ratio of theft of vehicles to burglary and theft of vehicles to theft from vehicles, 1980 to 2013



Source: ONS, police recorded crime.

The graph shows that the ratios are not constant over time. Overall, both lines fall from the beginning of the series to the end. This in itself is not a problem. It merely suggests that *something* reduced TOMV more than burglary and TFMV over the period – at an average rate of about 5,000 fewer offences per year. The problem is that the lines are not linear, as was assumed in the initial model. The *rate* of decrease also varies with time. Therefore, a better model would allow for this variation across time. In particular, we want to test whether the non-linearity in the downward trend matches the evidence on electronic immobilisers. Put more simply – does TOMV start falling faster than the other crimes once electronic immobilisers are introduced and begin to spread through the vehicle fleet.

The chart also shows that the ratio of Y/U falls very sharply at the beginning of the series. Whilst this could be due to changes in vehicle security that affected TOMV but not TFMV it is probably more likely that most of the effect is caused by an increased rate of TFMV *reporting,* as outlined in the main report. Crime Survey data for that period showed clearly that a greater percentage of TFMV were reported to the police in the early 1990s than in the early 1980s. Using U as a 'general theft propensity' variable is therefore problematic.[69] It was therefore excluded from the final research hypothesis and model – as outlined below - and burglary alone was used as the proxy for `general theft propensity'.

2. Research hypothesis

The research hypothesis was developed as follows.

- There is a time-varying (latent) variable Z, which is an underlying measure of "propensity for general theft" that cannot be measured directly but which affects both

[69] In addition, analysis revealed that the relationship between Y/V and Y/U varies greatly by force. Therefore, it seemed inappropriate to try and combine them all into a single model that takes into account the variation at force level and at the same time is meaningful and relatively easy to interpret. The analysis presented is therefore based on the aggregate (national) dataset where all forces have been combined per year, thus removing the force-level variation.

TOMV (Y) and burglary (V).

- Some unknown function of Z, affects V across the whole period from 1980 to 2013.
- V can be thought of as a function of Z (and also of time T, as there may be some other time-varying effect on V other than the function of Z).
- Y is also a function of Z (and T). However, unlike for V, we hypothesise that at an unknown time point t0, the introduction of electronic immobilisers changes Y (but not V). In other words, this modelling assumes no displacement or diffusion; the introduction of electronic immobilisers is assumed to have no effect on burglary.
- Therefore, up to t0, Y is only a function of Z and T (general theft propensity), but after t0, Y becomes a function of Z, T and also a new time-varying variable which we will call X (the electronic immobiliser variable).
- Given the other evidence showing a possible acceleration of the immobiliser effect when a majority of vehicles became protected, we hypothesise that there would be two discontinuities. It is important to note that does not mean there genuinely *are* only two. The modelling is set up with the presumption that there are two discontinuities and we test merely whether they are significant and what their effects are.

3 The model

The final model[70] was therefore:

$Y = a*V + b0* V* D0* (T-t0) + b1* V* D1* (T-t1)$

where:

- V=burglary
- Y=TOMV
- t0=1992
- t1=2004
- D0=0 if T<t0 & D0=1 if T>=t0
- D1=0 if T<t1 & D0=1 if T>=t1

Maximum Likelihood Estimation (MLE) was used to identify the “most likely” years where discontinuity takes place (T0 and T1), i.e. it identifies years in which the trend in TOMV changes in a way that would not be expected by the trend in burglary. This is in order to identify potential effects from the introduction and spread of electronic immobilisers. It is an iterative process equivalent to fitting models hypothesising a discontinuity in each and every year of the time

[70] This model does not have T in it directly and ideally should be a no-intercept model so that Y becomes directly proportional to V (i.e. if V is zero, then Y is zero irrespective of time). Also, the model did not include a time slope before the discontinuity. i.e. time was not included as a main effect. Therefore it was assumed that before the intervention, Y is just a constant multiple of V; any changes in time in V will automatically be expressed as changes in time in Y. After the intervention, the multiplier will start to decrease. A version of the model was also run with both the intercept and the “time-slope” included and neither was significant, which is in line with the assumption of a common factor driving all types of theft.

series (34 years in total), and picking the model with the “best fit”. The MLE was set up to find the “best model” when allowing for two point-changes.

4 Results

The MLE resulted in t0=1992 and t1=2004. This means that the model with these specific change points results in the best fit, which in this case translates to the minimum “Root Mean Square Error (RMSE)”.

This means, in effect, that the best-fit discontinuities are in line with other evidence on the introduction and spread of electronic immobilisers, i.e. the devices were introduced in England and Wales in around 1992 and had spread to half the vehicle fleet by the early 2000s. Model results are shown below:

Table A6.2: Main model results

Parameter Estimates

Dependent Variable:sum_TOMV

Parameter					95% Confidence Interval		
	B	Std. Error	t	Sig.	Lower Bound	Upper Bound	Partial Eta Squared
sum_Burglary	.447	.005	83.356	.000	.436	.458	.996
sum_Burglary * d_1992 * t_1992	-.008	.001	-6.907	.000	-.010	-.005	.606
sum_Burglary * d_2004 * t_2004	-.016	.004	-4.153	.000	-.024	-.008	.357

The interpretation is as follows:

- up to the first change (1992), Y (TOMV) can be predicted as being 44.7 per cent of the value of V (burglary)

- between 1992 and 2004, this reduces by 0.8 percentage points per year

- from 2004, the rate of reduction increases by a further 1.6 percentage points per year, so a 2.4 percentage point reduction per year in total.

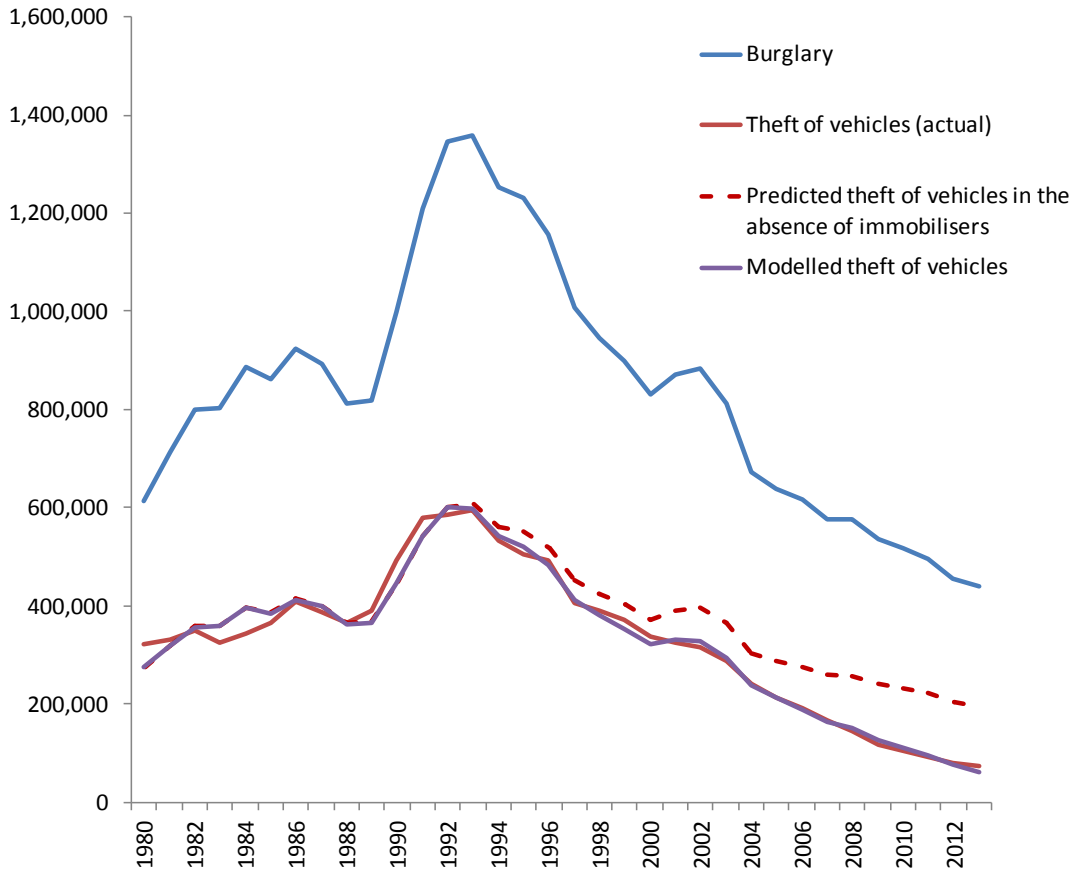
In other words, the model suggests that from the introduction of electronic immobilisers in 1992, TOMV starts falling at a slightly faster rate than theft generally (as proxied by burglary). But the effect is quite small until around 2004, when TOMV starts falling at a much faster rate, relative to burglary.

To more directly visualise the effect of the spread of electronic immobilisers relative to other factors, it is helpful to partition the model-predicted Y into its two components: Yz (i.e. the part of TOMV that burglary can predict) and Yx (i.e. the part of TOMV that is over and above what burglary can predict):

a) prediction of TOMVs if no intervention: Yz= a*V

Figure A6.2 shows Y together with the model-predicted value for Y and also the model-predicted value for Yz.

Figure A6.2: Police recorded burglary and theft of vehicles, modelled theft of vehicles and estimated trend in theft of vehicles in the absence of electronic immobilisers



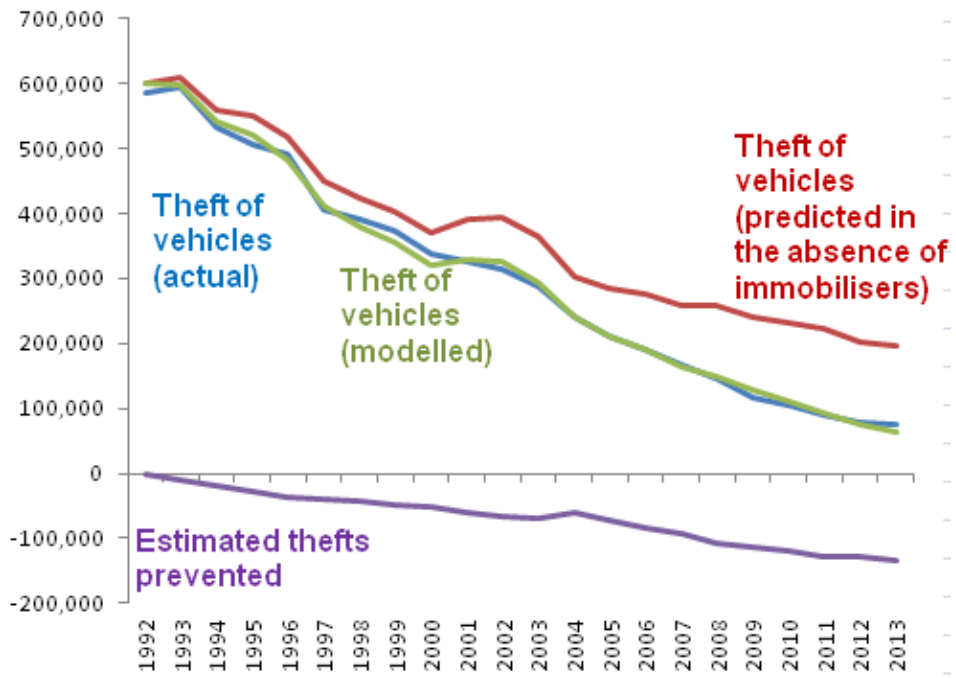
Source: ONS, police recorded crime.

Comparing the blue (Y) and green (predicted Y) lines, we can confirm that the model fits very well for all time points. The red dotted line shows Yz. This is the same as the predicted Y up to 1992 (i.e. the green and red lines are the same); after 1992, the red dotted line shows the estimated number of thefts of vehicles if electronic immobilisers had not been introduced. Note that it still falls considerably from its level during the early 1990s. This implies that 'general theft propensity' decreased from that point, but that electronic immobilisers had an additional effect.

b) prediction of prevented TOMVs after intervention: Yx = b0*V*(T-t0) + b1*V*(T-T1)

Figure A6.3 shows Yx after 1992 (i.e. the change in Y that cannot be predicted by V), together with Yz, Y and predicted Y. Yx can be seen as a direct estimate of the number of TOMV offences prevented by electronic immobilisers.

Figure A6.3: Theft of vehicles, actual and modelled, and the estimated number of thefts prevented by immobilisers



Source: ONS, police recorded crime.

Reading from the chart above, the actual numbers for 2013 are Yz=196,100 and predicted Y=62,887. This implies that without electronic immobilisers 'theft of vehicle' volumes would be about three times higher than they currently are, demonstrating the marked effect of immobilisers.

But this analysis suggests that the downward shift in 'general theft propensity' contributed even more to the drop in TOMV offences. The black line (prevented TOMVs: Yx) goes down from 0 (in 1992) to -133,213 (at 2013), implying that 133,213 vehicle thefts in 2013 were prevented by electronic immobilisers. The modelled number of total vehicle thefts fell by about 539,000 between 1992 and 2013 (shown by the fall in the green line). Taken together, these results suggest that around a quarter of the fall in vehicle thefts (133,213/539,000) from 1992 to 2013 can be attributed to electronic immobilisers. In reality this may be a lower bound for the actual effect because of the assumption that no benefits from electronic immobilisers diffused to burglary.[71]

[71] Note that this estimate is calculated in a slightly different way from the one in Chapter 3, as it takes a proportion of the total fall from 1993 to 2013 attributable to electronic immobilisers, rather than calculating a separate proportion for each year and aggregating. However, the current method was re-run calculating the proportion for each year and aggregating and the result was almost identical: 23 per cent of the fall was attributable rather than 25 per cent. We therefore use 23 per cent in the main report.

5 Conclusion

The results from this section suggest that there has been a strong relationship between trends in burglary and vehicle theft from 1980 to 2013. This implies that a factor or factors affecting general propensity for theft played an important role in both the rise and fall in crime.

However, the results also show the presence of an additional factor depressing levels of vehicle theft from 1992, which is in line with the introduction of electronic immobilisers. Results suggest that these devices prevented more thefts year on year from 1992 and that their effectiveness accelerated further from 2004, once a majority of vehicles were protected. Overall, the results imply that at least a quarter of the total decline in vehicle thefts between 1992 and 2013 were directly attributable to the devices even assuming no diffusion of benefits.

Appendix 7: Technical Appendix

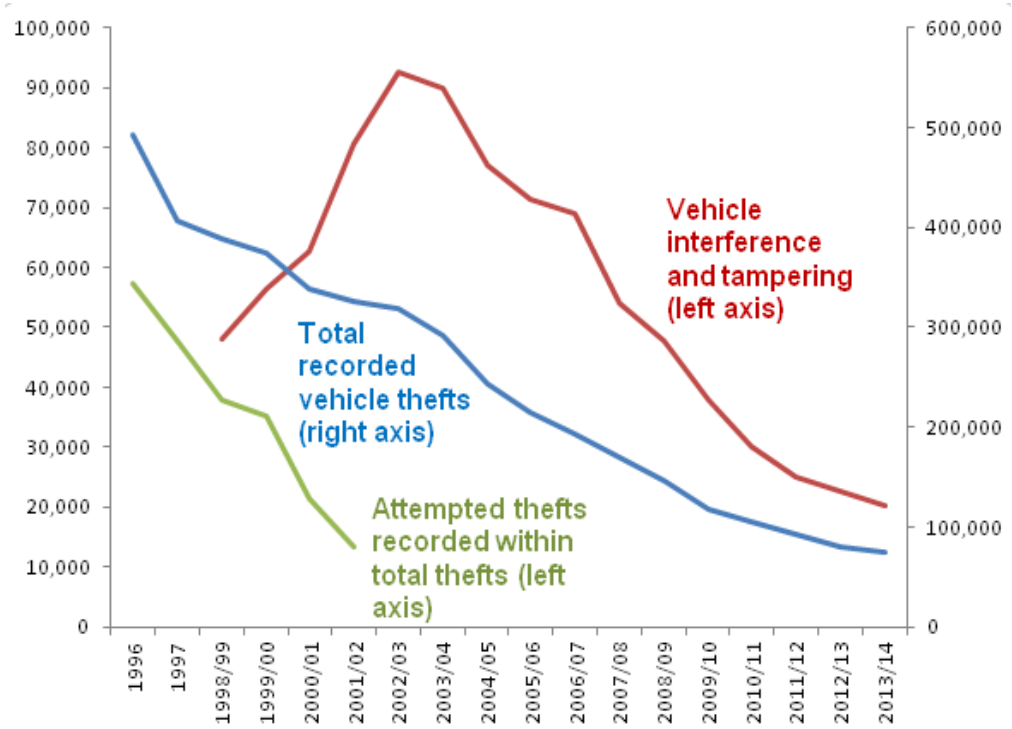
This technical appendix contains additional methodological details and findings.

1) Police recorded crime trends used in this report

This brief section gives details of the recorded crime trends used in this report including how recording practice and crime-type changes were incorporated.

For 'theft of vehicles' counts of crime type 48: 'Theft or unauthorised taking of a motor vehicle' were used. In 1992 the offence of 'aggravated vehicle taking' was created (code: 37.2) and these were also included in the annual totals as these were offences that would previously have been incorporated into crime type 48. In 1998/99 the offence of 'vehicle interference and tampering' was made notifiable. This offence, which was created in the 1981 Criminal Attempts Act, was a summary offence prior to 1998/99 and therefore would not have appeared in total police recorded crime figures. It includes "recorded crime offences where there is evidence of intent to commit either theft of or from a vehicle or taking without consent (TWOC), but there is either (i) no evidence of intent to commit one of these three offences specifically, or (ii) there is evidence of intent to commit TWOC (TWOC is a summary offence but, under the provisions of the Criminal Attempts Act 1981, it is not legally valid to have an attempted summary offence)" (Home Office, 2010). In other words, a proportion of attempted theft of vehicles (those that were not intended to be permanent thefts) would be included in 'vehicle interference and tampering' rather than in 'theft of vehicles', but they *should* have been excluded from the latter throughout the period 1981 to 2013/14. This means that the trend in crime type 48, with the addition of crime type 37.2 should be unbiased throughout the series – it will not include all attempted thefts but the types of thefts excluded should remain constant. However, in practice this may not have occurred, according to (Povey et al., 1998). They write that making 'vehicle interference and tampering' a notifiable offence may have caused some forces to shift offences previously recorded as (attempted) 'theft of vehicle' into the new category. To investigate this, the trend in 'vehicle interference and tampering' was examined along with trends in total recorded vehicle thefts and a count of the police-recorded attempted thefts that were included in crime type 48 (the main 'theft of' category). The latter was obtained from a supplementary data collection that ran from 1996 to 2002/03. These trends are shown in Figure A7.1 below.

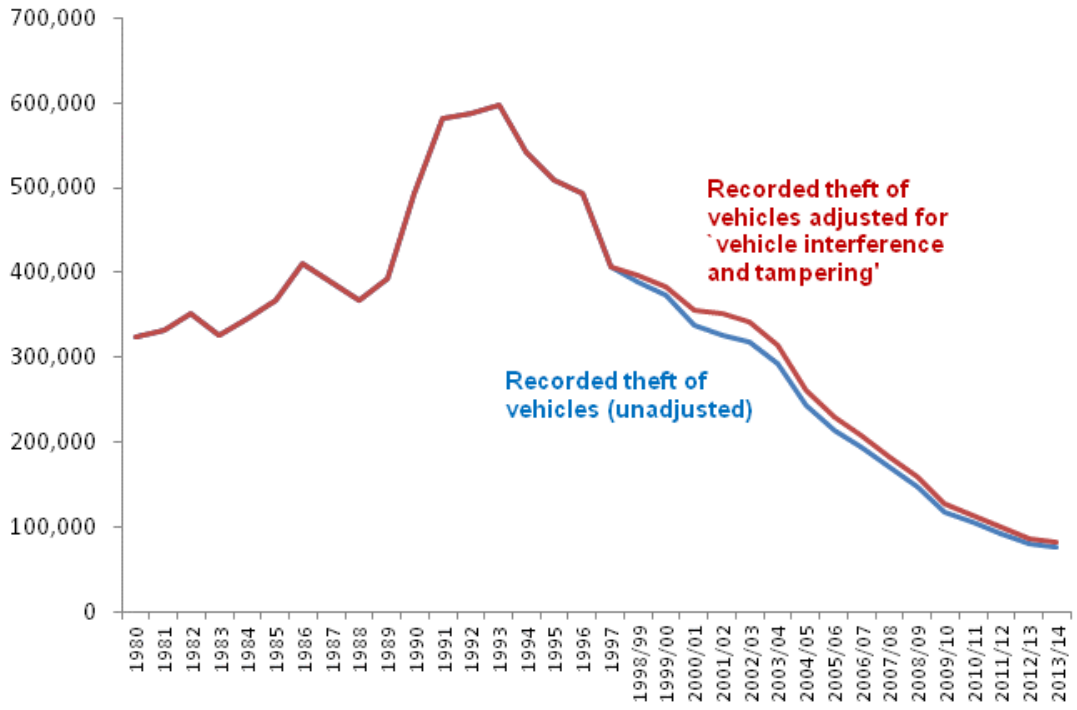
Figure A7.1: Police recorded trends in vehicle thefts, attempted thefts and vehicle interference and tampering



Sources: ONS, police recorded crime; Povey *et al*., 1998 Simmons *et al*., 2003

Figure A7.1 shows that from 2002/03 onwards 'vehicle interference and tampering' has a similar trend to total vehicle thefts. Both fell by around 75 per cent between 2002/03 and 2013/14. Between 1998/99 and 2002/03 though, 'vehicle interference and tampering' rises sharply. There are two possible reasons for this. The first is that, as suggested in Povey *et al*. (1999), there was some transference from 'theft of vehicle' into 'vehicle interference and tampering' during that period. Looking at the proportion of total thefts that were recorded as attempts, this remained constant at around 11.5 per cent of total thefts in 1996 and 1997, but from then on it fell sharply – i.e. the green line in Figure A7.1 declines more sharply than the blue line. This suggests that some attempted thefts may have moved into 'vehicle interference and tampering'. One way to estimate the degree of transference is to assume that if the new crime category had not been introduced, the proportion of attempted thefts recorded within 'theft of vehicle' would have remained constant. Assuming this, it is possible to estimate an adjusted trend in 'theft of vehicles'. This is shown in Figure A7.2.

Figure A7.2: Recorded theft of vehicles, including adjusted trend to incorporate offences that may have moved into vehicle interference and tampering



Source: ONS, police recorded crime.

Figure A7.2 suggests that although the introduction of 'vehicle interference and tampering' may have led to subsequent 'theft of vehicle' figures being *under*-estimated, any effect would have been slight with the degree of deflation ranging from 1.8 per cent to around seven per cent depending on the year.

However, there is another reason why 'vehicle interference and tampering' may rise sharply from 1998/99 to 2002/03. During that period all recorded crime was affected by two recording practice changes that culminated in the introduction of the National Crime Recording Standard (NCRS) in 2002. Full details of these changes can be found in Povey *et al*., (1998) and Simmons *et al*., (2003). In general though, the changes had the effect of increasing the number of offences recorded. Violence was the crime category most affected, but available evidence suggests that there was also a smaller impact on vehicle crime and burglary, with some crimes being recorded that would not previously have been. Available estimates of these effects are shown in Table A7.1.

Table A7.1: Effects of the recording changes on vehicle crime and burglary

	1998/99 change		
	Old rules total	New rules total	% uplift
Burglary	951878	953187	0.1%
Theft of vehicles	390891	391811	0.2%
Theft from vehicles	680937	685921	0.7%
	2002 change		
Theft of and from vehicles	895000	975924	9.0%
Burglary	870000	878547	1.0%

Sources: Povey *et al*., 1998 Simmons *et al*., 2003.

Table A7.1 shows that the impact of the 1998/99 recording change on burglary and vehicle crime was small; the uplift was less than one per cent in all cases. For the introduction of the NCRS the impact was bigger, though separate estimates were not attempted for theft of and from vehicles. However, separate analyses (see Table 3.04 in Thorpe (2005)) suggests that the majority of the uplift would likely have come from 'theft from vehicles' and that 'theft of vehicles' was very well reported and recorded even prior to 2002. Table 3.04 in Thorpe (2005) also shows that the impact of the recording changes on recorded *attempted* thefts may have been much larger. So it could be that the rise in the red line in Figure A7.2 simply represents improved recording of the attempted vehicle thefts (both thefts of and from) that would never have been included in the 'theft of vehicles' trend.

In addition, Table A7.1 shows that regardless of the impact of 'vehicle interference and tampering' the rule changes would have *inflated* the vehicle crime and burglary figures slightly (burglary and theft of vehicles would have been affected only marginally, with an uplift of up to 1.5 per cent at most, though there was probably a bigger effect on theft from vehicles). This would have counteracted any transference into 'vehicle interference and tampering' to some extent. Indeed, comparison with the CSEW suggests the unadjusted vehicle theft trend gives a better representation of the true trend. The decline from 1993 to 2013/14 on the CSEW is 88 per cent. On the unadjusted PRC trend it is 87 per cent and on the adjusted PRC trend which inflates figures post 1998/99 to account for vehicle interference and tampering, the fall is 86 per cent.[72]

As a result, the decision was taken, not to adjust the 'theft of vehicles' trend to take into account 'vehicle interference and tampering' for the purposes of the analyses in this report. This does mean however, that although the trend is very similar to the CSEW trend, see Figure 4, it will not include all attempted vehicle thefts. This is not the only difference between the series. The CSEW does not include offences against commercial targets and offences against individuals in institutions.

To summarise:

- In theory, the fact that 'vehicle interference and tampering' became notifiable in 1998/99 should not affect the theft of vehicles trend used in this report because the offences included should have been separate both before and after the change.
- But, evidence suggests some crimes previously recorded as 'theft of vehicle' may subsequently have been recorded as 'vehicle interference and tampering' during the period from 1998/99 to 2002/03. This would have a small *deflationary* impact on the 'theft of vehicles' trend from 1998/99 onwards.
- However, during the period from 1998/99 to 2002/03 there were two recording practice changes. These would have had a small *inflationary* impact on the 'theft of vehicles' trend from 1998/99 onwards.
- As a result of the evidence presented above, and the fact that the two effects will counter-balance to some extent (a fact supported by looking at the CSEW trend), the decision was

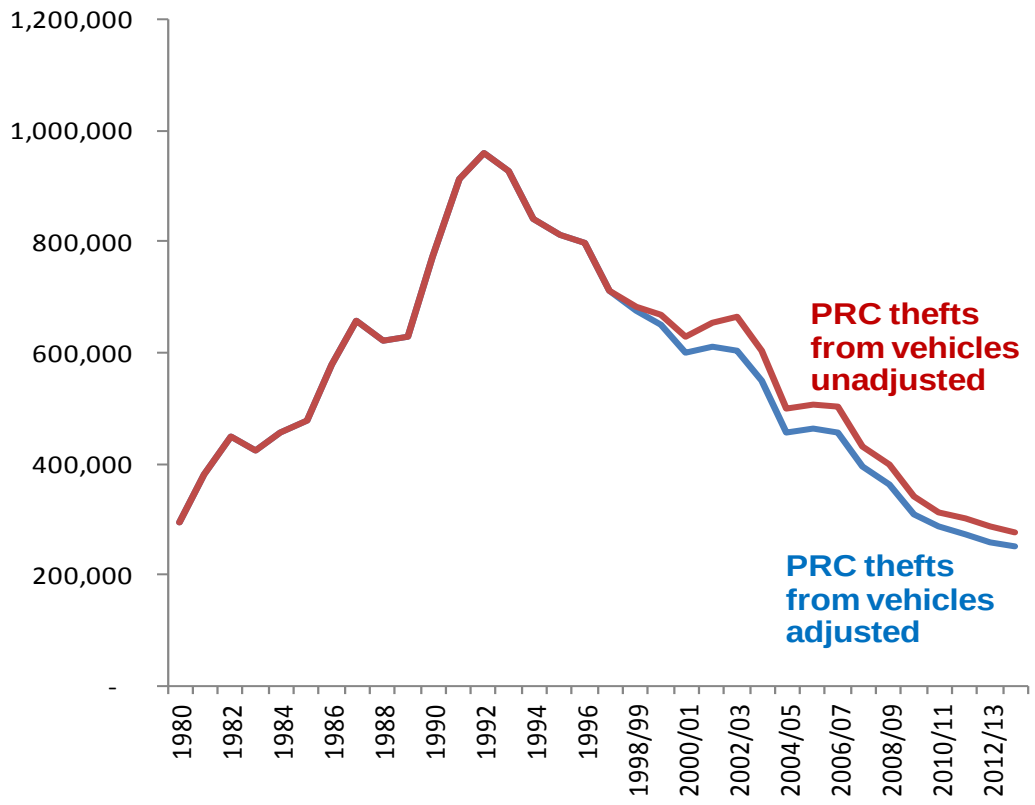
[72] The analysis in the main report suggests a third possible reason why 'vehicle interference and tampering' may have risen from 1998 to 2002 without apparent transference from the recorded 'theft of vehicles' figures: that attempted TWOC thefts genuinely increased. If this represents the period when electronic immobilisers reached critical mass, attempted thefts may genuinely have risen as more opportunistic thieves were thwarted by the improved security.

taken not to try and incorporate any or all of the 'vehicle interference and tampering' figures into the 'theft of vehicles' trend. But aggravated vehicle taking was included.

For the national and force-level burglary trends used in the main report, the PRC category of 'total burglary' was used which incorporates recorded attempts. No further adjustments were made as the likely uplift due to the 1998–2002 recording changes would have been around 1.5 per cent at most.

For theft from vehicles, trends in crime type 45 'theft from a vehicle' were used and no attempt was made to adjust for 'vehicle interference and tampering' becoming a notifiable offence (because in theory this should not affect the trend, as explained above). However, an adjustment was made for the recording practice changes in line with the evidence presented in Povey *et al*., (1998) and Simmons *et al*., (2003) and set out in Table A7.1 above. The effect of this is shown in Figure A7.3 below. The relevant analyses were also run with the unadjusted figures and results remained broadly the same.

Figure A7.3: Trends in thefts from vehicles recorded by police showing the adjustment for the recording practice changes



Sources: ONS, police recorded crime; Povey *et al*., (1998); Simmons *et al*., (2003)

2) Theft rates computed from Car Theft Index Data

In section 3, statistics relating to theft rates for cars registered in the 1990s and the 1980s are quoted. Table A7.2 provides the data from which these figures were computed.

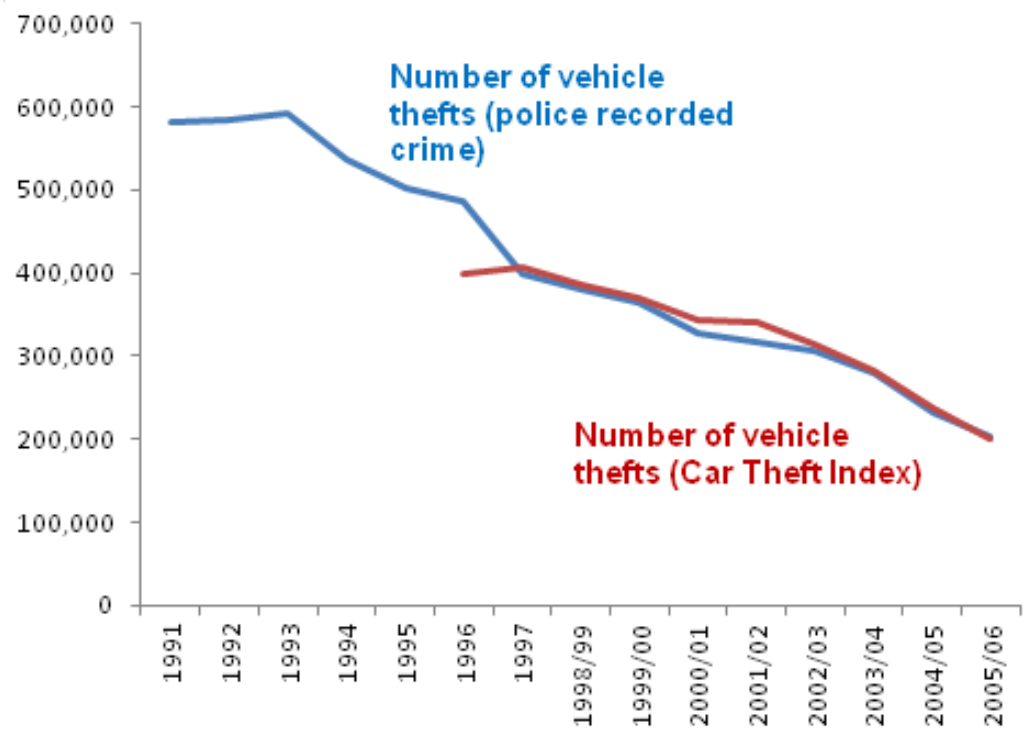
Table A7.2: Theft rates computed from Car Theft Index data

	Total cars registered in the 1980s or before	Theft of cars registered in the 1980s or before	Theft rate per car on the road	Change of theft rate compared with previous year
1996 Car Theft Index	11,864,930	337,094	0.028	
1997 Car Theft Index	11,084,781	265,767	0.024	-15.6%
1998 Car Theft Index	9,618,991	230,319	0.024	-0.1%
1999 Car Theft Index	8,133,109	200,975	0.025	3.2%
	Total cars registered in the 1990s	Theft of cars registered in the 1990s	Theft rate per car on the road	Change of theft rate compared with previous year
1996 Car Theft Index	12,418,241	148,601	0.012	
1997 Car Theft Index	14,092,225	140,175	0.010	-16.9%
1998 Car Theft Index	16,253,185	156,505	0.010	-3.2%
1999 Car Theft Index	18,123,251	169,488	0.009	-2.9%

Note that the 1996 Car Theft Index (CTI) employed a slightly different methodology from that used in subsequent years. This resulted in it capturing a slightly lower proportion of all thefts than the other years.

To adjust for this, the number of thefts recorded by the CTI was compared to vehicle thefts in the official police recorded crime (PRC) statistics. There are important differences between these series. The Car Theft Index records thefts of cars only but includes data from Scotland, whereas the police recorded crime data excludes Scotland but includes thefts of other types of vehicle. Also, the Car Theft Index data are recorded on a calendar-year basis whereas PRC switches to financial years in 1998/99. (Hence, the data point shown below as 1998/99 for the red line is actually the 1998 data.) Despite these differences, the two series show similar levels and trends for total numbers of thefts, see Figure A7.4.

Figure A7.4: A comparison of total car thefts recorded by the Car Theft Index and total vehicle thefts recorded by police recorded crime



Sources: Car Theft Index, ONS police recorded crime.

The correlation for the two series is very close except that the CTI recorded 87,000 fewer thefts in 1996 due to the different methodology. For the modelling then, the total number of thefts in the 1996 Index was converted to the PRC thefts total, but the *distribution* of thefts (in terms of age of vehicle) was maintained from the original Car Theft Index data. As such, it should not bias the results unless the missing 18 per cent of thefts had a different age distribution. There seems no obvious reason why this should be the case.

Also, Table A7.2 shows that theft rates for both 1990s-registered and 1980s-registered cars fell between 1997 and 1998 too (though only marginally in the case of the older vehicles). It is only in 1999 that theft rates on older vehicles start to rise, indicating possible displacement consistent with the impact of electronic immobilisers.

3) Calculations for immobiliser effectiveness

In section 3 of the main report, modelling of immobiliser impact is calculated using a range from "20 per cent effectiveness" to "80 per cent effectiveness." This was calculated by assuming that vehicles without electronic immobilisers continued to be stolen at the same rate as they were before the devices began appearing on any vehicles (adjusted for age using the 1996 Car Theft Index distribution as explained in the main report).

For vehicles that did have electronic immobilisers the same method and theft rates were used but they were multiplied by a given fraction depending on the level of effectiveness. So for the "20 per cent effectiveness" model, all theft rates for vehicles with immobilisers were multiplied by 0.8 to give a 20 per cent reduction. In the "40 per cent effectiveness" model, the multiplier was 0.6, and so on.

4) The sequencing of peaks for all police force areas in England and Wales

Table A7.3 gives the full results for the analysis of sequencing at a police force area level. The datasets used for this analysis contained counts of crimes in each financial year and the peak year is shown for burglary, theft of vehicle, theft from vehicle and other theft. Areas in which theft of vehicle peaked at the same time or before the other crime types were coded as being in accordance with a diffusion of benefits hypothesis.

Table A7.3: Crime peaks for theft offences by police force area

	Peak Crime Year				
Police Force Area	Burglary	Theft of Vehicle	Theft from Vehicle	Other Theft	Fits with Immobiliser sequencing
Avon and Somerset	1992/93	1993/94	1992/93	1993/94	NO
Bedfordshire	1992/93	1993/94	1991/92	1996/97	NO
Cambridgeshire	1993/94	1995/96	1996/97	1991/92	NO
Cheshire	1993/94	1992/93	1993/94	1999/00	YES
Cleveland	1995/96	1993/94	1990/91	1992/93	NO
Cumbria	1992/93	1991/92	1992/93	1991/92	YES
Derbyshire	1993/94	1995/96	1992/93	1992/93	NO
Devon and Cornwall	1993/94	1993/94	1993/94	1992/93	NO
Dorset	1995/96	1990/91	1995/96	1992/93	YES
Durham	1995/96	1993/94	1991/92	1993/94	NO
Dyfed-Powys	1992/93	1992/93	1992/93	1991/92	NO
Essex	1993/94	1992/93	1991/92	2000/01	NO
Gloucestershire	1993/94	1993/94	1993/94	2000/01	YES
Greater Manchester	1992/93	1992/93	1991/92	1992/93	NO
Gwent	1997/98	1993/94	1991/92	1992/93	NO
Hampshire	1992/93	1991/92	1992/93	1992/93	YES
Hertfordshire	1993/94	1992/93	1995/96	1991/92	NO
Humberside	1993/94	1994/95	1993/94	1991/92	NO
Kent	1995/96	1992/93	1993/94	1993/94	YES
Lancashire	1996/97	1993/94	1993/94	1992/93	NO
Leicestershire	1994/95	1993/94	1992/93	1993/94	NO
Lincolnshire	1993/94	1993/94	1992/93	1992/93	NO
Merseyside	1986/87	1987/88	1987/88	1995/96	NO
Metropolitan	1992/93	1982/83	1992/93	1991/92	(YES)
Norfolk	1993/94	1991/92	1992/93	2000/01	YES
North Wales	1992/93	1992/93	1993/94	1991/92	NO
North Yorkshire	1994/95	1995/96	1994/95	1995/96	NO
Northamptonshire	1993/94	1993/94	1991/92	1992/93	NO
Northumbria	1991/92	1991/92	1990/91	1985/86	NO
Nottinghamshire	1993/94	1991/92	1991/92	1992/93	YES
South Wales	1992/93	1994/95	1991/92	1991/92	NO
South Yorkshire	1993/94	1993/94	1993/94	1984/85	NO
Staffordshire	1993/94	1992/93	1993/94	2000/01	YES
Suffolk	1993/94	1991/92	1992/93	1993/94	YES
Surrey	1993/94	1992/93	1992/93	2000/01	YES
Sussex	1992/93	1991/92	1992/93	2000/01	YES
Thames Valley	1993/94	1993/94	1993/94	1992/93	NO
Warwickshire	1992/93	1993/94	1992/93	1991/92	NO
West Mercia	1993/94	1993/94	1996/97	1993/94	YES
West Midlands	1992/93	1996/97	1987/88	2000/01	NO
West Yorkshire	1993/94	1991/92	1991/92	1992/93	YES
Wiltshire	1992/93	1991/92	1993/94	1991/92	YES

Fifteen of 42 forces have sequencing that supports a diffusion of benefits hypothesis and 26 have sequencing that runs counter to the hypothesis[73]. Arguably 'other theft' is less reliably recorded compared to the other offences. When this crime type is excluded the number of forces with sequencing supporting a diffusion hypothesis rises to 22.

5) Sources for the international times series

Full sources for the data in the international time series used in this report are listed below.

England and Wales

Police recorded crime from ONS was used for all years. See: https://www.gov.uk/government/statistics/historical-crime-data

Scotland

Police recorded crime sourced from the Scottish government was used for all years. This was obtained by email.

The United States

Police recorded crime data from the Uniform Crime Reports data tool was used for all years. See: http://www.ucrdatatool.gov/

Canada

Police recorded crime data sourced from Statistics Canada. For the years from 1981–2001, data were sourced from Table 1 in this document: https://www.publicsafety.gc.ca/lbrr/archives/jrst85-002-x2003001-eng.pdf. For the years after 2001, table 252-0051 was used from here: http://www5.statcan.gc.ca/COR-COR/COR-COR/objList?lang=eng&srcObjType=SDDS&srcObjId=3302&tgtObjType=ARRAY

Australia

Police recorded crime data sourced from the Australian Institute of Criminology. For the years from 1980 to 1995, data were sourced from this publication: http://www.aic.gov.au/documents/8/C/D/%7B8CDE7EA6-7019-40D3-BAFA-DA1040BE608C%7DRPP07.pdf and converted from rates to volumes using population data from here: http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/3105.0.65.0012014?OpenDocument. For the years from 1996 to 1999, data were sourced from this document: http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/4510.02000?OpenDocument. For the years from 2000 to 2009 data were sourced from here: http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/4510.02009?OpenDocument and for the remaining years data were sourced from here: http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/4510.02013?OpenDocument

[73] The Metropolitan Police Service supports the hypothesis in the sense that theft of vehicles peaked first, but given that it peaked around a decade earlier than the other crimes, it does not seem likely that `diffusion of benefits' from security devices is a likely reason. The MPS has therefore been excluded from this bit of the analysis.

The Netherlands

Recorded crime data on vehicle thefts from RDW (the Netherlands Dept. of Motor Vehicles). Recorded crime data on burglary for 1980–1992 from this paper: http://www.crim.cam.ac.uk/people/academic_research/david_farrington/cnscj.pdf with rates converted to volumes using population data from here: http://statline.cbs.nl/Statweb/publication/?DM=SLEN&PA=37556eng&D1=0,21&D2=81-115&LA=EN&HDR=T&STB=G1&VW=T. Recorded burglary data from 1993 onwards were sourced from Eurostat (http://ec.europa.eu/eurostat).

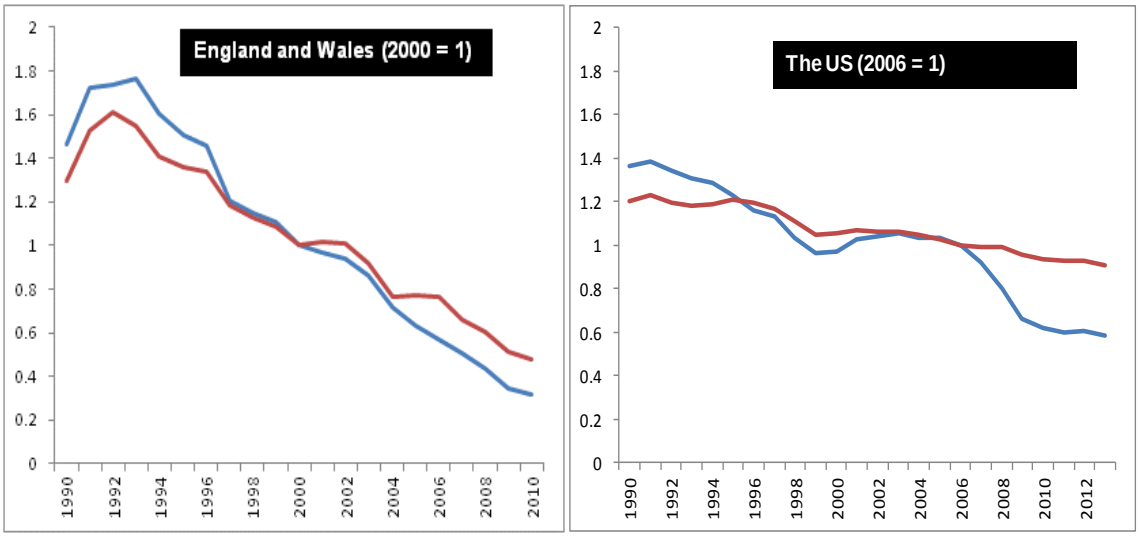
Sweden

Police recorded crime data for all years sourced from the Swedish National Council for Crime Prevention. See: http://www.bra.se/bra/bra-in-english/home/crime-and-statistics/crime-statistics/statistical-tables.html

6) Analysis of theft from vehicles trends, looking at possible displacement/diffusion

Figure A7.5 shows a panel of charts with indexed trends in theft of vehicles and theft from vehicles. The aim was to see whether trends in theft from vehicles deviated at the point at which immobilisers would be likely to have their maximum impact. However, data for theft from vehicles could not be sourced for the US, Australia or the Netherlands. For the US, therefore, Figure A7.5 shows theft of vehicles compared to the category of 'larceny-theft' which contains thefts from vehicles but also other types of theft. Similarly for Australia, the larger category of 'other theft' (which contains thefts from vehicles) was used in Figure A7.5. No suitable category could be found for the Netherlands.

Figure A7.5: Indexed trends in vehicle theft (blue line) and theft from vehicles or the wider category containing that crime type (red line)



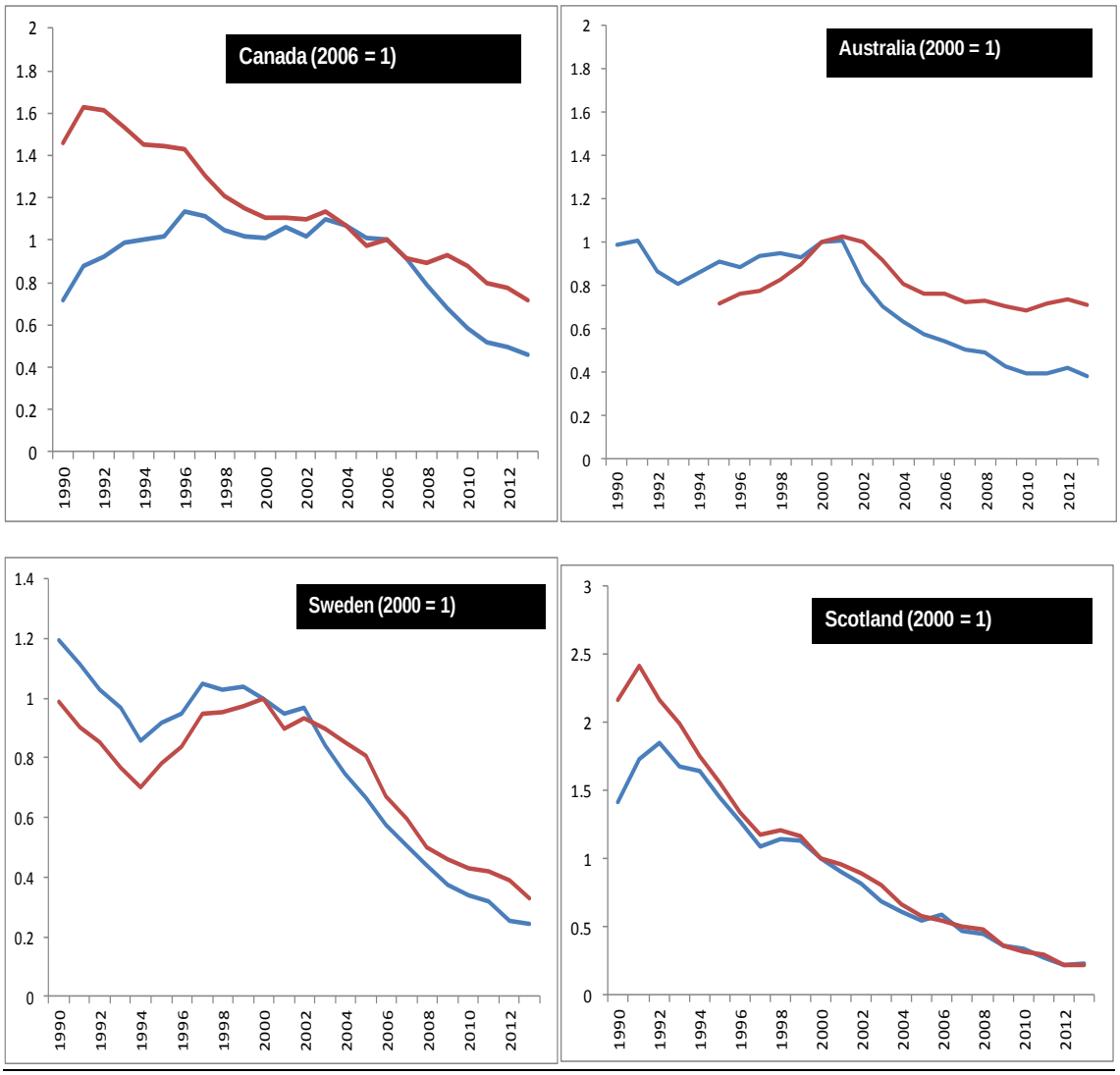


Figure A7.5 reveals a mixed picture. For the US and Canada, trends in theft from vehicle (or larceny-theft in the case of the US) show little if any deviation when theft of vehicles starts falling in 2006. But for most of the other nations (except Scotland), theft from vehicles (or for Australia, the wider theft category containing that offence) does show signs of deviation from 2000 on, often falling at the same rate as, or slightly slower than, vehicle thefts. There is certainly some support, then, for the theory that benefits from electronic immobilisers diffused to theft *from* vehicles as well as preventing theft *of* vehicles. This is in accordance with the evidence that some vehicles are stolen more for their contents than for the vehicle itself (Light *et al*., 1993). However, in the European nations and Australia, the degree of correlation through the entire series, even back to 1980 so long before immobilisers appeared, is very high. This perhaps suggests that other factors were also involved in driving both trends at certain points.

7) CSEW trends in types of items stolen in 'theft from vehicle' offences

Although the CSEW has contained questions on items stolen since 1981, the types of items listed have changed substantially making it difficult to construct consistent trends. Generally, over time, more categories have been added, both to increase precision and to reflect changing technology. For instance, the 1987 survey had only 17 possible categories, while the 2005/06 survey had 68 (Table A7.4).

Crucially, from 1991 onwards respondents were asked what types of vehicle parts/accessories were stolen (Table A7.4). This allows us to know whether these items were stolen from inside or from off the outside of the vehicle. It also potentially allows us to know whether 'radio/audio

equipment' relates to car stereos or other types of stereo equipment that just happened to be in the vehicle.

Two approaches were used to create meaningful groups of categories.

- **The first** was to use the groupings used in the ONS publication 'Focus on property crimes'. For surveys back to 2001/02 there is a set of derived variables that automatically give this particular grouping. For surveys back to 1991, the groupings had to be created manually. For surveys before this point, it is not possible to create this grouping as the detail on motor vehicle parts/accessories is required. (Table A7.5)
- **The second** was to condense these groupings into four categories: external fittings and parts (e.g. bumper, wheels, brakes), non-electronic valuables (e.g. purse, cash, jewellery), stereo-hi-fi/car radio, and other items likely to be inside vehicle (e.g. tools, mobile phone, camera). (Table A7.6)

The second grouping revolved around the type of security required to defend against that type of theft. For example, central locking aims to prevent thieves from entering the vehicle. It might therefore be expected that as these devices spread through the vehicle fleet, thefts from inside the car would fall, but thefts of exterior parts might be unaffected.

Table A7.4: Stolen item categories for selection of CSEW years

1981	1987	1991	1997	2001/02	2005/06
Cash	Car/van	Car/van	Car/van	Car/van	Car/van
Cheque book/credit card	Motorcycle/scooter	Motorcycle/scooter	Motorcycle/scooter	Motorcycle/scooter	Motorcycle/scooter
Car/van	Vehicle parts	Vehicle parts	Vehicle parts	Vehicle parts	Vehicle parts
Motorbike/scooter	Handbag	Handbag	Briefcase/handbag	Briefcase/handbag	Briefcase/handbag
Motorvehicle parts	Wallet	Wallet	Purse/wallet	Purse/wallet	Purse/wallet
Bicycle	Purse	Purse	Cash	Cash	Cash
Car radio/car cassette	Cash	Cash (not from meter)	Cheque book	Cheque book	Cheque book
TV	Money from meter	Money from meter	Credit card	Credit/switch/debit card	Plastic card
Radios/cassette player	Cheque book/credit card	Cheque book/credit card	Bicycle	Mobile phone	Mobile phone
Tapes/cassettes	Bicycle	Bicycle	Video equipment	Jewellery	Jewellery
Bicycle parts	Video equipment	Video equipment	Television	Clothes	Clothes
Personal papers	Television	Television	Stereo/hi-fi	Documents	Documents
Purse/wallet, handbag	Stereo/hi-fi	Stereo/hi-fi	Camera	Video equipment	Video equipment
Cameras	Camera	Camera	Computer equipment	Television	Television
Jewellery	Jewellery	Jewellery	Mobile phone	Stereo/hi-fi	Stereo/Hi-fi
Garden equipment	Silverware	Silverware	Jewellery	Camera	Camera
Tools	Other	Tools	Tools	Computer equipment	Computer equipment
Petrol		Clothes	Clothes	CDs/tapes/videos	CDs/tapes/DVDs
Clothing		Documents	Documents	House keys	House keys
Sports equipment		Other	Other	Car keys	Car keys
Toys				Tools	Tools
Alcohol				Bicycle	Bicycle
Food/tobacco				Garden furniture/equipment	Garden furniture
Household equipment				Wheely bin/dustbin	Wheely bin/Dustbin
Other items				Children's toys	DVD player
				Household items	Work materials
				Sports equipment	Caravan
				Other	Children's toys
					Household items
					Sports equipment
					Food/drink/alcohol
					Toiletries/make up
					Animals/pets
					Cigarettes/tobacco
					Glasses
					Furniture
					Doors/windows
					Books
					Bicycle parts
					Baby or child items
					Other
		Radio/tape/CD/stereo	Radio/tape/CD/stereo	Radio/tape/cd/stereo	Radio/tape/CD/stereo
		In-car telephone	In-car telephone	In-car telephone	In-car telephone
		Two-way radio	Two-way radio	Two-way radio	Two-way radio
		Instruments	Instruments	Instruments	Instruments
		Interior fittings	Interior fittings	Interior fittings	Interior fittings
	Motor vehicle parts accessories	Exterior fittings	Exterior fittings	Exterior fittings	Exterior fittings
		Wheel/tyre	Wheel/tyre	Wheel/tyre	Alloy wheels
		Tools kept in car	Tools kept in car	Tools kept in car	Non-Alloy wheels
		Mechanical parts	Mechanical parts	Mechanical parts	Tools kept in car
		Fuel	Fuel	Fuel	Mechanical parts
		Other	Other	Tax disc	Fuel
				Air bags	Tax disc
				Other	Airbags
					Number plates
					Other
				Bumpers	Bumper
				Hub caps	Hub caps
				Wheel trims	Wheel trims
				Aerials	Aerials
				Exhaust	Exhaust
			Exterior fittings of motor vehicle	Number plates	Number plates
				Maker's badge	Maker's badge
				Luggage rack	Luggage/bicycle rack
				Wing-mirror	Wing-mirrors
				Wipers	Windscreen wipers
				Other	Lights
					Other

Table A7.5: Items stolen in 'theft from vehicle' offences (by percentage and volume)

PERCENTAGES	1991	1993	1995	1997	1999	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14
External fittings	20.7	19.0	27.9	36.4	31.1	28.4	31.7	30.0	30.4	37.1	34.2	35.4	36.8	38.7	40.5	36.8	36.3	36.6
Stereo/hifi	38.8	30.6	30.9	27.9	23.9	24.6	23.5	23.6	24.8	19.7	18.0	16.7	12.4	11.2	7.5	7.3	4.7	4.4
Valuables	17.5	19.5	14.8	13.3	16.2	18.1	17.0	20.3	16.8	16.8	15.4	15.2	13.0	16.1	15.2	17.6	19.6	19.2
CDs/Tapes/DVDs						9.1	11.7	12.7	13.9	10.5	9.6	8.8	7.6	8.4	5.4	6.5	5.5	4.7
Other (non vehicle parts)	18.9	25.7	20.4	15.4	23.1	9.5	7.2	10.0	10.2	7.3	6.8	7.0	8.0	5.0	5.7	5.6	6.0	5.2
Tools	7.9	8.4	7.9	6.4	8.3	9.2	9.1	9.0	6.7	5.2	5.4	6.0	5.8	4.4	5.9	5.0	4.5	5.2
Mobile phone (or in-car telephone)	1.3	2.9	2.6	2.4	4.1	4.1	5.2	5.5	6.6	4.5	3.5	3.7	3.0	2.7	2.6	2.3	3.1	3.3
Other vehicle parts	5.7	8.4	5.9	4.0	6.7	4.7	3.6	3.8	5.4	7.9	7.7	5.7	7.6	7.7	8.1	9.3	10.4	12.8
Wheels/tyres	3.3	4.1	4.4	7.5	5.9	4.9	2.7	1.5	3.0	3.0	2.5	2.8	3.2	1.7	2.5	2.2	2.3	3.0
Electrical goods	0.3	1.0	1.0	0.7	2.0	2.0	1.6	2.8	2.6	2.6	9.4	11.6	14.0	14.8	13.5	16.1	16.0	18.9
Fuel	2.9	1.0				1.4	2.7	0.8	1.2	1.1	0.8	1.3	0.6	0.9	0.7	0.9		
House keys						1.1	0.5	1.1										
camera	1.0	0.8	1.3	1.0	0.8	0.9	0.8	1.2	0.8	0.8	1.6	1.0	0.7	1.6	1.2	1.2	1.1	0.7
Tax disc						1.3	1.3	1.0										
Household items						3.7	2.5	1.3	0.5	0.9	0.4	1.0	1.5	1.1	1.3	1.7	2.3	1.8
Car keys						0.3	0.4	0.5										
Vehicle stolen		0.4	0.4	0.1	0.6	1.7	0.6	0.5										
Garden equipment						0.3	0.3	0.0										
Bicycle	0.1	0.1	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.3	0.0
food/toiletries/cigarettes										1.3	1.3	1.6	2.0	1.4	1.4	2.3	3.1	1.9
VOLUMES (000s)	**1991**	**1993**	**1995**	**1997**	**1999**	**2001/02**	**2002/03**	**2003/04**	**2004/05**	**2005/06**	**2006/07**	**2007/08**	**2008/09**	**2009/10**	**2010/11**	**2011/12**	**2012/13**	**2013/14**
External fittings	500.6	482.6	695.1	783.1	559.7	416.0	441.0	389.1	356.7	402.3	372.7	338.1	373.2	320.5	342.3	323.9	275.1	263.4
Stereo/hifi	938.9	775.8	770.5	600.7	430.8	360.7	326.8	306.6	291.0	214.1	196.4	160.0	125.7	92.6	63.3	63.9	35.8	31.7
Valuables	422.1	494.8	368.8	286.3	292.2	265.9	236.2	264.1	197.0	182.5	167.9	144.7	132.1	133.7	129.0	154.8	148.4	138.1
CDs/Tapes/DVDs						133.9	161.9	165.1	163.5	114.2	105.0	83.9	77.5	69.7	46.1	57.1	41.6	33.6
Other (non vehicle parts)	456.3	651.8	508.5	331.8	416.3	139.6	99.6	130.3	119.9	78.9	74.2	66.6	80.8	41.1	48.2	49.7	45.8	37.2
Tools	189.8	213.7	196.6	136.9	149.9	135.3	126.8	117.3	78.0	56.7	58.8	56.9	58.4	36.4	50.1	43.7	34.0	37.6
Mobile phone (or in-car telephone)	32.2	74.4	66.0	52.0	73.0	59.9	71.9	71.4	77.0	49.4	38.4	35.6	30.1	22.7	21.8	20.2	23.6	23.6
Other vehicle parts	138.9	212.6	147.8	87.0	119.9	69.5	50.6	48.7	63.8	85.7	84.4	54.0	77.4	64.2	68.3	81.8	78.9	92.4
Wheels/tyres	79.4	102.8	108.7	160.2	105.6	71.5	38.1	20.0	35.5	32.6	27.1	26.4	32.1	14.5	21.5	19.7	17.5	21.5
Electrical goods	7.1	25.3	25.5	15.1	36.7	29.9	21.9	36.8	30.6	28.2	102.6	110.8	141.7	123.1	113.9	142.2	121.2	135.8
Fuel	69.9	24.2				21.2	38.0	10.2	14.0	11.6	8.5	12.0	6.4	7.3	5.6	8.4		
House keys						15.5	7.2	14.9										
camera	24.6	19.3	32.3	20.6	14.0	13.7	10.6	15.8	9.5	8.5	17.7	10.0	6.7	13.1	10.0	10.3	8.4	5.4
Tax disc						18.4	18.1	13.6										
Household items						53.8	35.2	16.3	5.4	9.7	4.2	9.7	15.2	8.7	11.2	15.0	17.7	12.9
Car keys						3.7	6.0	6.8										
Vehicle stolen		9.8	9.0	1.8	10.7	24.6	8.6	6.2										
Garden equipment						4.0	4.1	0.5										
Bicycle	2.4	1.9	0.0	0.0	9.6	0.4	0.6	0.0	0.4	1.5	0.6	0.0	0.5	0.3	0.4	0.0	1.9	0.0
food/toiletries/cigarettes										14.2	14.2	15.7	20.2	11.2	12.1	20.6	23.7	13.9

Source: ONS, Crime Survey for England and Wales.

Table A7.6: Trends in items stolen in 'theft from vehicle' offences, four categories

	1991	1993	1995	1997	1999	2001-02	2002-03	2003-04	2004-05	2005-06
PERCENTAGES										
External parts	25%	24%	32%	42%	34%	34%	35%	33%	35%	44%
Stereo-hifi/car radio	39%	31%	31%	28%	24%	25%	24%	24%	25%	20%
Other items inside vehicle	34%	44%	36%	30%	45%	41%	40%	43%	42%	38%
Valuables	17%	20%	15%	13%	16%	18%	17%	20%	17%	17%
ESTIMATED VOLUMES (000s)										
External parts	602	596	807	896	605	492	493	425	405	473
Stereo-hifi/car radio	939	778	772	601	432	365	329	308	288	212
Other items inside vehicle	820	1,113	894	642	802	595	562	556	488	413
Valuables	422	496	369	286	293	269	238	265	195	181

It is worth pointing out that the 'external parts' category in the second grouping (Table A7.6) includes things like tyres and wheels, which are listed as separate items in the published grouping (Table A7.5).

The tentative conclusions in the main report draw from the trends in Table A7.6 and are as follows.

- Trends show that stereo thefts probably peaked in the 1980s (or at the latest 1991) and declined thereafter.
- Thefts of external vehicle parts made up a sizeable component of all thefts from vehicles, featuring in between a quarter and two-thirds of thefts depending on the year.
- For the final years of the rise in thefts from vehicles (1991 to 1993), thefts of other items from inside the car – i.e. not stereos or exterior fittings – drove up theft levels.
- From the crime peak to 2014 thefts of virtually all types of items have fallen. The fall in stereo thefts has been particularly sharp, the decline in thefts of external parts, valuables and electrical goods from inside the car, slightly less so.

In addition, some further conclusions arise from looking at some of the smaller categories in Table A7.5.

- Electrical goods are the one category of good that buck the generally downward trend from the mid 1990s. These rise markedly in the mid-to-late 2000s before falling back slightly in the most recent years. This surge in thefts may be connected to GPS satellite navigation systems becoming commonplace.
- In the most recent period (since 2010), most types of items have seen falling trends, but there are some exceptions. Thefts of valuables have remained fairly stable and thefts of 'other internal vehicle parts' have risen. It is not entirely clear what is driving the latter trend.

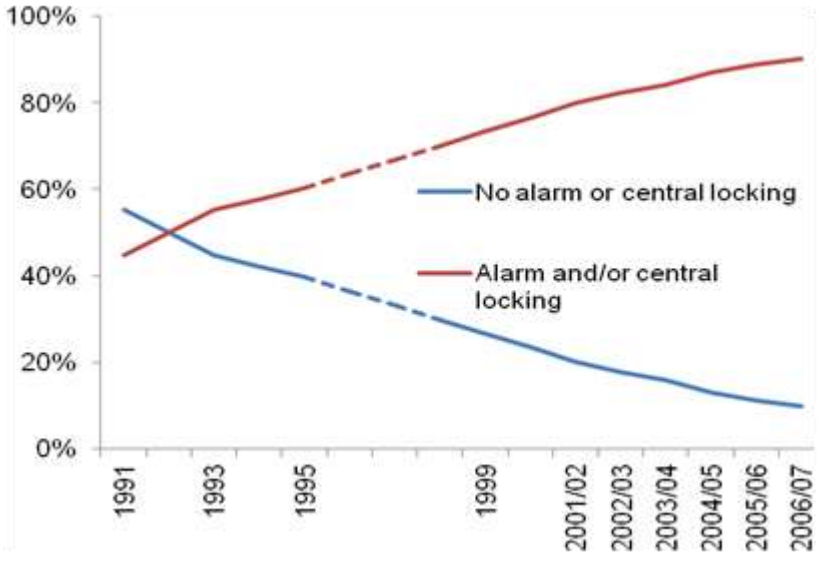
8) CSEW trends in theft of vehicle incidents and car security

One way of calculating rates of vehicle theft according to vehicle security is to, as Farrell *et al*. (2011) do, compare the security features of vehicles stolen, as reported by victims, with the overall security features of households' main vehicle. For example, if in the population five per cent of vehicles have no security, but this category makes up 50 per cent of stolen vehicles, it is clear that these types of vehicles are stolen at a higher rate than vehicles overall.[74]

However, before 2001/02 the CSEW did not ask victims of vehicle theft about the security features of the stolen vehicle. And only from the 1990s onwards did the survey ask about the security features of the household's most used car or van. Unfortunately, these questions changed for each survey in the 1990s, and the only security components consistently asked about were car alarms and central locking. (Note that no such questions were asked in the survey covering 1997.)

Figure A7.6 shows how throughout the 1990s and 2000s the presence of alarms and/or central locking on households' main vehicles increased substantially – from 45 to 90 per cent over 15 years.

Figure A7.6: Proportion of car/van owning households by whether the main car/van had an alarm and/or central locking



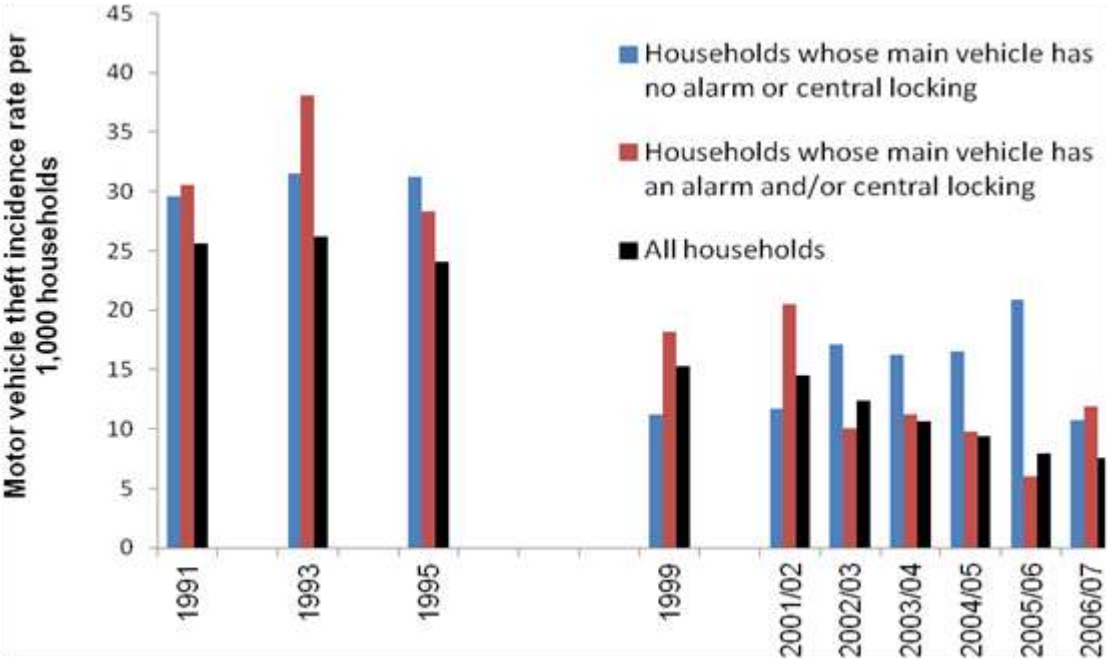
Source: CSEW.

The analysis in the main body of the text assumes that cars/vans without an alarm or central locking were very unlikely to have an electronic immobiliser.

[74] However, it is important to recognise that even this approach has limitations. Using data on households' main vehicle as, in effect, data on the entire pool of vehicles will also be slightly biased due to the issues involving theft of non-main vehicles and security improvements made post-theft.

Indeed, when we look at households' main vehicle in the 2001/02 survey, only eight per cent of cars/vans with an electronic immobiliser did not have an alarm or central locking.

Figure A7.7: Incidence rates of motor vehicle theft, split by whether household's main car had an alarm and/or central locking



Source: CSEW.

Note: The black bars are sometimes lower than the other two bars as the 'all households' incidence rates include in the denominator households that did not own a motor vehicle in the past 12 months. These households therefore cannot be victims of vehicle theft.

Once vehicle-owning households are split into two groups – those whose main car/van had an alarm and/or central locking, and those whose main car/van did not have either feature – it is straightforward to calculate incidence rates of motor vehicle theft, as shown in Figure A7.7. However, there are a number of potential issues with using these incidence rates to compare the security of vehicles and their risk of theft. Some of the following were mentioned in the main text.

1.) Thefts of motorbikes and scooters are included in the incidence rates, but are not represented in the security questions. Therefore in the main body of the text and for the rest of this appendix rates of theft only relate to cars or vans. However, the method of computing these incidence rates is substantially more time-consuming meaning that only a few key years around the crime peak and fall (1991, 1993, 1999, and 2001/02) were investigated.

2.) Respondents are asked about the household's **main** car/van, meaning that if a second or third car/van is stolen, the security features of these vehicles are not necessarily represented correctly in the data. This is

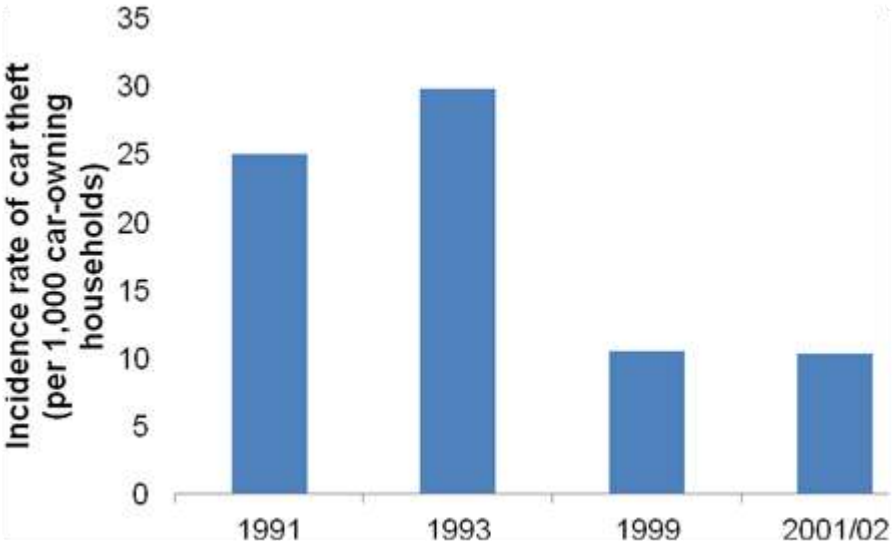
significant because secondary cars/vans are more likely to have worse security than the household's primary car/van, and are, therefore, at greater risk of being stolen.

3.) Respondents are asked about the household's **current** car. Regardless of whether the stolen vehicle is returned, if a household is a victim of car/van theft it is more likely that the security of the household's car/van will subsequently increase than if the household had not been victimised. For example, if the vehicle is not recovered, the victim is likely to buy a car/van with improved security, either as a conscious decision to prevent further thefts, or simply as a product of newer vehicles having improved security. Similarly, if a vehicle is recovered, the owner may decide to install security features to prevent further thefts.

4.) A final factor is that other security features not picked up by every wave of the survey, such as mechanical immobilisers, may be more likely on cars/vans without an alarm or central locking than those that did have those features. But the available data suggest this is not the case. In 1991 22 per cent of households whose main car had no alarm/central locking had a mechanical immobiliser, which was very similar to the proportion found for those households whose main car ***did*** have an alarm/central locking (24%).

An important question is whether these limitations affect the conclusion – as stated in the main text – that vehicle thefts fell during the 1990s, regardless of security levels. The conclusion seems sensible given that it would be unlikely a household would have a second car with better security than its main car, and it seems even more unlikely that a household would get a car with inferior security after experiencing a vehicle theft. But Figure A7.8 shows the findings from some further analysis on this issue. It shows theft incidence rates for households whose main vehicle had no security for the individual years investigated. The decreases in these rates from the early 1990s to the late 1990s and 2000s are statistically significant (Table A7.7) just as they are when the years are pooled, as shown in the main body of the text.

Figure A7.8: Incidence rates of car/van theft for households whose main car/van had no alarm or central locking



Source: CSEW.

Table A7.7: Statistical significance of changes in incidence rates shown in Figure A7.8

Change between	p value
1991 and 1999	p<.05
1993 and 1999	p<.01
1991 and 2001/02	p<.05
1993 and 2001/02	p<.01

Furthermore, to check that the fall in 'no-security' thefts was not being biased by the absence of mechanical immobilisers from the analysis, we re-calculated 'no-security' theft rates for two years in which these devices were asked about: 1991 and 1999. So households who had a mechanical immobiliser only were take out of the `no-security' group. This still showed a statistically significant fall in theft rates from the former year to the latter.

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