

Where There's Smoke There's Fire:

An Opportunity Theory Perspective on Vehicle Arson

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This thesis is presented in partial fulfilment of the requirements for the degree of

Bachelor of Arts Honours (Criminology)

November 2016

I declare this thesis is my own account of my research and contains as its main content work which has not been previously submitted for a degree at any tertiary education institution.

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Abstract

Opportunity theories of crime suggest that crime occurs in specific spatio-temporal patterns due to an increase in opportunity and a decrease in risk. Financially-motivated crimes have been demonstrated to be influenced by the economy. From an opportunity perspective this is likely to be due to changes in an individual's financial circumstances leading them to view the benefits of crime to outweigh the risks. To extend this idea, this research is examining whether financial hardship influences the perceived costs/benefits associated with crimes such as vehicle arson committed with the intention of escaping debt. From 1997-2003, vehicle fires in Surrey were occurring at a rate more than double the national average and many of these were transpiring under suspicious circumstances. Using an opportunity theory framework, this study aims to examine the spatio-temporal patterns of vehicle arson and discover how it was effected by changes in economic conditions. The data for this study were obtained from Surrey Fire Services and contain information on all fires that involved a vehicle in Surrey from 2000-2015. The vehicle fire data were separated into arson and non-arson groups depending on their recorded act/omission and various economic variables were considered to represent the market. Vehicle arson trends were examined over the study period along with motor vehicle theft data, economic variables and the non-arson fire data. Relative to the unsuspecting vehicle fires, vehicle arson was significantly more likely to occur at night in areas with little surveillance. Results indicate that vehicle arson increases during times of economic downturn. Vehicle arson significantly increased following a rise in unemployment and interest rates whilst non-arson vehicle fires remained stable throughout the study period thus supporting an opportunity theory of crime.

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Results are discussed with relation to situational crime prevention policy and practice.

Keywords: opportunity theories, vehicle arson, crime and the economy.

Word Count: 18,353

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Acknowledgements

First and foremost, a huge thank you to Joe Clare, my supervisor. Your guidance, support and mentoring were invaluable throughout my honours year. In particular, your encouragement, reassurance and never-ending patience were truly appreciated.

Thank you to everyone at Surrey Fire Services for trusting me with this research project and providing me with support and access to the vehicle fire data. In particular, I would like to acknowledge Len Garis and Sarah Hughans' contributions to this research. Sarah's assistance with anything and everything GIS kept me on track when everything seemed to be going wrong with my spatial analysis.

I would also like to thank the members of the criminology honours group at Murdoch. Thanks to Guy Hall and Jaimie Zander for providing feedback and encouragement throughout the year. To Ashlee, Greig and Amanda, thank you for your support and reassurance but mostly, thank you for finding humour in some of our most challenging moments.

Last but not least, I would like to thank my family. Firstly, thank you to my aunty, Margaret, and my grandparents, Kathleen and Brian, your expertise in editing and valuable feedback were truly appreciated. Finally, thank you to my parents, Kate and Marty, my sisters, Megan and Kat and my partner, Matt, whose ongoing support and encouragement kept me focused and motivated throughout the year.

Where There's Smoke There's Fire: An Opportunity Theory Perspective on Vehicle Arson

In 2007, Garis, Plecas, Neal and Huitson conducted a review of vehicle fire data in Surrey, British Columbia (BC), Canada (referred to as 'Surrey' for the remainder of this paper) after it became apparent that these fires were occurring at an unusually high rate compared to national research. Indeed, the review discovered that vehicle fires in Surrey were occurring at a rate more than double what was expected. The suspicious manner in which many of these fires were occurring led researchers to believe that these were the result of arson. Developing from this, this thesis will examine the spatio-temporal and longitudinal characteristics of vehicle fire in Surrey from 2000-2015. As crime has been found to occur in specific spatio-temporal patterns, the purpose of this research is to determine whether different patterns exist for arson and non-arson vehicle fires and if so, whether or not they are consistent with an opportunity theory of crime. Also from an opportunity perspective, fluctuations in crime are likely to have been caused by a widespread event that led individuals to perceive the costs/benefits of crime differently. As the economy has been found to have an impact on financially-motivated crime and the fact that the vehicle fires in the initial review were occurring at an increased rate, this thesis will also examine the influence of the economy on vehicle fire trends. The relevance of these research questions will be explained throughout the introduction by summarising opportunity theories of crime, the relationship between crime and the economy and what is known about arson generally. The current research methods will then be explained following the aims and hypotheses of this study.

Theoretical Framework

Crime occurs in specific spatial and temporal patterns (Wuschke, Clare & Garis, 2013). Indeed, different types of crime have been found to cluster in particular spatial patterns as well as during specific hours of the day, days of the week and months of the year (Henry & Bryan, 2000; Herrmann, 2015; von Elm et al., 2010; Wuschke et al., 2013). Recognising the spatio-temporal patterns of specific crimes can assist stakeholders in the development of targeted prevention initiatives. But first, understanding why these crimes are occurring in these patterns can ensure prevention efforts are applied effectively (Clarke, 1997). Opportunity theories of crime can provide researchers with an understanding of why certain crimes occur in the patterns that they do. These theories have been used to explain the occurrence and patterns of various types of crime including motor vehicle theft (MVT), property theft, violence and cyber-crime, to name a few (Bernasco & Block, 2010; Copes, 1999; Matsueda, Kreager & Huizinga, 2006; Pratt, Holtfreter & Reisig, 2010).

According to Eck and Weisburd (2015), criminological theories fall into two categories; those that focus on the offender and those that focus on the criminal event. Opportunity theories (such as routine activity, rational choice and crime pattern theory) fall under the second category (Eck & Weisburd, 2015). From an opportunity perspective, crime is viewed as a non-random event that occurs in specific places and at specific times due to an imbalance of costs/benefits associated with the crime (as perceived by the offender).

Using these theories, offenders are not necessarily viewed as inherently bad people but are instead perceived as 'normal everyday people' who, due to a change in circumstances, considered the benefits of crime to outweigh the

risks. Given the nature of vehicle arson as a means of financial gain, opportunity theories will be used to explain the spatio-temporal patterns and economic motivations behind vehicle arson. The results from this study will be used in conjunction with situational crime prevention (SCP) to develop targeted prevention strategies in locations that exhibit significant hot spots of vehicle arson.

Routine activity theory. As developed by Cohen and Felson (1979), routine activity theory suggests that crime is a normal event that can be explained through the convergence of three elements in time and space. Changes in an individual's daily routine activities (such as work, school, etc.) can lead to a motivated offender and a suitable target (or victim) crossing paths. Yet, for a crime to occur, three elements are needed; a motivated offender, a suitable target and a lack of capable guardians converging in time and space. A motivated offender could be anyone who has the potential to commit crime in a given situation (as explained below in rational choice theory) (Hollis, Felson & Welsh, 2013). A suitable victim/target is a person or object that is perceived by the offender as vulnerable, desirable or accessible (Hollis et al., 2013). Finally, a capable guardian can be anything or anyone whose presence is likely to deter the crime from happening (Hollis et al., 2013).

Developing this theory further, Felson (1986) and Eck (1994) (as cited in Felson, 1995) introduce an additional layer to the three elements of crime and determined that crime occurs when a motivated offender and suitable target meet at the same time in a specific place that is likely to facilitate crime (also known as the problem analysis triangle (Clarke, & Eck, 2005)). Each of these three elements also has a 'controller' that further impact the likelihood of crime

occurring. Controllers fall into three categories; handlers, managers and guardians. Handlers are those responsible for the supervision of likely offenders (parents, school teachers, employers, etc.). Managers deter crime through the supervision of places; these would be people such as the owner/s of property. Guardians protect the target; this role is largely varied and can consist of anything from a guard dog or a security camera to a neighbour who is likely to notice a break and enter next door. Controllers are people whose presence can decrease the likelihood of a crime occurring by 'controlling' either the offender, place or target. Therefore, for a crime to occur, an offender and target would need to meet in a specific place where crime is likely to occur in the absence of controllers.

Rational choice theory. When used in conjunction with routine activity theory, rational choice theory can be used to explain the motivated offender element of crime (Hollis et al., 2013). From a rational choice perspective, crime is considered a normal human behaviour (Cornish & Clarke, 2008). This is because, much like the decision-making processes people use on a day-to-day basis, individuals are also thought to undergo a cost-benefit analysis when deciding whether or not to engage in criminal behaviour (Cornish & Clarke, 2008). However, the benefits/rewards from the crime do not always have to be financial; rational choice theory can also be used to explain seemingly spontaneous violent crimes such as assault. For example, it could be argued that the decision to engage in a fight is the result of a cost-benefit analysis because the cost of the fight would most probably result in the individual getting seriously injured and considering this, if the individual were certain the fight would result in his/her injury without the likelihood of any benefits, it would seem

unlikely that the individual would engage in the fight. The decision to engage/not engage in the fight may be seen as senseless to others, but it is still a decision nonetheless.

A common argument against rational choice theory is that the notion of 'rationality' is largely subjective, and the human mind does not have the capacity or ability to make accurate/rational decisions that will ultimately result in the least risk and the most reward (Clarke & Cornish, 1985; Johnson & Payne, 1986). This is because the decision-making process differs with each individual, and what may seem like an important factor to consider for one person may seem irrelevant to another and subsequently result in different decisions. Therefore, what is considered rational to one person may seem irrational to another and so forth. Considering this, rational choice theory looks at crime in terms of 'bounded rationality', meaning that the rationality of the end decision is limited by certain factors yet the actual decision-making process can be considered rational.

However, it is important to note that in terms of crime prevention, as decision-making differs with each individual, the specific decision-making process used to get to the end decision is irrelevant as it does not provide any useful information on how to prevent certain crimes. Instead what is important is understanding the rewards/opportunities that cause people to consider engaging in criminal behaviour as well as the risks/efforts that can be put into place to lessen the perceived incentives of crime. This theory can be used to explain how under certain circumstances, normal 'everyday' people can begin to consider engaging in criminal activities such as vehicle arson.

Crime pattern theory. Offenders have been found to commit crime near their place of residence (Bernasco & Kooistra, 2010). This is best explained by crime pattern theory (Brantingham & Brantingham, 2008). Crime pattern theory describes how the routine activities of offenders can lead to crime in certain areas (Brantingham & Brantingham, 2008). Like everyday people, offenders spend a large amount of their days moving through their routine activities (such as work, school, home, grocery shopping, etc.) (Eck & Weisburd, 2015). When travelling to/from these routine activities, offenders become aware of criminal opportunities in certain areas (Eck & Weisburd, 2015). This is explained through nodes, pathways and edges, as developed by Brantingham and Brantingham (1993).

A node is the location of a routine activity such as the address of work, home or school. Pathways are the routes that are taken to get to/from the nodes. These comprise the offender's 'awareness space', which is the area connecting the routine activities in which the offender is likely to know about criminal opportunities and thus commit crime. Edges represent the perimeter of the offender's awareness space. Using this theory, the routine activities of an offender can lead to the discovery of areas with little guardianship and suitable targets within his/her awareness space. Therefore, criminal opportunities in areas outside the offender's awareness space are unlikely to be known to the offender, which explains why crimes are committed within a certain distance from the offender's residence (Eck & Weisburd, 2015).

Using routine activity theory and crime pattern theory an understanding can be gained of the spatio-temporal characteristics of certain crimes. Crime pattern theory can be used to explain why crime is occurring in certain areas

and possibly how the offenders became aware of these spaces, whilst routine activity theory can provide us with an understanding of certain aspects of the area that facilitate crime (such as an absence of guardians and a suitable target) (Eck & Weisburd, 2015). These theories have been used to understand the spatio-temporal clusters of crime, how offenders become aware of opportunities and how these areas facilitate crime.

Opportunity theories have also been used to explain fluctuations of crime. One variable that has been found to have a significant influence on crime trends is the economy. From a rational choice perspective, changes in the economy can have substantial impacts on people's financial circumstances, resulting in individuals perceiving the financial incentives of crime as a more timely solution to their financial hardship than other legitimate alternatives. Considering this, the next section describes how fluctuations in the economy can alter people's decisions to engage in crime and how this has been supported by previous research.

Crime and the Economy

Many studies have sought to understand what causes crime to increase or decrease over time (Farrell, Tilley & Tseloni, 2014). The temperature-aggression theory, legalisation of abortion (leading to fewer juvenile delinquents) and the increased use of capital punishment are but some of the theories that have been studied in relation to fluctuations in crime generally (Farrell et al., 2014; Hipp, Bauer, Curran & Bollen, 2004). Yet, one variable that has been thought to be one of the biggest predictors of crime is the economy (see Andresen (2013) for further discussion). The economy fluctuates according to how well, or poorly a country is performing at a given time, as reflected by

various economic indicators. When the economy is headed towards a recession or is on the decline, economic indicators such as unemployment, under-employment and foreclosure rise, suddenly leaving many families with little to no income and in severe cases, homeless.

The economy plays a fundamental role in understanding how law-abiding people can come to commit crime. Certain aspects of the economy can be volatile. Not only can people suddenly find themselves unemployed and unable to find new employment but employed people could also be acquiring loans while the interest rate is low without factoring into their budget the fact that the interest rate could unexpectedly rise, leaving them unable to afford their repayments. When people are faced with situations such as these, they can experience substantial levels of stress. Financial stress can lead individuals to go to extreme lengths to escape these stressors. For example, crime and suicide have both been found to increase during times of economic downturn (Milner, Niven & LaMontagne, 2015; United Nations Office on Drugs and Crime, 2011).

The relationship between crime and the economy has been of interest for some time (Chiricos, 1987). Initially, researchers were specifically interested in the effect of unemployment on crime generally (Arvanites & DeFina, 2006). Cantor and Land (1985) considered the effect of motivation and opportunity on crime, and proposed that crime is both positively and negatively impacted by unemployment, depending on the timescale of analysis. In the short-term following unemployment, crime is expected to decrease. This is because as unemployment increases more people are likely to be at home during the day, when they used to be at work, thus increasing guardianship and reducing

opportunities for individuals to commit crime in these areas. In the long run, however, unemployment is said to increase crime. As people are out of work for extended periods of time they begin to spend a large proportion of their savings which could result in increased motivation to obtain an illegitimate source of income (Greenberg, 2001).

Possibly as a consequence of the importance of the timing of analysis, studies in this area have produced largely inconsistent results which have led many academics to doubt whether or not a relationship even exists between unemployment and crime in general (Yearwood & Koinis, 2011). Due to the doubt created by the mixed results from these studies, Chiricos (1987) reviewed 63 multi-disciplinary studies looking at the relationship between crime and unemployment. Through this review, it was concluded that unemployment was consistently related to property crime, while violent crime was significantly less likely to be affected. In fact, Arvanites and DeFina (2006) found that the only violent crime impacted by the economy was robbery, which was not surprising given its financial motivation. While conducting the review, Chiricos (1987) discovered that three common methodological issues were often to blame for the inconsistent results found between studies. The first of these methodological issues related to the level of aggregation in the data. Studies conducted at a state- or national-level were more likely to produce inconsistent results than those conducted at a city-level. Therefore, studies that focused on a smaller geographic area were more representative of the sample. Secondly, results varied depending on the type of unemployment rate used. Age- or gender-specific unemployment rates led to increased inconsistency of results compared to general unemployment. Finally, cross-sectional studies produced

more consistent results than studies that used time series data. However, it is important to note that the majority of time series studies in the review had used national-level data. Data collected monthly has also been found to provide a more robust level of analysis than data collected annually (Phillips & Land, 2012).

Recently studies in this area have begun to branch off from the traditional method of using only the unemployment rate as an economic indicator (Arvanites & DeFina, 2006). Arvanites and DeFina (2006) argue that the unemployment rate is not representative of the true level of unemployment as it excludes people who are not actively seeking (or never sought) employment and those who are under-employed. Instead researchers have started to use multiple economic indicators in order to explain the crime-economy relationship (Andresen, 2013). Following a study on the crime-economy relationship using multiple indicators, Andresen (2013) concluded that by just using one economic indicator the research is at risk of 'omitted variable bias' and therefore when examining this relationship, researchers should consider multiple indicators in their studies to achieve reliable results. Wages/salaries, gross domestic product/gross state product, the index of consumer sentiment, inflation and interest rates are among some of the economic indicators that have been found to significantly impact the crime rate (Andresen, 2013; Jones & Kutan, 2004; Rosenfeld & Fornango, 2007; Seals & Nunley, 2007; Yearwood & Koinis, 2011).

Due to the financial motivation behind property crime it is not surprising to find that these types of crime share the strongest relationship with the economy (Arvanites & DeFina, 2006). As well as economic indicators in general, research has found that crime also fluctuates with the market value

and availability of certain products (Sidebottom, Belur, Bowers, Tompson & Johnson, 2011; Wellsmith, 2004). For example, theft rates of products that are new to the market (such as mobile phones when first introduced) increase from their introduction right up until the product reaches market saturation and then the product begins to become less desirable to offenders (Wellsmith, 2004). This is because when a product is new to the market not many people are in possession of it initially, meaning that offenders are more likely to be able to resell it and obtain a greater value for the product than if it were widely available (Wellsmith, 2004).

The fact that certain types of crime not only fluctuate with different economic indicators such as unemployment and average wage but also with the market value and availability of certain products provides support for a rational choice theory of crime. As noted earlier, changes in the economy can have major impacts on people's financial circumstances leading them to consider the financial incentives of crime to help them escape financial hardship. Yet, the influence of market value and availability of products on theft trends also suggests that individuals are more likely to engage in crime when they are likely to receive maximum benefits. For example, Sidebottom et al.'s (2011) research found that there was a strong positive correlation between copper theft rates and the price of copper, meaning that as the price of copper rose so did copper theft. It could therefore be assumed from a rational choice perspective that as the price of copper increases, the benefits of copper theft begin to outweigh the costs, resulting in an increase in this crime.

Like property crimes such as theft, fluctuations in certain types of arson can be explained using opportunity theories and the economy. As many people

have loans on their houses and vehicles it would not be surprising to find that during times of financial hardship people may find themselves unable to make their repayments and instead consider turning to arson to destroy their property to receive a financial gain through insurance and to remove their debt.

Arson

Internationally, arson results in substantial costs every year. In fact, the annual cost of property damage alone reaches almost one billion dollars in countries such as Australia and the United States of America (U.S.) (Australian Institute of Criminology, 2011; Campbell, 2014). As well as the financial costs accumulated, the consequences of arson are long-lasting and widespread; people lose their homes, jobs, and businesses, natural bushland and wildlife are destroyed, students are unable to attend school, and in severe cases, people's lives are lost (Drabsch, 2004).

Due to the critical nature of arson, it is viewed as a serious offence that can result in life imprisonment in many countries (*Criminal Code* 1985 (CA) s. 433; *Criminal Code Act* 1913 (WA) s. 444; *Criminal Damage Act* 1971 (UK) s. 4). Yet, even though arson is viewed as severe, it rarely results in a conviction (FBI, 2011). In fact, of the 43,412 reported arson offences in the U.S. in 2011, only 19.9% were cleared, meaning they were arrested, charged and/or prosecuted for the offence (FBI, 2011). This is because the act in itself often destroys the evidence of the crime, making the investigation of arson a difficult task (Drabsch, 2004). Besides the low clearance rates associated with arson, one reason it is seen as such a serious offence is because fire can quickly spread out of control, putting nearby people and properties at significant risk (U.S. Fire Administration, 2009). Arson is an offence that requires little skill and

unlike obtaining a gun, the equipment used to start a fire can be easily acquired by many (Drabsch, 2004).

As mentioned above, a review was conducted on fire data collected in Surrey from 1997-2003, after it became apparent that vehicle fires in this area were occurring at an unusually high rate (Council of Canadian Fire Marshals & Fire Commissioners, 2004. as cited in Garis et al., 2007). According to the findings, half of all fires attended by fire services during the review period were found to have occurred in vehicles, which at that time, was more than double what was reported in national research (Council of Canadian Fire Marshals & Fire Commissioners, 2004. as cited in Garis et al., 2007). Of these vehicle fires, a large proportion were transpiring at night during hours when vehicle use is least likely (U.S. Department of Transportation, 2009), in areas with little traffic volume, and involved newer and more expensive vehicles than vehicle fires that were occurring during the day. Considering the suspicious nature of these fires and what has been found in previous research about the spatio-temporal characteristics of arson in general, it seems likely that these fires were the result of arson (Garis et al., 2007). Similar trends also occurred in South Australia and England during this time (Merrall, & Chenery, 2005; Potter, 2000). In South Australia, the number of stolen vehicles that were discovered burnt more than doubled between 1995 – 1999 (Potter, 2000), while England experienced a 70% increase in vehicle arson from 1998 – 2002 (Merrall & Chenery, 2005).

Like all crime, arson has been found to display significant spatio-temporal patterns (Grubb & Nobles, 2016). As discovered by Asgary, Ghaffari and Levy's (2010) research, arson is most likely to occur over the weekend, between the hours of 7pm – 4am and during the summer months. From an

opportunity perspective this is likely to be because people (including offenders) are more likely to have free time over the weekends and more places are likely to be unsupervised over the weekends and at night. The night also provides increased security against detection due to the decreased visibility during these hours. Arson could also be occurring in higher rates during the summer months because people (including offenders) are likely to be out of the house more during this time (Asgary et al., 2010).

As well as property crime, research has found that arson and insurance fraud are influenced by economic factors (Dionne & Wang, 2015; Eriksen & Carson, 2015). Although little is known about the extent of the issue, a best estimate suggests that 14% of suspected arsonists commit arson as a means of insurance fraud (U.S. Fire Administration, 2009). MVT insurance fraud has been found to increase during times of recession (Dionne & Wang, 2013) and arson as a means of financial gain (to escape debt) has also been found to increase during times of financial hardship (Eriksen & Carson, 2015). Due to a rise in foreclosure in the U.S., various studies have examined the effect of housing foreclosure and mortgage on the prevalence of residential arson (Goebel & Harrison, 2012). Results indicate that residential arson significantly increases in areas with high rates of foreclosure and unemployment (Goebel & Harrison, 2012), while house appreciation has been found to share a negative correlation with arson (Eriksen & Carson, 2015). Eriksen and Carson (2015) found a direct relationship between decreases in house prices and increases in arson. These increases in arson were also more likely to occur in (recourse) States that allow the mortgage lender to sue for recovery of losses following foreclosure (Eriksen & Caron, 2015). These findings are consistent with opportunity theories,

because in recourse States, when house prices decline and the individual cannot make his/her mortgage repayments, the mortgage lender could sue the individual for the losses incurred by the decline in housing prices, whereas if the house burnt down the individual could avoid having to repay these losses. In non-recourse States, however, the house would go into foreclosure and the mortgage lender can seize the house without suing for losses, meaning the individual forfeits the house but is not required to make any additional payments (Eriksen & Carson, 2015).

Studies such as these provide evidence of an arson-economy relationship, however the effect of the economy on vehicle arson remains un-researched. Due to the fact that cars depreciate in value from the moment they are purchased (resulting in the car loan being greater than the value of the car) and that cars can be transported to areas with little surveillance or guardianship, it would make sense that vehicles are also set alight in order to earn a financial gain through insurance and escape debt (Davis, 1946). While economic issues are possible contributing factors in vehicle arson for financial gain, MVT has been found in previous studies to influence vehicle arson generally (Merrall & Chenery, 2005).

Motor Vehicle Theft

Previous research has found that MVT shares a strong correlation with vehicle arson (Merrall & Chenery, 2005). Indeed, over 50% of the vehicles recovered burnt in Merrall and Chenery's (2005) study had been reported stolen. The most commonly cited reason behind burning a stolen vehicle was to remove DNA evidence, such as fingerprints (Merrall & Chenery, 2005). However, some offenders did report being paid to burn the car so the owners

could claim the insurance money. Similar research conducted in South Australia, comparing the characteristics of stolen vehicles subject to arson and those that were recovered undamaged found reasons to indicate that many of the vehicles recovered burnt possibly involved insurance fraud (Potter, 2000). Stolen vehicles recovered burnt that were found to be either stolen by professional thieves or for insurance fraud were found to be stripped of valuables before being burnt, therefore being difficult to distinguish between the two motivations. Vehicles reported stolen and recovered burnt were significantly newer and more expensive than non-burnt stolen vehicles. Temporal analysis of the stolen vehicle data also revealed that burnt vehicles were more likely to occur during the night and over the weekends while no seasonal pattern was evident. Stolen vehicles that were burnt were also significantly more likely to be stolen from residential addresses while non-burnt vehicles were significantly more likely to be stolen from streets/carparks. Potter (2000) argues that the vehicles being stolen from residential addresses is likely to be due to insurance fraud or revenge while the non-burnt vehicles being stolen from streets/carparks is likely to be due to opportunity. This supports opportunity theories because in the case of vehicle arson for fraudulent insurance the motivated offender is the owner of the suitable target, therefore removing the barrier of guardianship. Considering this, it therefore makes sense that vehicles stolen for other reasons are likely to be stolen from streets/carparks as these areas would have little guardianship over the suitable target and therefore would be less likely to be detected straight away. Also consistent with opportunity theories, burnt stolen vehicles were also more likely to be recovered in isolated areas. Finally, vehicles recovered burnt that resulted in insurance claims were significantly more likely to have agreed value policies than market value policies. Potter

(2000) argues that agreed value policies commonly place a greater value on the car than market value policies, resulting in a larger insurance payout on the car, suggesting vehicle arson for insurance fraud. The results from Potter's (2000) study suggest many of the stolen vehicles recovered burnt were indeed set alight for the purpose of making fraudulent insurance claims. When studying longitudinal trends in crimes such as MVT during the early 2000s, it is important to consider the impact of the crime drop.

The crime drop. In the 1990s crime (including MVT) significantly declined in most western countries (Farrell, Tseloni, Mailley & Tilley, 2011). Many hypotheses were developed to explain this phenomenon (deemed the 'crime drop') including the legalisation of abortion, increased use of capital punishment and the introduction of the internet, among others (see Farrell et al., 2014 for further discussion). After testing the validity of these hypotheses, Farrell et al. (2014) concluded that many could only account for changes in the U.S. crime rate. In fact, only one (the security hypothesis) passed each of the four standardised tests developed by Farrell et al. (2014). Supported by opportunity theories of crime, the security hypothesis proposed that the introduction of increased security measures during this time led to a decrease in opportunity and consequently a reduction in crime. This hypothesis was supported by research from each of the countries affected by the crime drop, showing a decline in household crime and MVT following increased security. Considering the strong correlation between MVT and vehicle arson, it would be expected that vehicle arson would have displayed similar reductions during this time.

Aims and Hypotheses

Building on the findings related to opportunity theories of crime, the relationship between crime and the economy, and what is known about arson in general, the purpose of this research is to examine the spatio-temporal patterns of vehicle fires and understand whether or not it is influenced by variables such as the economy and MVT. The hypotheses for this analysis are outlined below, following this section the methodology for this research will then be discussed.

Fire trends in the U.S. show a decline in all fire (besides structural fire) over the last 15 years (National Fire Protection Association [NFPA], 2016). NFPA (2016) suggests this decline in overall fire can be attributed to the decline in vehicle fires, which has displayed a downward trend since 1980 (NFPA, 2014). However, this decline in vehicle fire could be due to a reduction in fires caused by legitimate reasons such as mechanical failure or a reduction in MVT as expected by the crime drop and not necessarily a reduction in vehicle arson for financial gain. Indeed, as mentioned earlier, research on vehicle arson in the late 1990s and early 2000s revealed that vehicle arson had in fact been increasing in places such as Surrey (Garis et al., 2007), South Australia (Potter, 2000) and England (Merrall & Chenery, 2005). Yet, due to the fact that arson destroys most of the evidence of the crime, it can often be hard to determine the specific cause/motivation behind it. Insurance fraud has been mentioned in various studies as a possible motivation for vehicle arson yet little research has been done in this area.

Spatio-temporal patterns of arson show a higher amount of incidents occurring at night, over the weekend and in areas with little surveillance (Potter, 2000; Asgary et al., 2010). Spatio-temporal analysis of crime is important in

order to understand the environmental influences in a certain area that are facilitating crime and what can be done to reduce it (Clarke, 1997). From an opportunity theory perspective, it is expected that arson and non-arson vehicle fires will exhibit distinct spatio-temporal patterns significantly different from one another. Using these theories, non-arson vehicle fires would be expected to occur due to issues such as faults with the vehicles, motor vehicle accidents and objects igniting within the vehicle such as a cigarette lighter. Given these circumstances it would make sense that these fires would occur during the day, in areas with high traffic volumes while people are driving to/from their routine activities. In order for an individual to successfully claim insurance in relation to a vehicle fire, they need to ensure they cannot be suspected of arson, therefore, in order to avoid detection it would be expected that vehicle arson would be occurring at night and in areas with little surveillance and guardianship.

When economically-motivated crimes such as vehicle arson for financial gain increase, opportunity theories would suggest that something widespread has occurred that has caused a number of individuals to perceive the benefits of receiving an insurance payout and escaping debt to outweigh the risks of a potential conviction for arson/insurance fraud especially when they are not fully aware of the consequences. During times of economic downturn, many people lose their jobs, experience a decrease in income and suffer significant stress as a result of their new financial status (Milner et al., 2015). Financial pressures such as these could cause individuals to seek illegitimate sources of income or consider ways to escape a loan they find they can no longer afford through means such as arson, and previous research on residential arson suggests this is likely (Eriksen & Carson 2015).

MVT is thought to share a strong correlation with vehicle arson due to the fact that many stolen vehicles are recovered burnt (Potter, 2000). As mentioned above, in the 1990s crime (including MVT) significantly declined in most western countries (Farrell et al., 2011). The crime drop was believed to be due to an increase in security during this time, therefore creating fewer opportunities for potential offenders (Farrell et al., 2011). Considering this, MVT would be expected to decline over the study period. If vehicle arson in the study declined at a similar rate it would suggest that a large proportion of the vehicles were most likely reported stolen and were being burnt remove DNA evidence. It would be surprising to find any correlation between the non-arson vehicle fires and MVT as the non-arson fires should be transpiring under normal circumstances and therefore be uninfluenced by MVT. Given previous research in this area and the opportunity theory foundation, the following hypotheses were developed:

H₁ Vehicle arson will exhibit different spatio-temporal patterns than non-arson vehicle fires. Fire data from Surrey Fire Services contains information on the date, time, location and cause of each vehicle fire in the data. Using this information the data will be spatially and temporally mapped in order to discover the spatio-temporal patterns of vehicle fires in Surrey.

H₂ Vehicle arson will be influenced by economic variables while non-arson will remain unaffected. Multiple economic indicators will be considered to represent the economic activity during the study and to explain the relationship between vehicle arson and the economy. These economic indicators will be chosen based on previous research finding a significant link between the selected indicators and crime generally.

H₃ MVT will share a significant positive correlation with vehicle arson.

MVT data from BC will be examined in relation to arson and non-arson vehicle fires over the study period. It is expected that non-arson fires will not exhibit a significant relationship with MVT as these fires would have been occurring under legitimate circumstances and therefore should not be influenced by fluctuations in MVT.

Method

Vehicle Fire Data

Time series data containing information on all vehicle fires that occurred in Surrey from 2000-2015 (n=4,117) were obtained from Surrey Fire Services. The data was originally collected by qualified fire inspectors from Surrey Fire Services as administrative data following post-fire inspections of vehicles that had caught fire. This is routine practice when responding to and investigating fire incidents. The term 'vehicle fire' includes any fire that occurred in or involved a motorised vehicle (such as cars, boats, buses, campervans, motorbikes, etc.), this also includes structural fires that involved a vehicle. Details regarding the make and age of the vehicle, the suspected act or omission that caused the fire, and the spatial and temporal characteristics of each incident were included in the dataset.

All fires that occurred in or involved vehicles that could also be used as a living space (such as caravans and RV's) were removed from the dataset, as these fires could have been the result of common residential fire causes (such as cooking fires and misuse of electrical appliances). The remaining data were cleaned, geocoded and separated into two groups (arson and non-arson vehicle fires) using 'R': a language and environment for statistical computing

(<https://www.r-project.org/>). Groups were determined by the act or omission believed to have had caused each fire that were recorded in the data. As vehicles contain fuel, when set alight they burn at a high intensity and as a result, burn out completely very quickly leaving the cause of the fire unknown in many cases, hence the large amount of unknown act/omissions in the data. Fires with an unknown cause (n=2,211) were removed from the dataset, leaving a final sample of 1,905 fires.

Once the fire groups were established, each group was spatially joined to 2011 Canadian census dissemination area (DA) polygons (as per Wuschke et al.'s, 2013 study). Dissemination areas are the smallest geographic area that census information is reported in Canada (Statistics Canada, 2015). These areas remain geographically stable over time and consist of approximately 400 to 700 residents (Statistics Canada, 2015). The area of Surrey consisted of 592 DAs in 2011. The individual coordinate points from the fires were then aggregated to the DA boundaries which determined the count of arson and non-arson vehicle fires per DA.

Economic Data Suitable for use in Monthly Time Series Modelling

This section summarises the economic variables that were considered for the analysis used to determine whether vehicle arson is influenced by the economy. The economic variables used in this study were obtained from publicly available data from Statistics Canada's Canadian Socio-economic Information Management (CANSIM) database. Average weekly income (BC), unemployment rate (BC), house price index (BC), consumer price index (BC) and the Canadian interest rate were considered as economic variables in the study, all data were collected on a monthly basis from 2000-2015. As discussed

above, the reason multiple economic variables were considered in this study is to account for the possible underestimation of the relationship between vehicle arson and the economy that could occur if only unemployment were used as a representation of the economy.

Unemployment. The unemployment rate was considered as a representation of the economy in this study because it had been found to share a significant positive correlation with property crime (Chiricos, 1987). The use of the unemployment rate accounts for the number of people that are currently out of work but actively looking for work (Statistics Canada, 2016). As mentioned earlier, according to Cantor and Land (1985), unemployment can explain both decreases and increases in crime. In the short term following an increase in unemployment, crime is expected to decrease, this is due to the fact that as unemployment increases more people are likely to be at home during the day, when they used to be at work, thus increasing guardianship and reducing opportunities for individuals to commit crime in these areas. In the long run however, unemployment is said to increase crime, because when people are out of work for extended periods of time they begin to spend a large proportion of their savings which could result in increased motivation to obtain an illegitimate source of income (Greenberg, 2001).

The unemployment rate estimate is collected as part of the Canadian Labour Force Survey (Statistics Canada, 2016a). The labour force consists of all individuals 15 years and over who, at the time of the survey, were considered employed or unemployed, as per the definitions provided in the survey. Unemployment is measured as the number of people who were without work but had been actively seeking work within four weeks of the survey

reference week (Statistics Canada, 2016a). The unemployment rate is calculated as the number of unemployed people expressed as a percentage of the labour force. Unemployment has undoubtedly been the most commonly used economic indicator when researching the economic influences on crime (Rosenfeld & Fornango, 2007). However, because the unemployment rate is unrepresentative of the true level of unemployment it is now recommended to study the relationship between crime and the economy using multiple indicators (Arvanites & DeFina, 2006).

Average weekly income. Average weekly wage was considered for this study as wages/salaries have been found to have a significant influence on crime (Machin & Meghir, 2004). As discussed by Gould, Weinberg and Mustard (2002), wages and salaries are an important economic indicator to consider as the unemployed are not the only people committing crime. Considering the unemployment rate does not account for those who are under-employed, wages/salary can explain the relationship between crime and the economy from the perspective of those who are working, but not earning enough to keep them afloat financially. Average weekly wage estimates are also collected as part of the Canadian Labour Force Survey (Statistics Canada, 2016a).

The house price index. The house price index was considered as an economic variable in this study because regional housing appreciation has been found to share a negative correlation with residential arson (Goebel & Harrison, 2012), and to the best of the author's knowledge, has not been studied in relation to vehicle arson. When people are under a lot of financial stress and the house price index is low it could lead people to commit arson in order to reduce/remove an outstanding loan on their vehicle by receiving an illegitimate

income from the insurance payout, whereas if the house price index were high, they may have the incentive to earn a legitimate income through the sale of their house. The house price index is used to measure the changes in the selling prices of new houses, over time, in a given region. The index is calculated using housing quotes across different builders and through comparing city estimates to national totals (Statistics Canada, 2016b).

The consumer price index. The consideration of the consumer price index was used as it explains how far the average income can be extended at a given time. Devine, Sheley and Smith (1988) described the importance of using the inflation rate (expressed as a percentage, reflecting changes in consumer price) as it explains how individuals lose confidence in the market due to an “erosion of real income”. The consumer price index is used to measure changes in consumer prices over time. The price of a fixed basket of goods and services, of the same quality and quantity, is measured over time in order to gain insight into the observed changes in price of the selected goods/services. Changes in consumer prices over time are reflected in the inflation rate.

Interest rate. Finally, the interest rate was considered for this study because, due to the volatility of interest rates, when consumer confidence is high and interest rates are low, people could be acquiring loans for cars/property that they find they can no longer afford when interest rates suddenly rise, causing individuals to seek income through illegitimate means such as theft or fraudulent insurance claims. This is supported by research conducted by Jones and Kutan (2004) who found that economically-motivated crimes rise significantly after interest rates are tightened by the Federal

Reserve. The interest rate (also known as the bank rate) represents the rate of interest applied on loans through financial intermediaries.

Annual Motor Vehicle Theft Data

As mentioned earlier, studies have found a relationship between MVT and vehicle arson (Potter, 2000). Vehicles set alight in order to claim insurance or to destroy DNA (by professional thieves) were commonly found to have been stripped of valuables before being torched (Potter, 2000), making it difficult to identify between the two different motivations. However, since vehicles set on fire in order to receive insurance money would need to appear unrelated to the owner/s of the vehicle it would seem likely that the vehicle would be reported stolen before being destroyed to claim the insurance. Considering this, MVT data was considered for this study in order to compare the relationship between vehicle arson and MVT over the study period.

MVT data was obtained for BC over the study period of 2000-2015, from Statistics Canada's CANSIM database. This data was collected using police reported crime statistics, from the Uniform Crime Reporting (UCR) survey. The UCR survey is conducted nationally on an annual basis in Canada (Statistics Canada, 2016c).

Control variable. As discussed earlier, opportunity theories of crime suggest that crime is a non-random phenomenon that occurs in specific places at specific times (Wuschke et al., 2013). Using this perspective, it is expected that vehicle fires listed as arson will differ spatially and temporally from fires that occurred under legitimate circumstances. Due to the criminal nature of vehicle arson it is likely that these fires would occur in areas with little surveillance and during the night in order to avoid detection, whereas non-arson vehicle fires

would be likely to occur near a roadway and during the time of day that people are likely to be driving to/from their routine activities such as work, school, the shops etc. As well as arson and non-arson vehicle fires occurring in unique spatio-temporal patterns, it is unlikely that non-arson vehicle fires would be impacted by changes in economic circumstances and are therefore likely to remain stable throughout the study period. Based on this information, the fires that fall into the non-arson vehicle fire group (n=590) discussed above were used as the control variable in this study, in order to evaluate the differences in fluctuations of vehicle arson over the study period.

Statistical Analysis

As discussed above, many studies in this area have resulted in inconsistent findings due to methodological errors (Chiricos, 1987). As well as the inconsistent results caused by level of aggregation and variable selection, many of these studies do not choose models that sufficiently test the theories they are researching (Greenberg, 2001). In order to accurately test H_1 , H_2 and H_3 in accordance with opportunity theories, appropriate selection of models is important.

Spatial and temporal analysis. The spatial and temporal analyses were conducted as per the precedent set by Wushcke et al. (2013). The spatially aggregated data were imported into ESRI's ArcGIS 10.4 to conduct hot spot analysis in order to address H_1 . Hot spot analysis is used to examine where crimes cluster spatially. When certain areas have higher than average rates of crime they are known as 'hot spots', similarly when an area has a crime rate lower than average it is referred to as a 'cold spot' (Eck, Chainey, Cameron, Leitner & Wilson, 2005). In relation to this study, hot spot analysis works by

examining the occurrence of one fire in the context of the fires surrounding it, the fires within this area are then compared to the sum of all fires in the dataset. If the area's sum is different from the expected sum for that area, it is considered to be a significant hot/cold spot.

The Hot Spot Analysis tool in ArcGIS calculates the Getis-Ord G_i^* statistic for each of the fires in the dataset and determines a Z-score which is then used to decide the significance of the clusters found within the data (ArcGIS Pro, n.d.). For a cluster to be regarded as significant not only would a particular fire have a large Z-score but so would the fires surrounding it. Z-scores with high values ($Z > 1.96$) represent significant hot spots, whereas low Z-scores ($Z < -1.96$) signify areas with significant cold spots. Hot spot analyses were conducted for both arson and non-arson fire groups in order to discover any differences in spatial patterns between the groups. Data was then temporally analysed using circular plots for hour of day, day of week and seasonal variations between the arson and non-arson fire groupings.

Time series analysis. To analyse the relationship between vehicle arson, non-arson vehicle fires and the economic variables an ordinary least squares (OLS) regression was used. This model was chosen as prior research has used this particular model when examining the relationship between crime and the economy (Rosenfeld & Fornango, 2007; Sidebottom et al., 2011; Smith, Devine & Sheley, 1992). OLS regression is used to test the relationship between a dependent variable (e.g. vehicle arson or non-arson vehicle fires) and one or more independent variables (e.g. unemployment and interest rates) (Pohlman & Leitner, 2003). The model works by calculating and minimising the sum of squared errors and produces regression coefficients and an intercept

(also known as betas) for the variables (Pohlman & Leitner, 2003). Errors are the difference between a predicted value and actual values in the data, OLS works by fitting a regression line that produces the smallest sum of squared errors. The intercept produced from the model specifies the size/count of the dependent variable if the independent variables were zero, whereas the coefficients show the size of the change in the dependent variable following an increment rise of one unit in the independent variable/s. An issue with the OLS model is that it assumes the data are independent and therefore are not serially dependent (also known as autocorrelation) (Sidebottom et al., 2011). Time series data are data collected for the same variable over a series of regular time points (weekly, monthly, annually etc.) and because of this, it is common for time series data to be serially dependent (Sidebottom et al., 2011). When autocorrelation is not adjusted for, the results produced can be biased, producing a significant result where there may not normally be one. To account for this a Durbin Watson statistic was calculated on the OLS model in order to test and subsequently adjust for autocorrelation, where required.

Motor vehicle theft. Due to the annual collection of the MVT data it could not be included in the statistical analysis as the other variables were collected on a monthly basis. Instead a Pearson's r correlation was run on the MVT and arson and non-arson group data in order to see if a relationship exists between the groups.

Results

Descriptive Statistics

As mentioned above, the data were split into two groups according to the recorded act/omission for each fire. The arson group consisted solely of

incendiary or suspicious fires, whereas the non-arson group contained 32 different recorded acts/omissions that fell within eight broad categories. The majority (85%) of the non-arson vehicle fires were the result of electrical/mechanical failure/malfunction or human failing (Table 1).

Table 1

Recorded Act/Omission for Arson and Non-Arson Vehicle Fires.

Act or omission	Arson vehicle fires		Non-arson vehicle fires	
	#	%	#	%
Incendiary	1315	100	0	0
Misuse of ignition	0	0	27	5
Misuse of material ignited	0	0	20	3
Mechanical/electrical failure/malfunction	0	0	432	73
Construction, design or installation deficiency	0	0	3	1
Misuse of equipment	0	0	2	<1
Human failing	0	0	69	12
Vehicle accident	0	0	29	5
Miscellaneous act or omission	0	0	8	1
Total count	1315		590	

Significant differences were found for vehicle ages between the arson and non-arson fire groups. Vehicles in the arson category (*Median* = 10 years) were significantly newer than vehicles in the non-arson group (*Median* = 14

years), Mann-Whitney $U = 22865.00$, $p < .001$. While non-arson vehicle fires were more likely to occur in older vehicles, they also displayed a larger age range than vehicles listed as arson, which is why the median was chosen as the measure of central tendency (Table 2).

Table 2

Descriptive Statistics for Car Age (Years) Between Arson and Non-Arson Groups.

Fire group	Median	SD	Range
Arson	10	9.69	-1* – 32
Non-arson	14	4.28	0 – 49

*It is common for new cars to be released from September – December the year before the listed production date, which explains why four of the vehicles in the arson category were listed as -1 years of age.

No differences were found for vehicle make between the groups, both arson and non-arson fires were most likely to occur in Ford vehicles.

Spatial Analysis

Hot spot analysis on the vehicle fire data revealed multiple significant hot and cold spots in Surrey DAs with meaningful differences found in the spatial clusters of the arson and non-arson groups. Vehicle arson significantly clustered ($Z = > 1.96$) in multiple DAs across Surrey, with two prominent cold spots ($Z = < -1.96$) showing in the north-central and south-western regions (*Figure 1*). Significant hot spot clusters for non-arson vehicle fires occurred in similar areas to vehicle arson, with cold spots also occurring in similar regions but at a much smaller magnitude (*Figure 2*). Although some overlap was observed between the hot and cold areas for each group, both arson and non-arson fires exhibit hot spot areas in which the other did not occur.

VEHICLE ARSON AND OPPORTUNITY

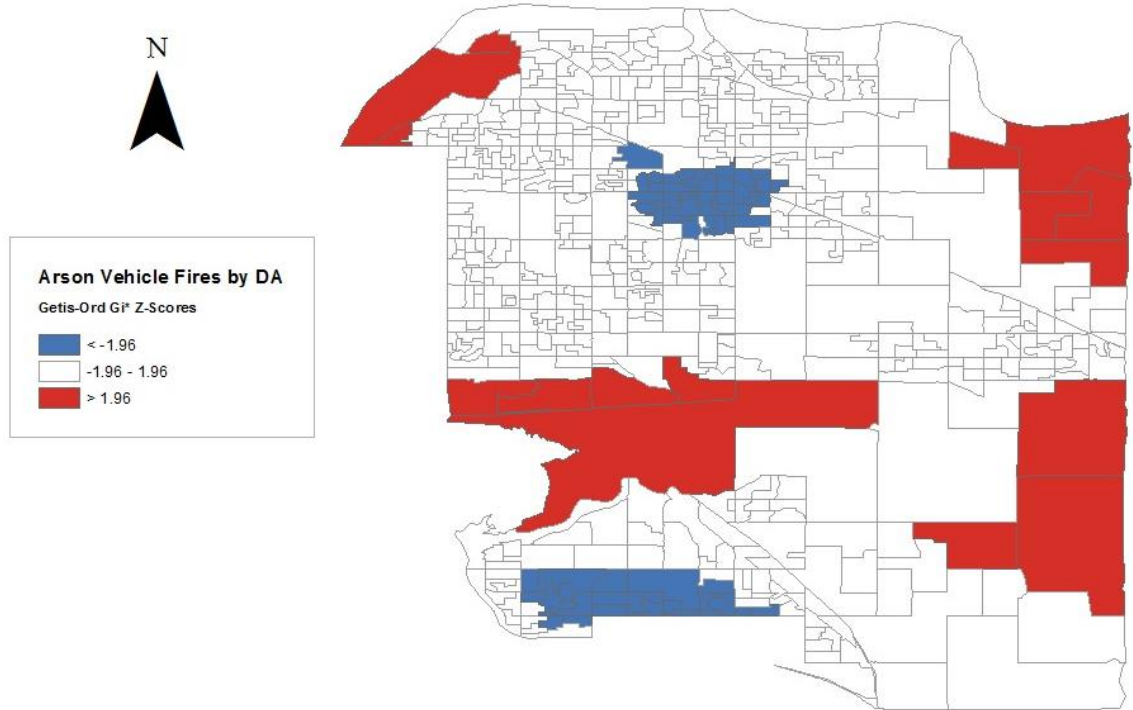


Figure 1. Significant Hot and Cold Spots of Vehicle Arson in Surrey DAs.

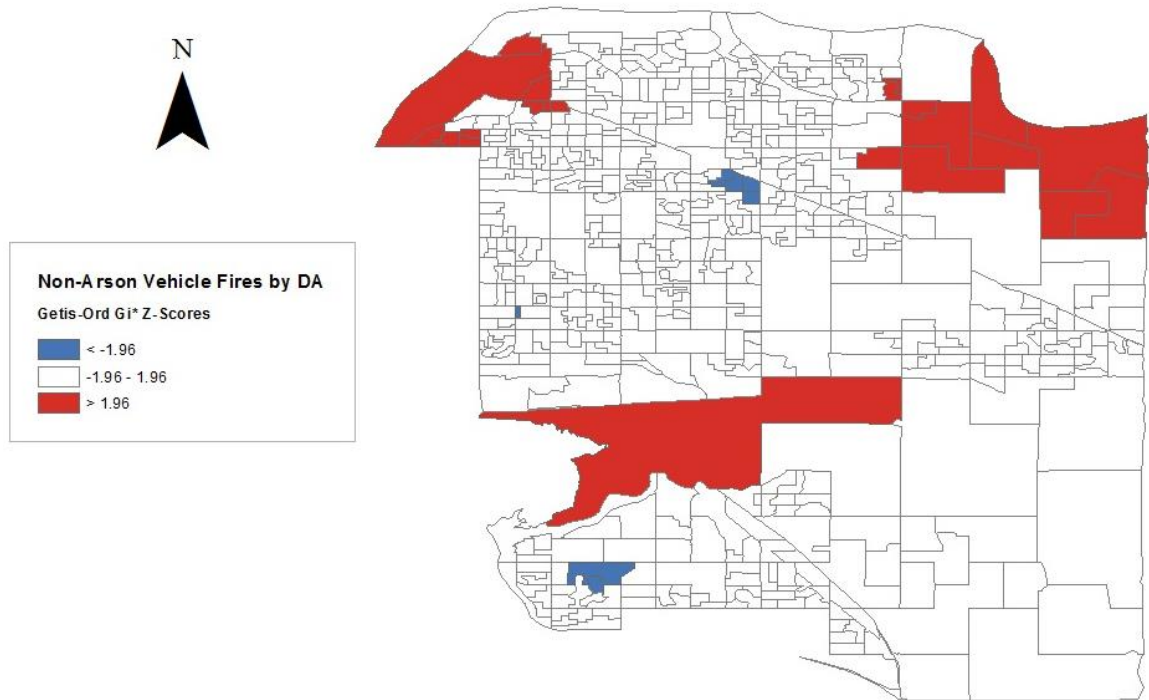


Figure 2. Significant Hot and Cold Spots of Non-Arson Vehicle Fires in Surrey DAs.

Firstly, the arson vehicle fires displayed hot spots in DAs that were not exhibited for the non-arson fires. These hot spots can be seen on *Figure 1* in the central/south-western and south-eastern areas of Surrey. Both of these regions contain urban areas that border on rural expanses.

Secondly, non-arson vehicle fire hot spots can be seen in the north-eastern regions of Surrey that were not displayed for vehicle arson (*Figure 2*). This area contains an entry point to the Port Mann Bridge, the second longest bridge in North America and the widest in the world (Transport Investment Corporation, 2016).

The recorded land uses for each DA show slight differences in the areas in which the arson and non-arson hot spots occurred (Table 3). The Z-scores for each DA were ranked for the arson and non-arson fire groups, and a Spearman's rho was conducted on the data, a significant moderate correlation was found between arson and non-arson DA Z-scores $r_s = .58, p < .001$, indicating that no significant spatial differences were found between arson and non-arson vehicle fires.

However, land use information for Surrey DAs reveal differences between the areas the arson and non-arson hot spots were occurring (Table 3). A large proportion (42%) of arson hot spots transpired in industrial areas (commercial, industrial and agricultural) compared to the 28% of non-arson fires in these regions. Furthermore, only 28% of arson hot spots occurred in urban areas while 57% of non-arson fires exhibited clusters in these zones.

Table 3

Recorded Land Use for DAs that Arson and Non-Arson Vehicle Fire Hot and Cold Spots Occurred.

Land use	Arson hot spots (%)	Arson cold spots (%)	Non-arson hot spots (%)	Non-arson cold spots (%)
Urban	15	56	37	57
Suburban	10	17	9	29
Multiple residential	3	13	11	14
Mixed employment	13	0	4	0
Commercial	8	8	15	0
Town centre	0	3	0	0
Conservation & recreation	5	2	4	0
Agricultural	26	0	7	0
Industrial	8	0	9	0
Suburban – urban reserve	13	0	4	0

Temporal Analysis

Different temporal characteristics were found for arson and non-arson vehicle fires (*Figure 3*). Non-arson vehicle fires were most likely to occur between the hours of 6 am – 7 pm and remained relatively stable throughout the week with slight increases between Wednesday and Saturday. While vehicle fires in the arson group occurred at night and early morning between the hours of 10 pm – 4 am and mostly over the weekend.

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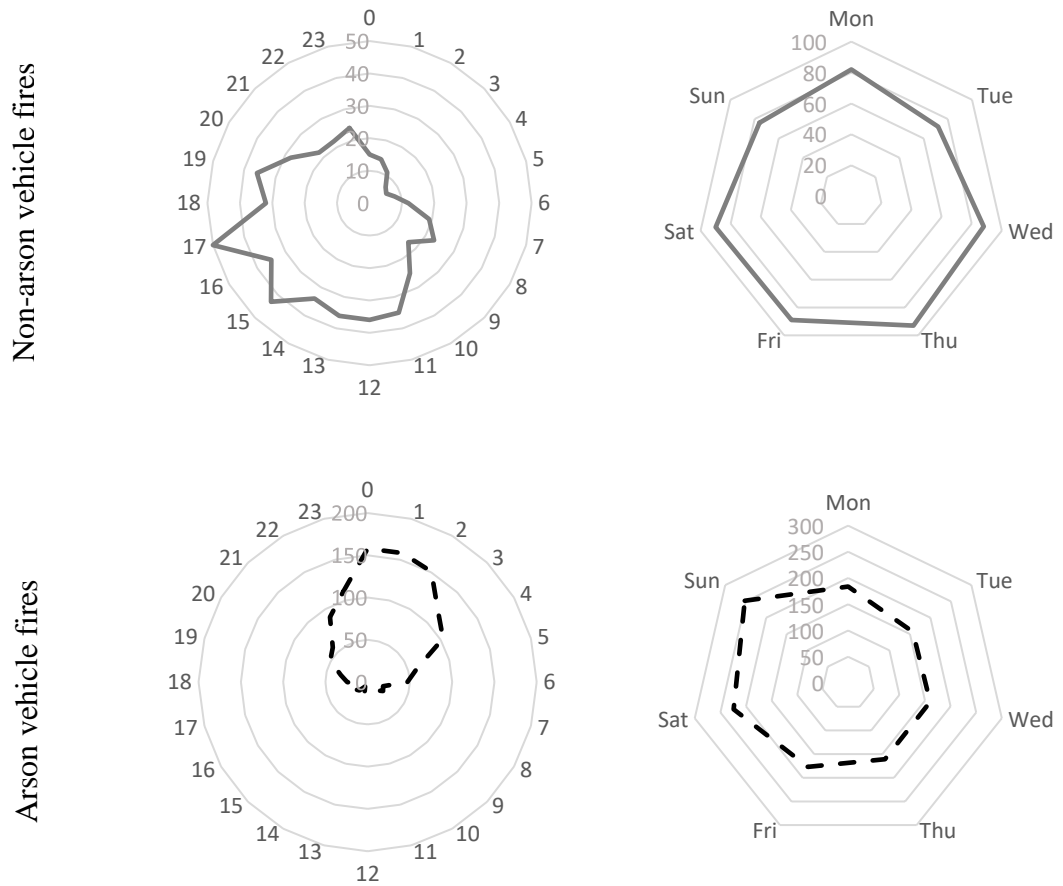


Figure 3. Non-Arson and Arson Vehicle Fires by Hour of Day and Day of Week.

The figures/text on the outside of the plot represent the hour of day/day of week and the light grey figures inside the plot represents the total count of vehicle fires (as represented by each line within the plot) (*Figure 3*).

No seasonal differences were observed between the groups (*Figure 4*).

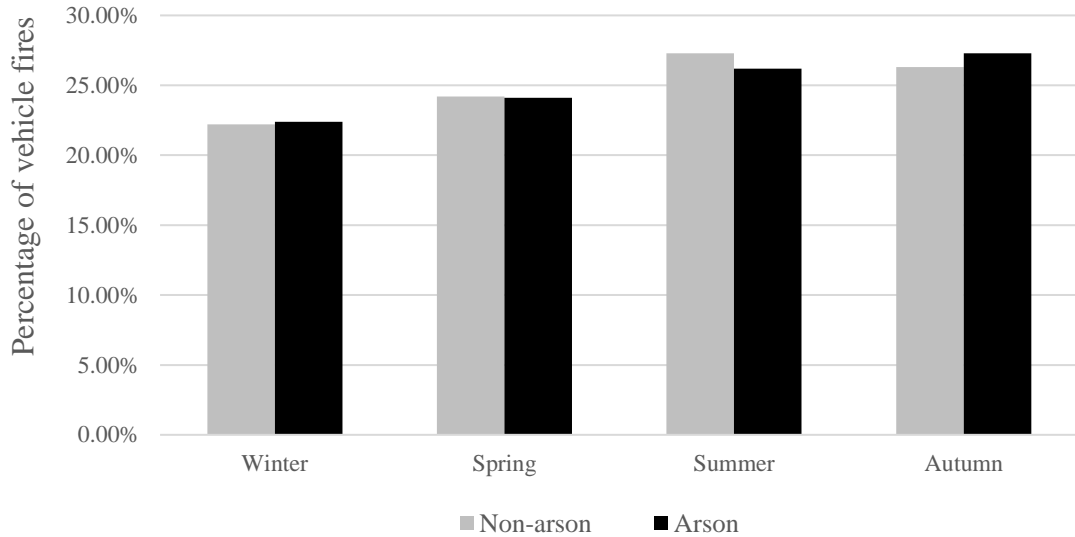


Figure 4. Seasonal Variation Between Non-Arson and Arson Vehicle Fires.

Vehicle Arson and the Economy

The average unemployment rate for BC from 2000-2015 was 6.65% (Table 4). Unemployment in BC remained relatively stable from January 2000 through to November 2001 when it rose to 9.8% in January 2002, which was its highest peak during the 15 year study period, from then on it remained at a stable high until August 2004 when it steadily declined until its lowest point (3.8%) in December 2007. Canadian interest rates ranged from a high of 6% from May – December of 2000 to a low of 0.5% from April 2009 – May 2010.

Table 4

Descriptive Statistics for Economic Indicators.

Economic variable	Mean	SD	Range
Unemployment rate (%)	6.66	1.38	3.8 – 9.8
Interest rate (%)	2.56	1.59	0.5 – 6

Both the unemployment and interest rates show a large change in trajectory in late 2008 (*Figure 5*). This is arguably when the global financial crisis came into effect in Canada, which would explain the sudden rise in unemployment and the decline in interest rates. After a period of rapid change (2008-09) that coincided with the onset of the global financial crisis, unemployment and interest rates have remained relatively stable since 2009 (*Figure 5*).



Figure 5. Economic Indicator Trends from 2000- 2015.

Pearson's r correlations were conducted on each of the economic variables in order to determine if each of the variables could contribute meaningful levels of independent variation to the study, as was done in a study by Andresen (2013) which researched the relationship between crime and the economy using multiple economic variables. Moderate ($r > 0.50$) to strong ($r > 0.70$) correlations were found for each of the economic variables except the unemployment rate, consumer price index and the interest rate. However, consumer price index and interests rates shared a strong negative correlation (r

= -0.74), making the inclusion of both unnecessary. Because house price index, consumer price index and average weekly earnings all shared a moderate or strong correlation with the unemployment or interest rates (Table 5), building on the precedent set by Andresen (2013) it was concluded that they were unable to contribute any meaningful independent variation to the analysis and were therefore excluded from the study. Although consumer price index can reflect changes in how far the average income can be extended, it was excluded over the interest rate. This is because, the interest rate can explain changes in the amount an individual is paying towards his/her loan and therefore would have a direct impact on the decision to reduce/remove their loan through means such as vehicle arson.

Table 5

Pearson's r Correlation Matrix of Economic Indicators.

	Average income*	Unemployment rate	House price index	Consumer price index	Interest rate
Average income*	1				
Unemployment rate	-0.21	1			
House price index	0.70	-0.60	1		
Consumer price index	0.97	-0.31	0.80	1	
Interest rate	-0.77	-0.27	-0.41	-0.74	1

*Average weekly income

Considering it is unlikely that the economic variables would have an immediate impact on one’s decision to commit insurance fraud via vehicle arson, the arson and non-arson variables were lagged by one month (as per Sidebottom et al.’s, 2011 study). Results from the OLS model reveal significant positive relationships found between vehicle arson and the economic variables (Table 6). However, the economic variables accounted for only 22% of the variation ($R^2 = 0.22$) in vehicle arson, meaning a large portion of the variation in vehicle arson is not explained by these variables. As expected, the economic variables did not account for variations in non-arson vehicle fires over the study period ($R^2 = 0.01$) (Table 7).

Table 6

OLS Regression Results for the Relationship Between Vehicle Arson and the Economic Indicators.

	β	SE	p value
Unemployment rate	1.19	0.22	<.01
Interest rate	1.16	0.19	<.01

Table 7

OLS Regression Results for the Relationship Between Non-Arson Vehicle Fires and the Economic Indicators.

	β	SE	p value
Unemployment rate	0.08	0.13	0.53
Interest rate	0.11	0.11	0.31

To test for autocorrelation, a Durbin-Watson statistic was calculated in the OLS model. The Durbin-Watson statistic works by testing for autocorrelation in the residual errors with a value of 2.0 signifying no autocorrelation was present (Sidebottom et al., 2011). The Durbin-Watson test revealed a value of 1.70 for the arson OLS and 1.28 for non-arson, meaning significant positive autocorrelation was found in both models ($p < .01$). To ensure the bias created by autocorrelation is accounted for, a generalised least squares regression that adjusts for autocorrelation was used for the analysis.

Results show a significant positive relationship found between vehicle arson and unemployment ($p < .01$) and vehicle arson and interest rates ($p < .01$) (Table 8), with the economic indicators now explaining 36% of the variation in vehicle arson counts over the study period ($R^2 = 0.36$).

Table 8

Auto-Regressive Generalised Least Squares Results for the Relationship Between Vehicle Arson and the Economic Indicators.

	β	SE	p value
Unemployment rate	0.93	0.30	<.01
Interest rate	1.12	0.30	<.01
AR1	-0.42	0.07	<.01

Results for the non-arson vehicle fires show no significant relationship was found with unemployment ($p = 0.66$) or interest rates ($p = 0.48$) (Table 9). With adjustments for autocorrelation, the generalised least squares regression model accounts for 14% of the variation in non-arson vehicle fires ($R^2 = 0.14$).

Table 9

Auto-Regressive Generalised Least Squares Regression Results for the Relationship Between Non-Arson Vehicle Fires and the Economic Variables.

	β	SE	p value
Unemployment rate	0.07	0.17	0.66
Interest rate	0.11	0.16	0.48
AR1	-0.36	0.07	<.01

The generalised least squares regression (AR1) model accurately accounted for the autocorrelation for both arson ($DW = 2.18$) and non-arson ($DW = 2.18$) models.

Vehicle Arson and Motor Vehicle Theft

As discussed above, MVT has been found to share a relationship with vehicle arson in previous studies (Potter, 2000). For this reason, even though the annual collection of data excluded this variable from analysis, a Pearson's r correlation was conducted on this variable and both of the fire groups in order to examine whether a relationship existed between MVT and the vehicle fire data in this study. Vehicle arson shares a strong significant positive correlation with MVT, $r(1) = 0.85$, $p < .01$, while the non-arson vehicle fires were unaffected by MVT, $r(1) = 0.33$, $p = 0.22$ (Figure 6). Because the economic indicators were collected on a monthly basis and MVT data was available only annually, the relationship between MVT and the economy could not be analysed in a time series model that used monthly data.

VEHICLE ARSON AND OPPORTUNITY

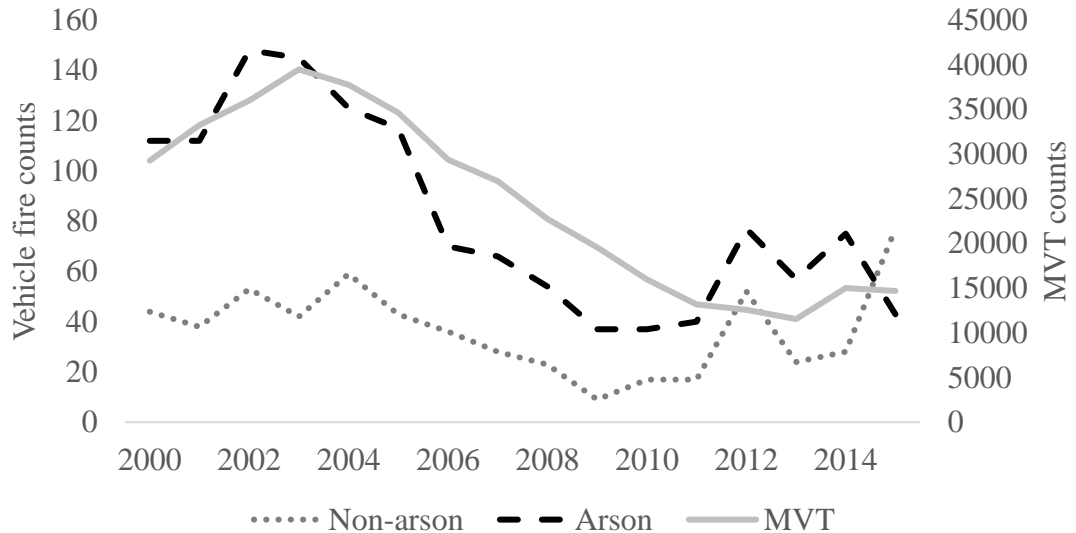


Figure 6. MVT (BC) Trends in Comparison to Arson and Non-Arson Vehicle Fire Trends in Surrey.

Discussion

The findings from this study are supported by previous research and opportunity theories. Not surprisingly, cars in the vehicle arson group were significantly newer than the non-arson vehicles. Not only are newer cars more likely to have existing loans out on them but mechanical/part failure (being the most commonly cited reason behind non-arson vehicle fires in this study) would also be more likely to occur in older vehicles. As expected, based on previous research and opportunity theory, vehicle arson was more likely to occur at night, over the weekend and in areas with little surveillance. Isolated areas provide the opportunity to commit arson with decreased likelihood of getting caught, while the night offers additional protection against the offenders being discovered, making these areas attractive to offenders. Further support for the crime-economy relationship was found, with results showing that vehicle arson is significantly influenced by the economic indicators while non-arson vehicle fires were not, suggesting the vehicle arson fires were indeed likely to be driven by financial motivation (such as insurance fraud). Finally, also consistent with prior

research, vehicle arson shared a significant positive correlation with MVT while non-arson vehicle fires remained unaffected. The strong relationship between MVT and vehicle arson is not surprising as not only are stolen vehicles often set alight to destroy DNA evidence but it would also be expected that vehicles set alight for fraudulent insurance would also be reported stolen to remove suspicion from the owner/s of the vehicle. These findings will be discussed further below by reference to practical implications and SCP.

Vehicle Age

Compared to vehicles that caught fire under legitimate circumstances, vehicle arson occurred in significantly newer vehicles. This is supported by previous research conducted by Potter (2000), who found that stolen vehicles recovered burnt were newer and more expensive than stolen vehicles that were not set on fire. Potter (2000) argued this was most likely due to insurance fraud or revenge arson. However, it would seem unlikely that revenge arson would be occurring at such high rates, or very often at all. Further support for vehicle arson for financial gain from Potter's (2000) study was also found when examining the areas in which vehicle theft occurred. Stolen vehicles recovered burnt were more likely to be stolen from residential addresses while non-burnt vehicles were stolen from streets/carparks. This is consistent with opportunity theories, as it makes little sense that offenders would increase their chances of getting caught by stealing a car from someone's house for the sole purpose of taking a newer vehicle when it is going to be torched regardless. This makes it likely that these stolen vehicles recovered burnt were the result of vehicle arson for financial gain as it is likely that the owners of the vehicles would have reported the vehicles stolen to remove suspicion. Results from the current study

were also consistent with opportunity theories, specifically, rational choice theory as newer vehicles would have a larger outstanding principal on their loans with more onerous repayment terms, it is likely the owners of newer vehicles would not only receive a larger insurance payout but would also have longer to pay off their debt, thereby providing a greater incentive to commit insurance fraud.

Spatial Patterns of Vehicle Arson

As expected, the arson and non-arson vehicle fires displayed different spatial patterns with hot and cold spots of vehicle arson occurring in a larger magnitude across Surrey than the non-arson fires. Although overlap was observed between the hot and cold spots in which the arson and non-arson fires were occurring, vehicle arson did display independent, meaningful variation from the non-arson spatial patterns. Previous research has found that arson is most likely to occur in isolated areas (Potter, 2000). Consistent with this research, vehicle arson was likely to occur in areas that would be considered 'isolated'. Forty-two percent of the vehicle arson fires occurred in industrial type areas, which are arguably unlikely to be frequented by many people, especially after business hours. These results are consistent with an opportunity perspective, as vehicle arson would be expected to occur in isolated areas to ensure reduced chances of detection. Due to the private nature of these areas, it is unlikely that people would become aware of the crime until sometime after it began, giving the offender ample opportunity to set their vehicle alight and flee the area with little risk of being detected. In comparison, non-arson vehicle fires were most likely (57%) to occur in urban areas whereas only 28% of vehicle arson clusters were found in these regions. Urban areas consist mainly of

residential properties, meaning that people are likely to frequent these areas, therefore increasing the chances that the offender would be apprehended.

Furthermore, non-arson vehicle fires would be expected to occur in these areas, as people would regularly use these regions to drive to and from their houses, making it likely that if they were to experience a vehicle fire it would be on this route.

Also consistent with opportunity theory, are the two areas in which arson displayed hot spots while non-arson did not, both of which contained rural/urban interfaces. The proximity of the rural and urban zones means that people that live in the urban areas are likely to be aware of the layout of the rural regions, the different escape routes and the opportunities within them (consistent with crime pattern theory). Areas with rural/urban boundaries therefore provide the incentive of committing the act in an isolated area yet being close enough to an urban area to ensure easy escape.

A hot spot area that was unique to the non-arson vehicle fires was also found. As mentioned earlier, this area, (in the North-Eastern region of Surrey) contains the Port Mann Bridge, one of the longest bridges in North America (Transport Investment Corporation, 2016). Considering that this bridge is used by more than 800,000 vehicles in a given week, it would not be surprising to find that this area and the ones surrounding it often experience motor vehicle accidents and traffic congestion. Because of this, it would seem likely that if a car were going to over-heat, experience mechanical failure or be involved in a motor vehicle accident, resulting in the vehicle catching alight, it would occur more often in this area.

Temporal Patterns of Vehicle Arson

As expected, temporal differences were found between arson and non-arson fires. Vehicle arson was most likely to occur over the weekends and at night, consistent with previous findings (Potter, 2000). As a large proportion of people work during the week (including offenders) and have the weekends free, it makes sense that vehicle arson was occurring over the weekend. Even though more people are likely to have spare time over the weekends and subsequently be out and about, so too are motivated offenders. The free time over the weekend leaves more time in which the offender can prepare for the crime and have the opportunity to commit the crime late at night without the added stress of going to work the following day. Regardless of the increased number of people around over the weekends, most people are still likely to be at home or inside during the hours of 10pm-4am when vehicle arson was most likely. Presumably, vehicle fires would draw attention quickly during the night and the day; however, the night provides certain securities against detection. Not only are people more likely to be at home during the night, therefore reducing levels of guardianship/surveillance in the hot spot areas, but the night itself reduces visibility making detection of the offender less likely.

Non-arson vehicle fires remained somewhat stable throughout the week and were most likely to occur during the day between the hours of 6 am - 7 pm. This is when cars are most likely to be on the road (84.5%) (U.S Department of Transportation, 2009) therefore supporting the theory that these fires would occur when people are most likely to be driving to/from their routine activities. Vehicle fires during this time would also attract attention quickly making it less likely that these would be the result of arson.

Consistent with Potter's (2000) research, no seasonal differences were found between the vehicle fire groups. Although previous research has found evidence to suggest that arson is most likely to occur during the summer months (Asgary et al., 2010), it is likely that this relationship was not observed in this study due to the influence of the economic factors. Indeed, if someone were desperate enough to commit vehicle arson for financial gain in the first place, it would seem unlikely that they would be willing to wait until the summer months in order to do so.

The Relationship Between Vehicle Arson and the Economy

Due to the risk of 'omitted variable bias' and the under-representation caused by using only the unemployment rate, multiple economic indicators were considered for this study. However, as many economic indicators are highly related, it was important to look at how much independent variation each of the variables would contribute to the study. Of the five variables considered, three (average weekly earnings, consumer price index and house price index) were correlated and excluded from the analysis leaving unemployment and interest rates to represent the economy.

During an economic downturn, many individuals may unexpectedly find themselves unemployed and struggling to find a new job. After a prolonged period of unemployment, people may begin to spend large proportions of their savings leaving them unable to afford bare necessities as well as to support existing loans they may have on their property or vehicles. However, it is also important to consider people who are still working but for one reason or another are also struggling to make ends meet. Individuals may acquire loans without accounting for the volatility of interest rates in their budget leaving them unable

to afford their repayments when interest rates rise. Substantial increases in interest rates means a greater proportion of disposable income is suddenly going towards paying off a loan, therefore leaving a smaller budget for essential goods and services such as food and rent.

Consistent with previous findings on the relationship between financially-motivated crimes and the economy (Arvanites & DeFina, 2006), vehicle arson was significantly positively influenced by the unemployment and interest rates. From an opportunity theory perspective, as unemployment and interest rates rise, more people are likely to find themselves in situations where they can no longer afford to pay their loans and may search for ways in which to remove/reduce them. While not all people will ultimately turn to crime to relieve their financial stress, people in desperate situations may view the benefits of receiving insurance money and escaping their loan to outweigh the risks of getting caught, especially if they believe their chances of being apprehended are unlikely.

As hypothesised, non-arson vehicle fires remained unaffected by the economic indicators. This was expected as vehicle fires transpiring under legitimate circumstances such as motor vehicle accidents, or faulty mechanics would be occurring randomly and therefore would not be influenced by external variables such as the economy, unless people kept their vehicles longer in hard times leading to more chance of breakdown or mechanical issues over a long economic downturn.

Vehicle Arson and Motor Vehicle Theft

It is important to note, however, that only 36% of the variation in vehicle arson was explained by the economic indicators, leaving a large proportion of

the trend unexplained. In conjunction with previous research (Merrall & Chenery, 2005), the findings from this study show that vehicle arson and MVT share a strong correlation and therefore could account for the remaining variation. This is because stolen vehicles used in the commission of a crime are likely to be set alight in order to destroy DNA evidence. As the act of arson destroys the evidence and vehicles burn at very high temperatures, it is often hard to distinguish between the different motivations behind vehicle arson. For this reason, it is important to consider the trends of MVT in relation to vehicle arson in order to identify any relationships that may exist.

Unfortunately, due to the annual collection of MVT data, it could not be included in the monthly analysis with the economic variables. Therefore, to determine if a relationship existed between vehicle arson and MVT, a Pearson's r correlation was conducted on the two, which revealed a strong positive correlation, consistent with previous research (Merrall & Chenery, 2005). This suggests that many of the vehicle arson fires in this study were indeed occurring in stolen vehicles. Due to the strong correlation found between these variables and the fact that the economic variables accounted for only part of the vehicle arson fluctuations it would seem likely that the remaining variation in vehicle arson was influenced by changes in MVT rates.

However, not all stolen vehicles are set alight (Potter, 2000). In fact, many differences have been found between stolen vehicles recovered burnt and stolen vehicles recovered undamaged (Potter, 2000). Compared to stolen vehicles that were not burnt, stolen vehicles recovered burnt were more likely to occur in significantly newer and more expensive vehicles. These vehicles were also significantly more likely to be taken at night and recovered in isolated areas

(Potter, 2000). As mentioned earlier, vehicles recovered burnt were significantly more likely to be stolen from a residence while non-burnt stolen vehicles were mostly stolen from streets or car parks. Finally, stolen vehicles recovered burnt were also more likely to have agreed value insurance policies on the vehicle rather than market value policies. Given the newer age of the vehicles and the higher likelihood of agreed value policies, vehicles recovered burnt that had insurance claims on them would be expected to result in larger insurance payouts.

Findings from this study are consistent with the characteristics of stolen vehicles recovered burnt in Potter's (2000) study. The age, expense, spatio-temporal characteristics and insurance claim information of the burnt stolen vehicles in Potter's (2000) research suggest that many of these fires may be the result of vehicle arson for financial gain and not necessarily in order to destroy DNA evidence. Even though it was concluded in Potter's (2000) study that MVT arson was most likely to be the result of joyriders, from an opportunity theory perspective, when an offender steals a car in order to use it for joyriding or in the commission of a crime, it would seem unlikely that the age, expense and insurance policy information would influence the likelihood of a car being stolen over opportunity. Vehicles stolen from a residence are likely to be under the guardianship of either the owner or neighbours, making the successful theft of these cars less likely than those parked in the street or in car parks, further making it seem unlikely that joyriders or offenders using the stolen vehicle as a getaway car would increase their chances of getting caught just to burn it in the end. Furthermore, increases in vehicle arson cannot adequately be explained by joyriding. Vehicle arson for financial gain is influenced by the economy

meaning that as economic indicators such as unemployment and interest rates increase, so too does vehicle arson. However, joyriding is generally the result of opportunity, meaning that even though some joyriders may come across increased opportunity in certain areas, it seems unlikely that this alone would lead to a significant increase in vehicle arson.

For insurance companies to believe an individual's car was set on fire by thieves/joyriders, it would seem likely that the individuals claiming fraudulent insurance on the vehicle would first report the car stolen to remove some of the suspicion from themselves. Therefore, it would not be surprising that the MVT data and annual vehicle arson counts are so strongly correlated because the owners of these vehicles were reporting them stolen before setting the vehicles on fire.

An interesting finding to note is the trends found in vehicle arson during the period of the crime drop. As mentioned earlier, an increase in security resulted in a significant decline in crime (including MVT) in most western countries in the 1990s. However, as discovered in previous research, vehicle arson displayed an opposite trend, significantly increasing in multiple countries in the late 1990s and early 2000s (Garis et al., 2007; Merrall & Chenery, 2005; Potter, 2000). Because MVT and vehicle arson are so strongly correlated one would expect vehicle arson to decrease in a similar pattern to MVT during this time, however, vehicle arson for financial gain could be a possible explanation for this discrepancy. As vehicle arson used as a means of insurance fraud is committed by the owners (or an accomplice), it makes sense that an increase in security would not reduce the likelihood of these crimes occurring, considering

the offender owns the car and therefore can access it without having to worry about bypassing security measures.

As these findings were supported by opportunity theories, SCP will be discussed in regards to the applied implications of this research.

Situational Crime Prevention

SCP is a problem-solving crime prevention model built from an opportunity theory framework that involves the management and manipulation of environmental/situational factors in order to reduce criminal opportunities and precipitators (Cornish & Clarke, 2003). According to Wortley (1998), crime is a two stage process. When people perceive the benefits of crime to outweigh the risks, it does not automatically mean the individual will indeed engage in criminal activity. Instead, crime is likely to occur when people develop the motivation to commit the crime (through a cost-benefit analysis caused by precipitators) *and* also become aware of areas that provide the opportunity to commit crime with little risk/effort and maximum reward. From this perspective, anyone has the propensity to commit crime when put in a given situation and because most people have the capacity to commit crime and do not, it would seem likely that most people will try to avoid crime, where possible. Therefore, by increasing the perceived risk and effort associated with the crime and outweighing the rewards, the opportunity and motivation are reduced, causing individuals to seek legitimate alternatives.

Historically, crime prevention was largely derived from offender-based research specifically offender rehabilitation and incapacitation (Clarke & Cornish, 1985). While these methods can and do reduce recidivism they each have downfalls for which SCP can account for. First, offender-based prevention relies on the

assumption that offenders are different than other people due to a 'criminal disposition' (Clarke & Cornish, 1985). Second, because of this assumption offender-based prevention techniques focus on the individual and the need to reduce their disposition towards crime, therefore putting the onus of change on the offenders themselves. Finally, due to the focus on changing the individual's criminal tendencies, these prevention methods require the offender to first be apprehended, which, in the case of crimes such as arson, is often not the case. SCP however, is based on opportunity theories, which recognise that *anyone* has the propensity to commit crime given the right circumstances and therefore the focus of SCP is on reducing the opportunity to commit crime, thereby stopping crime at the source without the reliance on the offender being caught.

To successfully apply SCP to a given situation an understanding of where, when, how and why the crime is occurring first needs to be gained (Clarke, 1997). It is important to note that for SCP to be effective, it needs to be applied to specific crimes only (Clarke, 1997). General categories of crime have multiple crimes that fall within them, for example; arson in general, could include structural arson, vehicle arson, bushfire arson, etc. as well as the broad range of motivations behind each of these offences. Through focusing on the specific offence, SCP can identify the precipitators and environmental factors enabling these crimes and what can be done to reduce them (Cornish & Clarke, 2003). Twenty-five situational prevention techniques that fall under five broad categories were developed by Cornish and Clarke (2003) that can be applied to specific crimes in order to reduce opportunity and increase risks associated with the crime. These five categories are:

- Increase effort,

- Increase risk,
- Reduce reward,
- Reduce provocation, and
- Remove excuses.

Through the use of SCP many types of crime have been reduced in various settings (Clarke, 1997). Some examples of effective applications of SCP have been 'Operation Cul-de-sac' in Los Angeles (Lasley, 1996), the University Student Crime Prevention Awareness Project in Cincinnati (Madensen & Skubak, 2005) and the Breath Alcohol Ignition Interlock Device (BAIID) Program in Illinois (Raub, Lucke & Wark, 2001).

Operation Cul-de-sac significantly reduced gang violence and drive by shootings in a Los Angeles neighbourhood through the installation of permanent traffic barriers in areas that were commonly targeted. Reductions in murder were also noted in areas surrounding the study location. The reduction of drive by shootings in this area also led to a large reduction in truancy levels at nearby schools as residents felt safer to go about their routine activities.

The University Student Crime Prevention Awareness Program was developed to reduce property crime on campus after a substantial amount of property crime was reported by students following their return from their winter break. This prevention initiative involved providing students with crime prevention advice on 'door hangers' that were distributed to students one week before the winter break. Significant reductions in theft were observed during the treatment period as well as significant reductions of theft in neighbouring areas.

Finally, the BAIID program was introduced in Illinois to reduce the occurrence of driving while under the influence of alcohol, specifically with repeat offenders. The program included a control (no BAIID fitted) and experimental group (those who had a BAIID fitted to their vehicle) of individuals who had multiple DUIs who had applied for a restricted driving permit. The BAIID requires a clean breath sample below 0.025 breath alcohol concentration in order for the vehicle to start. Drivers with a BAIID installed were significantly less likely to be rearrested for DUI than the control group.

The results of these initiatives demonstrate the diversity of the application of SCP and its success when applied correctly. Suggestions for how SCP can be applied to this research will be discussed below in relation to the five broad categories and each of the suggestions that fall within them.

Increase effort. Increasing the effort associated with crime is the first category that SCP techniques fall under. As mentioned above, many people will try and avoid engaging in criminal activity where possible, so by increasing the effort associated with the crime, people are likely to be dissuaded from committing crime in these hot spot areas.

Control access. Limiting the amount of entry and exit points to the hot spot areas can increase the chance that people will recognise the vehicles coming and going from the area. This also reduces the number of escape routes offenders can take after committing the crime, making it easier for police to apprehend the suspect if they know the route they will be taking upon fleeing the scene.

Screen exits. Screening exits through measures such as entry/exit tickets can provide information on when the crime took place and how many people were involved. As vehicle arson is likely to occur in isolated areas, more than one offender is likely to be involved as the offender would need another way to get home following the torching of his/her car. By screening the exits, either two cars would need to obtain tickets to enter, thereby showing that more than one person was involved or the offender would need to commit the crime and leave the site on foot, increasing their chances of being detected.

Deflect offenders. Offenders can be deflected from committing crime in the area by limiting access to the area during a particular time. Either by closing roads to the public during hours when vehicle arson is most likely (10pm-4am) or requiring people to apply for a permit for after-hours entry, reduces the likelihood that offenders will be able to access this site without identification.

Increase risk. The second category of SCP is increasing risk. Increasing the risks of crime can lead to increased chances of the offender getting caught. As crime is the result of a cost-benefit analysis, it would make sense that by increasing the risks associated with the crime, offenders are more likely to be deterred.

Assist natural surveillance. As mentioned earlier, vehicle arson is mostly committed at night to avoid detection. By increasing the lighting in the area, people in the vicinity of the area are more likely to notice the fire and the offender, therefore reducing the opportunity for the offender to get away undetected.

Reduce anonymity. Introducing permits to access the area after a certain time frame means the offender would need to provide identification to access the area. Only allowing particular people to the area after a certain time, not only limits the number of suspects when a crime is committed during this time frame but when used in conjunction with entry and exit tickets and limited entry and exit points it is unlikely that offenders will be able to commit vehicle arson in the area without being identified.

Utilise place managers and strengthen formal surveillance. The use of Closed-circuit television at entry and exit points as well as on-site security further increases the risk associated with the crime. Closed circuit television used in conjunction with entry/exit tickets provides police with footage of the vehicle, its number plates, the potential offenders and the times they entered and exited the property. Having security staff situated near the entry and exit points or on the ground increases the chance that the offenders will be seen and any suspicious activity will be recorded/noted.

Reduced rewards. As the findings of this study have shown, vehicle arson is likely to be influenced by the economy, suggesting that it is motivated by financial gain. By imposing conditions making it more difficult to have immediate access to insurance money, people may be less likely to consider vehicle arson as a timely alternative to receive a large sum of money.

Deny benefits. As the benefit of vehicle arson for financial gain is the insurance payout and escaping the loan, denying the benefits of this type of crime would need to focus on the insurance policies. As the findings of this study have shown, legitimate car fires do occur therefore denying insurance in instances of all vehicle fire is unreasonable. Instead, if the vehicle fire is

suspicious in nature, the insurance policy should require a 6-12 month cooling off period before any monies can be claimed. This lengthens the period of investigation and also extends the timeframe in which the benefits of crime can be received. If people are desperate enough to commit vehicle arson to receive insurance money, it would be expected that an extended cooling off period would deter people from seeking money this way. To ensure innocent people are not too adversely affected by these measures, insurance companies could provide a hire car during the cooling off period, this way innocent people are not without transport, noting that they would still be obliged to repay their loans during this period. In these circumstances, potential offenders would be unlikely to destroy their vehicles to receive insurance.

Reduce provocations. Certain aspects of the environment can provoke people to commit crime, for example, overcrowded areas can increase feelings of frustration and areas where young teenagers are likely to hang out may have increased acts of delinquency due to peer pressure. By reducing provocations in specific areas, crime caused by these provocations can be reduced.

Discourage imitations. If people believe they can get away with a crime and have also heard of instances when others have successfully done so, it would seem likely that they may try to imitate the original act. The existence of hot spots suggests that this is likely as for one reason or another, people are committing vehicle arson in similar places throughout Surrey. The introduction of media campaigns or frequent news reports of unsuccessful attempts to claim insurance through vehicle arson could reduce this issue as campaigns such as these are likely to be remembered by people in similar situations. Measures such as these could also lead people to believe that prevention efforts to reduce

vehicle arson are highly successful and widespread, thereby convincing people that getting away with it is unlikely. Considering that vehicle arson was found to be influenced by the economy, these campaigns could be strengthened during times when unemployment or interest rates are high.

Remove excuses. Studies show that when people commit crime, they tend to try and neutralise the situation to remove some of their guilt/shame/responsibility. By putting measures into place that frequently remind people of the consequences of their actions and the need to comply with the law, it limits the chances of people trying to neutralise their acts.

Assist compliance. When people take out new car loans over a certain amount, insurance companies could provide free or discounted financial planning advice so individuals can save more money (increasing their savings in cases of emergency such as unemployment and ensuring they have extra money set aside for their bills when interest rates increase), also by understanding smarter ways to invest/spend money, individuals may be better equipped in the event of financial hardship. In addition, insurance companies could adopt certain strategies to assist individuals with accounts in arrears, such as; offering extensions on repayment terms and reducing repayment rates to relieve some of the financial stress during times of economic hardship.

Post instructions/Alert conscience. Often when weighing the pros and cons of a situation, people may not have all of the information needed to make a rational decision. The term of a potential prison sentence, the total amount of potential fines and the likelihood of getting caught, are all likely to be unknown by many people. Therefore, by making people aware of these consequences they may make better-informed decisions, ultimately deciding the costs

outweigh the rewards. Creating warning signs with maximum penalties for vehicle arson and insurance fraud displayed in areas in which vehicle arson is likely to occur can make individuals aware of the potential consequences they may face if caught. Insurance companies could also send out letters to their clients discussing the consequences of vehicle arson for financial gain as well as the detection strategies in place and information about people who have been caught.

The above techniques are solely suggestions for the different ways in which vehicle arson can be reduced in the hot spot areas found in Surrey. As it can be quite expensive to implement all possible reduction strategies to a given area, not all need to be in place; however, it would be most effective if at least one technique from the five categories could be used where possible. As vehicle arson affects police, fire services and insurance companies, the use of SCP along with the collaboration of these three stakeholders would likely produce the most substantial reductions in vehicle arson.

Limitations

As with all research, this study did present certain limitations that future research could improve on. Future research could benefit from mapping the specific vehicle fire locations, using monthly level MVT data and by including insurance/loan information.

Dissemination areas. DAs each contain populations between 400-700 people, therefore providing small areas that the vehicle fire data can be aggregated to, in order to distinguish spatial patterns between the groups. However, as the data were aggregated per DA, the precise spatial information for each fire was lost, leaving only general estimates of where these fires were

occurring. DAs can contain multiple land uses, meaning areas such as industrial, urban, multiple residential and agricultural could exist within a single DA. To determine the areas the in which vehicle fires were occurring, land use information was collected for each DA where a significant hot or cold spot was found. The most common land use for arson and non-arson vehicle fires was determined by calculating the frequency that each land use appeared (as developed from research conducted by Wushcke et al., 2013), meaning that if vehicle arson was listed in a DA with a single land use of agricultural and a mixed land use DA of urban, agricultural and suburban, these fires were considered most likely to occur in agricultural areas. If future research were to consider the specific location of each fire, using opportunity theories, it would be expected that more definitive spatial differences would emerge from the results.

Motor vehicle theft. The lack of access to MVT data at a monthly level meant that a more in-depth analysis of the relationship between vehicle arson, MVT and the economy could not be obtained. For this reason, it is unknown how much of a variation in vehicle arson can be accounted for by fluctuations in MVT. Through further research on the incidence of MVT and vehicle arson, researchers may be more likely to determine when burnt stolen vehicles are indeed the result of fraudulent insurance claims or instead occurring for other reasons such as destruction of DNA evidence.

Insurance information. As this study is analysing the incidence of vehicle arson for financial gain, the inclusion of insurance/loan information would have provided a more definitive conclusion on this subject. By including this variable, researchers would be able to determine how many of these vehicle fires resulted in insurance claims, how many were suspected to be

fraudulent, the types of policies out on each of the vehicles and the estimated insurance payout/time remaining on the repayment of the loan. Information such as this would not only provide a clearer picture on vehicle arson for financial gain but with the inclusion of MVT data, it may also provide a better understanding of how to determine the different motivations behind vehicle arson.

Future research could include consideration of the above limitations in this area as well as considering the inclusion of cross-sectional data. Cross-sectional data would examine the incidence of vehicle arson over a range of locations which would allow for the comparison of vehicle arson trends in different areas over time in order to determine if the vehicle arson-economy relationship exists elsewhere. Also, because similar trends in vehicle arson were observed at similar times in Surrey, South Australia and England, the relationship between MVT, vehicle arson during the time of the crime drop in different international locations would also make for an interesting study.

Conclusion

From 1997-2003 in Surrey, vehicle fires were occurring at a rate more than double what was reported in national statistics (Council of Canadian Fire Marshals & Fire Commissioners, 2004. as cited in Garis et al., 2007). The increased number and nature of these fires lead researchers to believe that these fires were occurring as a result of arson (Garis et al., 2007). Vehicle arson is an area of research that remains largely under-researched. What has been done in the area suggests a rise in vehicle arson around the same time as these fires were occurring in Surrey also occurred in places such as South Australia (Potter, 2000) and England (Merrall & Chenery, 2005). Different

studies in this area have considered various motivations behind these vehicle fires such as vandalism and destruction of DNA evidence, and while vehicle arson for financial gain has been mentioned as a possible motivation behind vehicle arson, it has not been the focus of any studies to date. From an opportunity theory perspective, increases in a particular crime can be understood by analysing any widespread events that may have led people to consider the benefits of crime to outweigh the risks.

Opportunity theories of crime suggest that crime is a non-random phenomenon. From this perspective, crime is believed to be the result of a cost-benefit analysis with the offender perceiving the benefits of crime to outweigh the costs. However, the cost-benefit analysis alone does not always lead to crime; the offender must also be aware of an environment that presents the opportunity to take part in criminal activity with as little risk/effort as possible and is likely to result in the most reward. Considering this, crime can be understood and prevented by identifying where and when crime is occurring, what parts of these environments are facilitating crime and what the possible motivation is that has led to an increase in this particular crime.

Crime takes place in specific spatio-temporal patterns (Wushcke et al., 2013). Certain aspects of an environment can tempt, provoke or facilitate certain criminal opportunities (Cornish & Clarke, 2003) and when individuals have decided that crime is going to result in the most reward and the least cost, environments that provide decreased chances of being detected may lead to criminal hot spots. For example, if an area has little surveillance and it is easily accessible (therefore making it also easier to escape) offenders would be more likely to commit crime in this area than a city street in the middle of the day. By

identifying where and when crimes are likely to occur, measures can be put in place to reduce the occurrence of these crimes. Arson, like most crime, has identifiable spatio-temporal patterns in which it is most likely to occur (Asgary et al., 2010). As found in this research, consistent with previous studies (Potter, 2000), arson is most likely to occur at night and in isolated areas. This is consistent with opportunity theories, which would suggest that this would enable the offenders to commit arson with reduced chances of being apprehended.

As mentioned earlier, when specific types of crime rise, it is important to identify any widespread events that may have resulted in a large number of individuals turning to crime. Unlike offender-based theories that view offenders as different from the rest of the population, from an opportunity theory perspective, anyone has the propensity to commit crime, given the right circumstances. When people go through a change of circumstances, they may view crime as a way to escape the new situation in which they have now found themselves. Fluctuations in crime have been studied for some time now, and one of the most consistent indicators of changes in crime trends is the economy (Andresen, 2013). Many studies in this area have found a significant relationship between property crime and the economy while violent crime has mostly remained unaffected by changes in the economy, with the exception of robbery which is not surprising given its financial motivation (Arvanites & DeFina, 2006). The increase in financially-motivated crimes during an economic downturn makes sense as from an opportunity perspective, during times of financial hardship people may find themselves in situations where they are in desperate need of money in order to maintain their lifestyles or pay off existing loans. Rises in unemployment and under-employment can have substantial

negative impacts on people and their families, and financial stress can lead people to go to extreme measures to escape the pressure put on them by their newly diminished financial status (Milner et al., 2015). As vehicle arson for financial gain is an economically-motivated crime, it does make sense that changes in the economy were found to be related to occurrence of vehicle arson in this case.

The primary goal of this study was to determine the spatio-temporal characteristics of vehicle arson and whether or not it was affected by the economy to gain a better understanding of this crime. As hypothesised, different spatio-temporal patterns were observed between vehicle arson and the control (non-arson vehicle fires). In line with previous research and opportunity theories, vehicle arson was most likely to occur at night, over the weekend and in isolated areas. While the control group remained stable throughout the week, and occurred mostly during the day between working hours and in areas where people are likely to commute to/from work, school, home, etc. As spatio-temporal differences were found between the arson and non-arson vehicle fires H_1 was supported, however with specific analysis of vehicle fire location, it is expected that more definite, significant differences will emerge.

Understanding the spatio-temporal patterns of crime is paramount when developing targeted crime prevention strategies such as SCP. However, it is also important to understand why certain crimes fluctuate to determine what is driving these crimes and when they are most likely to occur. The relationship between crime and the economy has been well researched over the years with many studies concluding that changes in the economy influence changes in financially-motivated crimes. The findings from this study are consistent with

previous research on the relationship between financially-motivated crime and the economy (Arvanites & DeFina, 2006; Chiricos, 1987). As expected, vehicle arson was significantly influenced by the economic indicators while the control group remained unaffected, therefore supporting H_2 . From an opportunity theory perspective changes in the economy can lead to an imbalance of costs-benefits associated with crime, resulting in generally law-abiding people considering the incentives of crime. As vehicle arson can have a multitude of different motives, these findings suggest that the vehicle arson in this study was likely to be economically-motivated (committed with the intention of escaping debt). Yet, given previous research finding a relationship between vehicle arson and MVT, it is important to consider the effect of MVT on vehicle arson.

Due to the strong relationship found between MVT and vehicle arson, many studies have concluded that stolen vehicles are set alight to destroy DNA evidence. However, in order to commit vehicle arson and successfully claim insurance, the owners of the vehicle evidently cannot be suspected of arson or insurance fraud, making it likely that some stolen vehicle fires could be the result of vehicle arson as a means of financial gain. Considering this, it would seem plausible that many people committing vehicle arson as a means of financial gain would first report the car stolen. This research examined the occurrence of vehicle arson and MVT to determine whether or not a relationship existed. As expected, MVT and vehicle arson shared a strong positive correlation, therefore supporting H_3 . Given the relationship found between the two variables it is likely that many of the vehicle fires in this study were occurring in stolen vehicles. As vehicles set alight to destroy DNA evidence and to receive fraudulent insurance money display similar characteristics it is difficult

to definitively conclude that all of these stolen vehicles were the result of vehicle arson for financial gain. However, considering the large proportion of variance in the vehicle fires that was accounted for by the economic variables, it is plausible that many of these stolen vehicles were indeed set alight in order to reduce debt, through insurance fraud.

Little is known about vehicle arson and specifically vehicle arson for financial gain. What we do know about arson, in general, is that it can be committed with ease and the consequences can be severe and far-reaching (Drabsch, 2004). Because vehicles contain fuel, the act of vehicle arson is particularly dangerous, putting not only the offender at risk of serious injury but also emergency personnel responding to the scene and people nearby. This research is one of the first studies to examine the spatio-temporal patterns of vehicle arson and its relationship with the economy from an opportunity theory framework. By understanding the patterns in which vehicle arson is occurring and the motivation behind it, these findings can be put towards developing prevention efforts with the hope of reducing vehicle arson and insurance fraud.

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