Pol-1536

Stephanie Sharp

Fitzwilliam College

Supervisor: Dr Tim Coupe

Pickpocketing on the Railway:

Targeting Solvable Cases

Submitted in part fulfilment of the requirements for the

Master's Degree in Applied Criminology and Police Management

2016

Abstract

This study aims to identify and exploit the circumstantial factors associated with the solvability of pickpocketing on the railway. Through the development of a statistical case screening model derived from these factors, comparisons are made between this method and the current intuition-based approach to case screening at BTP. Finally, the study aims to understand the impact of secondary investigations upon pickpocketing solvability, following case screening and allocation. Using a five-year dataset of 36,260 cases split into two equivalent samples, statistical tests were performed on one sample to understand the strength and significance of factor relationships with solvability, before developing the screening formula through logistic regression. A suitable cut-off point is established to balance what would be missed opportunities or wasted efforts. Following the inclusion of automatic screen-in factors, the final model was tested for predictive accuracy using the second sample and compared to that of current practices. Finally, the relationship between the volume of investigative actions and case solvability was assessed, for the full population and controlling for cases screened in by the statistical model.

A range of factors reported significant correlations with pickpocketing solvability, including suspect information; witness accounts; CCTV availability and committed time range, amongst others. The statistical screening model developed presents a predictive accuracy rate of 74.7% compared to BTP's current processes at 14.4%. There was no significant relationship reported between the volume of investigative actions and case solvability. These findings led to the conclusion that significant efficiencies would be associated with implementing the statistical model due to it screening in fewer crimes for investigation (29.8% reduced from 90.6%). The absence of association between detectives' activity and solvability informs the conclusion that the surplus resources should be removed from pickpocketing investigations. The estimated savings would be £2.5M over five years. Finally, due to data limitations, a Randomised Control Trial (RCT) is proposed to test the effectiveness of the screening model and subsequent pickpocketing investigations, in a real operational context.

Acknowledgments

I am incredibly grateful to the staff and lecturers at the Institute of Criminology for everything they have taught me over the past two years. In particular, Dr. Barak Ariel for his calming direction during the first year and dealing with my regular intervals of panic. During the preparation and delivery of my thesis, I am extremely grateful to Dr. Tim Coupe and his vast knowledge of crime solvability and statistics which has allowed me to take a much bolder approach to this research, safe in the knowledge that I was on the right course. I would also like to thank Charlotte De Brito and Chris Casey for their friendship and support over the past two years.

I am indebted to Andrew Critchley for teaching me everything I had previously learned about Excel, even though it turned out to be not nearly enough! To Paul Watson who has offered great assistance in securing an extensive dataset, Lisa Mylett for her advice and direction on crime management processes and Sharon Mui who has been incredibly patient and informative in teaching me some of the statistical methods. I would also like to thank Tom Olphin, who has not only inspired my thesis topic with his own research, but also has personally offered his assistance to keep me on track when the analysis started to get tricky. I would also like to thank my family for appearing at Cambridge formals at every conceivable opportunity, especially my partner Caroline Sparks for the proof-reading and looking after our animals while I have been away.

Finally, I would like to acknowledge the British Transport Police for allowing me to undertake this Masters course. In particular, Mark Newton for his patronage and confidence in me and Susan Yeomans-Jones and Matt Wratten from the Justice Department for supporting my research and at least pretending to understand the methodology. In addition, I would also like to say a preemptive thank you to the Chief Officer Group for agreeing to fund an experiment to test the practical implications of this research, to ensure it truly makes a difference to policing.

Contents

List of Tables

List of Figures

Introduction

Scarce resources continue to limit the efficiency of policing. The perennial demand, to create a relationship of mutual trust and confidence with society whilst suppressing the harm associated with crime, is supplied only by increasingly limited investment. In recent years, this has led police leaders to scrutinise practices which have evolved over time, intent on delivering more with less. On the brink of an evidence-based revolution, policing is forced to strengthen its relationship with research in the ambition to pinpoint inefficiency, developing more informed strategies to provide the maximum return on public investment. In stark contrast to advances in the medical sciences field, policing has continued to rely heavily on policy steeped in the instinct and intuition of practitioners. Whist there is a place for this type of decision making, much of the current policing approach has gone untested. Although evidence plays a specific role in how police solve crime at a case level, it is still very much absent from the development and implementation of broader practices to deter and detect crime.

This is especially evident from the way in which crime is investigated. Although the appearance of detectives may have moved on from the trench coat and magnifying glass, their role in criminal investigations remains shrouded in mystery. There remains a widely-held view that criminal investigations are too nuanced for science to successfully compute, which would distract from the finely-honed experiences and skills of good detectives. This translates to an earlier phase of criminal investigations; attempts to decide which crimes would benefit most from a detective-led investigation. This decision making phase is critical in targeting resources to investigate those ‘power few’ cases likely to disproportionately benefit from the investment (Sherman, 2013). The issue is further compounded through limited funding availability to grow or even maintain current headcounts. Where detectives continue to investigate almost all crime, it is crucial to understand what benefit this brings and if there is a more efficient way to operate. The objective of this study is to understand the interactions between crime circumstances, investigative efforts and solvability with the intent of developing a finely-tuned targeting strategy.

One crime type which is investigated in high volumes whist continuing to present an extremely low detection rate is pickpocketing on the railway. It is thought to negatively impact upon passenger confidence, heightening the concern and subsequent commercial interest of Train Operating Companies. Whilst reliance upon the intuition of detectives has not modernised in many decades, this cannot be said for pickpockets, who continuously evolve in their methods to evade capture. For the British Transport Police (BTP), pickpocketing is not just one of the most prolific crime types across the rail network, but leads to an extensive investment in terms of secondary investigations. The time taken to investigate thousands of pickpocketing crimes which are never solved is a sizeable distraction from less persistent crimes which contribute proportionately greater harm to the victim and society. The filtering system used to determine which pickpocketing offences should be allocated for secondary investigations is also untested.

At the initial investigation stage conducted by a national Crime Management Unit (CMU) a decision is made whether to screen a pickpocketing offence in or out. If an offence is screened in, it is allocated along with an investigation plan to a detective for further investigation; if screened out, it is closed. Although this is a means to target investigative resources based on what is thought to be 'solvable' crimes, it is entirely based on the intuition and experience of the relevant CMU Operative making the screening decision. With the current process screening in 90.6% of crime for a detective-led investigation (despite only 5% of resulting in a successful outcome) it is evident that without intervention there is a considerable false positive rate resulting in extensive wasted efforts. As police time is the most valuable currency in the achievement of strategic crime reduction and detection targets, it is necessary to consider whether there are more intelligent screening techniques available.

Through the systematic analysis of existing literature, this thesis will aim to establish the extent to which evidence in relation to predictive solvability can be translated to pickpocketing on the railway. Early on, the disadvantages of subjective assessment became clear (Meehl, 1954; Kahneman, 2011) which reinforced the ambition to develop an understanding of alternative methods. Various studies have almost consistently found that a relationship exists between crime circumstances and solvability. This research has developed further into the production of statistical predictive models, with varying degrees of accuracy; 85% (Eck, 1979); 64% (Olphin, 2015) although the factors in play were entirely specific to the crime type and context.

Where the evidence casts doubt over the efficiency of allocating equal effort across the broad spectrum of cases (Paine, 2012) it is important to develop a deeper understanding of the factors associated with solvability. A series of circumstantial factors have been tested over the years, presenting varied correlations with solvability. Whereas some of these are enduring, many are constrained by their associated crime types and contextual settings. Pickpocketing in a mass-transit environment also brings to the table a bespoke list of factors, which have previously been untested. The unique stealth-like nature of pickpocketing (Smith, 2008) presents both limitations to available information and new opportunities in terms of assessing how the absence of information itself could become a negative predictor of solvability. Although there is a breadth of research into solvability factors which provides a starting point for the testing of significance and effect, it cannot be assumed that these would remain valid in application to pickpocketing.

Where previous research falls short in identifying and testing both generic and specific factors which may contribute to pickpocketing solvability, it is necessary to generate further data to address the specific operational requirement. An analytical study will be undertaken to establish both the individual and combined effects of circumstantial factors upon pickpocketing solvability. A predictive model will be developed and presented as an alternative to the intuition based screening decisions currently undertaken. This model must be developed solely using crime characteristics as independent variables, which would ordinarily be available to a CMU Operative. The analytical methods will follow the approach of Olphin (2015) by splitting the full dataset into two equivalent groups; one for analysis and one for testing. The predictive accuracy of this statistical model will be contrasted with that of current practice to ascertain whether such a method would be applicable to replace pickpocketing screening decisions. The findings of this phase are closely linked to the final area of research this study proposes. Namely, understanding what, if any, solvability advantage is provided by the detectives' efforts.

Arguably, there is no practical advantage to a statistical model, even one with greater predictive accuracy, if it does not offer operational benefits either through creating efficiencies in police time or improving positive outcome rates. This assessment can only be undertaken by understanding the value added throughout secondary investigations. The literature is divided in this area. Despite the growing body of research in relation to solvability factors, there is still inadequate evidence surrounding the effectiveness of investigative actions (Telep and Weisburd, 2012). A measure of effort in relation to secondary investigations conducted for pickpocketing will be scrutinised in terms of its relationship with solvability. This analysis will be completed both for the entire dataset and a smaller sample of cases which would be allocated by the predictive model, if it were to replace the existing screening system. This final step will allow the researcher to draw conclusions over the contribution of both the circumstances of pickpocketing offences and investigative efforts to the entire criminal investigation. The application of findings from this study will be discussed in terms of feasibility, ethics and limitations. This will include their contribution to wider policing and empirical value to research.

There are several gaps in existing literature which would prevent an evidence-based approach being considered to address the solvability of pickpocketing on the railway. By securing a dataset of 36,260 crimes over a five-year period, this study will examine the interaction of crime circumstances and secondary work efforts to present recommendations to improve BTP policy. There is a clear opportunity to consolidate the learning from previous studies, whilst moving towards the development of an evidence-based targeting system designed to enhance service offerings to victims of crime and wider society. Whether this will be catching more offenders or saving police time will be determined by the results of analysis bespoke to the issue in hand. The following section will critically examine the relevant literature, after which a set of specific questions will be established to address the weaknesses in research whilst sharpening the focus towards the issues for resolution. The methodology and results will be presented sequentially, whilst the discussion and conclusions will propose fundamental changes to improve the efficiency of policing, even with scarce resources.

Literature Review

This literature review will critically assess the existing research base for crime solvability predictions and the secondary value contributed by detectives. Within the context of pickpocketing on the railway, decision making processes for case screening will be assessed in line with evidence of more systematic procedures in terms of predictive validity. The historical development of underpinning hypotheses such as circumstance-results and effort-results (Eck, 1983) will be reviewed along with their respective implications for case screening and the subsequent actions undertaken throughout follow up investigations. An array of previous research into the strength of the individual circumstantial factors affecting case clearance will be described and critically assessed in terms of suitability for broader application, which precedes a specific discussion as to the nature of pickpocketing on the railway. Finally, a methodology will be proposed for the further examination of relationships between screening variables, subsequent investigative actions and solvability. This literature review will consolidate gaps in existing research before focusing attention upon the formulation of research questions to address the specific operational requirements.

Solvability and Triage

Solvability is *"the ease with which offences may be solved and whether or not it is possible to solve them."* (Robb *et al.,* 2014, p.2). The foundation of solvability research is the targeting of resources to predictable concentrations of crime which when administered a 'treatment' are more likely to be solved (Sherman, 2013). This idea that some crimes are easier to solve than others is rooted in triage. The concept of triage as a decision making process has been used since the Napoleonic War. Doctors prioritised casualties who would die without immediate treatment over those who were less injured, or would die irrespective of treatment. The cases disproportionately benefiting from the treatment can be established as the 'power few'

(Sherman, 2007). By targeting efforts towards these 'power few' cases through a triage process, it is possible to markedly increase efficiency.

This system can be applied to criminal investigations. In a world where scarce police resources dictate limitations to investigative effort, difficult choices must be made. There are cases which would be solved immediately, irrespective of a follow up investigation (treatment). There are also cases which, by their very nature are unlikely to ever be solved despite the best efforts of investigators. More interestingly, there are those cases with seemingly uncertain fates; whose solvability is dependent on factors associated with their nature, including the subsequent treatment they may receive. By sharpening focus upon the 'power few' cluster of cases likely to disproportionately benefit from secondary investigations, police agencies could boost the rate of solved cases whilst cultivating efficiency. This sorting process is known as case screening where key solvability decisions are made after crime is reported and recorded by call handlers.

Case Screening Techniques

Case screening is known as *"a structured system to help target investigative resources on crimes most likely to be detected"* (ACPO, 1989). However, in practice this system is often far from structured. Within policing, intuition leads the majority of case-screening decisions based on a number of subjective perceptions (Gill *et al., 1*996; Robinson and Tilley, 2009). Officers have been known to informally screen out cases which present to them as less solvable (Brandl and Frank, 1994; Coupe and Griffiths, 1996). This is the case for BTP. It is not that a 'triage' process is absent entirely, yet the system is highly distorted by the individual experiences and intuition of up to 25 national CMU Operatives responsible for making these case screening decisions. It is necessary to consider what evidence previous research can offer regarding the implications of such a system.

Systems directing the allocation of crime often neglect to consider the way in which circumstantial factors may impact upon the likelihood of solvability (Gill *et al.,* 1996; Jansson, 2005). Waegel (1982) interpreted crime handling techniques during a nine-month participation study, finding that the extent of each investigation was dependent on whether cases were deemed to be routine or non-routine; with the latter receiving enhanced investigative efforts. This categorisation method was found to be widely open to interpretation by detectives exercising their own discretion. Although routine cases could be 'upgraded' to non-routine if further evidence became known, Waegel found that those carrying greater caseloads were less likely to establish new leads and re-define the categorisation, due to the suppressed interactions during the investigation. This relationship between caseload and subjective influences creates variable outputs stemming from individual decision makers.

Further research echoed that case screening is likely to introduce inconsistent practices stemming from decision makers (Couple and Griffiths, 1996; Robinson and Tilley, 2009). In a national UK police survey into burglary and auto crime, Gill *et al.* (1996) found that managers had considerable discretion to screen in cases based on seriousness over solvability. Discretional consideration would include case elements such as media attention, aggravating factors and stolen property value. Individual factors affecting solvability are discussed further within this literature review, although it is pertinent to note the absence of evidence linking perceived seriousness of offences to their solvability. Coupled with the varying professional experience, personal motivations and judgements of screening decision makers, the system outputs can be more than inconsistent. They can quickly become distorted (Waegel, 1982; Coupe and Griffiths, 1996). Despite best efforts to target resources to cases causing a greater degree of harm, this would only be justified in effectiveness if the prioritised cases are solved.

We know that not all reported crime will lead to an arrest or charge, let alone a conviction. What remains to be understood is how to improve screening accuracy, ensuring scarce police resources are targeted based on their optimal contribution. Meehl (1954) compared both clinical and statistical methods within 20 studies. Clinical methods involved the subjective assessment of professionals whilst statistical methods were based on simple algorithms using relevant data on the subjects. The study found that statistical methods were consistently more accurate; yet even when predictive accuracy was comparable to that of clinical methods, they were considerably more cost effective. Since these initial findings, there have been over 200 repetitions in which statistical forecasting produced greater accuracy in 60% of cases (Sherman, 2013). It could be that subjective assessments are introducing the cognitive bias of operators through System 1 thinking (Kahneman, 2011). Case screening should be systematic and standardised. Improving such processes could not only increase the number of cases solved but also deliver an efficient and effective operating model (Coupe and Griffiths, 1996).

Eck (1979) evaluated the predictive accuracy of the statistically derived Stanford Research Institute's (SRI) solvability model using 12,001 burglaries. Eck found the model correctly predicted whether burglaries would be solved in 85% of cases. These cases were defined as 'true positives' or 'true negatives'. Nine per cent of incorrect predictions consisted of 'false positives' categorised as wasted investigations where the offence was investigated but not detected. More concerning, six per cent were incorrectly screened out yet would otherwise have been detected. This is where police would let victims down (Eck, 1983) and careful consideration must be given to policies which present a high false negative rate, cognisant of the variable harm experienced by victims of different crime types. The study concluded that statistical models screened in fewer cases for investigation and therefore could result in resource reductions.

Applying statistical modelling to predicting solvability and the subsequent case screening decisions could considerably increase positive outcome rates for residential burglary (Eck, 1979). Yet, this method is not applied to any crime categories across UK policing. At worst, comparable levels of solved cases would be present whilst assigning fewer resources through a more accurate targeting process (Eck, 1979; Sherman, 2013). For BTP, the stark reality is that while 90.6% of railway pickpocketing offences currently screened in for further investigation, only 5% of all cases are actually solved. Eck (1979) would define these cases screened in but unsolved as wasted investigations and the associated process cost for BTP is extortionate. In austere times, we must not waste money on practices which do not work (Bueerman, 2012). A targeted approach to reducing these false positives and, as such, the wasted efforts of detectives, would afford BTP immense efficiencies.

Fortifying Theories

Theories have developed over time in relation to the extent to which investigative effort impacts upon solvability. In the Boston Detective System, Folk (1971) analysed a variety of information used by detectives to solve 61 cases with a breakdown of reported crime by day of the week. Folk concluded that investigative efforts are critical to case clearance; albeit relying on a small and perhaps non-representative sample. In an observational study involving six police departments, Bloch and Weidman (1975) suggested several investigative actions influencing crime solvability. These include resource and budget-allocation; good relationships with victims, witnesses, patrol officers and prosecutors; the use of civilian employees and decentralisation of assignments. Within New York based study, Bloch and Bell (1976) found that certain leadership techniques such as the inclusion of patrol officers and encouraging a team approach were positively correlated with arrests. This evidence suggests the assumption of responsibility for successful case clearance upon the efforts of investigators and was later categorised by Eck (1983) as the effort-result hypothesis.

Assertions that investigative effort is responsible for case solvability have been plagued with contradictory evidence. Goldstein (1977) asserted that detectives' capacity to solve crimes has been significantly exaggerated. This statement sparked a growing research base into the relationship between investigative efforts and case clearance. The RAND study combined direct observations with surveys to understand the value of secondary investigations (Greenwood and Petersilia, 1975). Using a list of available evidence to demonstrate the predictive accuracy of certain factors in relation to the solvability of 2,000 burglary offences, Greenwood and Petersilia (1975) isolated six factors which demonstrated significant positive correlations with solved cases, weighted based on the strength of each relationship. These factors were combined to develop a predictive model, found to exhibit between 67% and 92% accuracy; significantly greater than intuitive assessment. This suggested that case solvability can be reliably predicted at the point of initial assessment. Replicative studies with greater statistical power have generated similar results (Eck, 1979; Paine, 2012; Olphin, 2015).

The RAND study into burglary and robbery found that 22% of solved cases involved an arrest at the scene whilst 44% had an identified offender within the initial report. Enhanced investigation activity above and beyond the routine procedural work was only present in 3% of solved cases. These findings led the authors to reject the notion that detectives are responsible for 'solving' crime and instead found that pre-determined circumstances would have a more substantial effect on case clearance than leads identified by investigators. This was later supported by Weisburd and Eck (2004) who suggested there was no significant relationship between investigator efforts and clearance for non-homicide cases. This recognition was categorised (Eck, 1983) as the circumstance-result hypothesis. In a more complex study, Coupe (2014) found that although crime circumstances were the greatest indicators of positive results, targeting resources to incidents where certain pre-determined circumstantial indicators exist will also contribute to detection rates.

In 1979, The Police Executive Research Forum analysed investigator logs for burglary and robbery offences, along with observing the actions of detectives in concurrence with case solvability (Eck, 1983). The findings suggested co-presence of both the effort-result and circumstance-result hypotheses. Eck (1983) concluded that both could be true within suitable context. This formalises three categories; crimes which are likely to be solved, irrespective of investigative effort; crimes are unlikely to be solved, irrespective of investigatory effort and finally those which could be solved as a *direct* result of investigatory effort. This came to be known as Eck's triage hypothesis (1983) and reinforces the need to substitute subjective case screening assessment for statistically weighted models. This would ensure cases which are not likely to be solved are screened out and not offered follow up investigations, whilst those which are either self-solvers or possible to solve with further resource investment will be screened in and allocated to detectives. Nevertheless, the composition of predictive models relies almost entirely on the identification of correlations between crime characteristics and case solvability.

Factors Influencing Crime Solvability

Resource allocation should be informed by reliable predictions of case solvability, and some of the strongest and most consistent evidence has been in relation to suspect information. Research has developed considerably since the early evidence of correlations between suspect information and clearances (Isaacs, 1967; Reiss and Bordua, 1967; Greenwood, 1970; Greenwood et al., 1975). *"If a thorough preliminary investigation fails to establish a suspect's identity in a less serious offense, then the victim should be notified that active investigation is being suspended until new leads appear"* (Chaiken *et al., 1*976, p.38). However, it is necessary to consider the relevance of these studies conducted over 40 years ago.

Brandl and Frank (1994) have supported these initial findings through discovering a correlation between stronger suspect descriptions and arrests for burglaries and robberies. On-scene capture of suspect information has been the most consistent solvability factor evidenced throughout a variety of crime types such as burglary (Greenwood, 1975; Eck, 1979; Eck, 1983; Coupe and Griffiths, 1996; Paine, 2012), non-residential burglary (Coupe and Kaur, 2005), violent crime (Eitle *et al., 2*005; Peterson *et al., 2*010; Olphin, 2015) and theft from motor vehicles (Burrows *et al., 2*005). Incidents where the suspect is known to the victim increase clearance rates for rape (Roberts, 2008), robbery and aggravated assault (Snyder, 1999; D'Alessio and Stolzenberg, 2003). Witness accounts could be considered an independent factor, although it is possible that inter-variable correlation exists with suspect identification. Farrington and Lambert (2000), Tilley *et al.,* (2007) and Baskin and Sommers (2012) have all established links between victim and eyewitness accounts and crime solvability. Nonetheless, despite the empirical consistency regarding suspect identification, there are a number of alternative factors which have demonstrable correlations with case solvability.

Clawson and Chang (1977) identified a correlation between reporting delays and solvability. From a sample of 949 crime calls analysed in Kansas City, Bieck and Kessler (1977) found that an arrest is considerably more likely if the crime was reported immediately. This was reinforced by the findings of Spelman and Brown (1981) who followed the study in Kansas City with a larger, stratified sample of 3,332 volume crimes, suggesting that the greatest effect was for crime reported within five minutes of commission, assuming no arrests at or near the scene would be possible after this period. In 1994, a West Midlands study into residential burglary investigations was conducted by Coupe and Griffiths (1996) with a sample of 704 cases. Most primary detections were ascribed to actions undertaken by the first responder such as interviewing neighbouring households and catching offenders during the burglary (attributable to 43% of detections). This was later supported by Robinson and Tilley (2009). When evaluating the attrition of 3,000 burglary and motor vehicle cases across England and Wales, Robinson and Tilley (2009) also found that the number of sources giving a name, forensic evidence available and number of potential leads all correlated positively with detection.

Due to a degree of variance across crime types, these additional solvability factors should be considered in relation to their respective samples to draw appropriate inferences. Footprints, fingerprints and DNA evidence have been shown as stronger predictors for burglary (Bond, 2009; Paine, 2012) although contradicted by findings from Burrows *et al.,* (2005) and Coupe and Griffiths (1996). Victim ethnicity has a varying impact, with non-white victims correlating with increased clearance rates for rape (Roberts, 2008), yet lower for robbery (Snyder, 1999). CCTV demonstrated positive effects for metal theft (Robb *et al., 2*014) but negative effects for violent crime (Olphin, 2015). Offence commission during daylight hours and early reporting have been found to positively affect burglary (Coupe and Blake, 2006) and homicide (Alderden and Lavery, 2007) detection.

There has previously been research into the solvability of railway offences, focusing upon metal theft. Robb *et al.,* (2014) identified twelve key solvability factors for 4,001 metal theft offences including scrap metal dealer visits, witnessed offences and presence forensic evidence, amongst others. Of note, there were significant variations in detection rates across BTP's national jurisdiction. Although solvability factor variance accounts for this to an extent, the authors note that inconsistent investigative practices could also contribute. Much of the existing research indicates notable variances in solvability factors throughout crime types (Coupe, 2014). Although there are some consistent findings such as suspect information, the external validity of these individual studies is somewhat limited by the respective samples and geographical placements, input (crime type) and output measures (detections, arrests). Thus, the nature of pickpocketing on the railway is likely to present distinct solvability factors. There is an absence of solvability studies upon pickpocketing, which creates a notable evidence gap. A greater understanding as to the nature of this crime type will focus attention upon the analysis of variables which may be of interest.

Pickpocketing on the Railway

Pickpocketing is defined as a stealth crime (Smith, 2008) which has afflicted the public for hundreds of years. In a study of Old Bailey cases from the late 19th century, Andersson (2014) noted several observations. Firstly, it was easy to steal from a person standing still, although the risk of apprehension was greater. Also, that increased crowding and interaction left targets open to distractions, where bumping in to people to disguise a theft can appear accidental. Newton *et al.* (2014) went on to analyse factors which encourage or reduce pickpocketing offences within London Underground stations. Although the focus of this study was similarly upon predictors of theft and not detection, Newton echoed previous findings from Andersson (2014) that concentrated congestion and high passenger density offered greater anonymity and therefore reduced the likelihood of apprehension. Factors which suppress the risk of theft such as higher staffing levels and fewer tourists are also likely to also encourage detections. A weakness of this study was the lack of data captured on visibility, lighting and CCTV of which there may have been a correlation with crime occurrence, solvability, or even both.

The tactics of pickpockets on the railway can include a single ‘dip’ into a bag or pocket; a group jostling the target; a distraction such as spilling a drink or even surrounding the target and slashing open a bag (British Transport Police, 2011). Anecdotally, pickpocketing offences can be solved through information received from CCTV or eyewitness accounts of the victim, witnesses or the police. However, a skilled pickpocket will deploy measures designed to ensure the offence goes unnoticed (University of Pennsylvania Law Review, 1955). It is often the case that a victim will notice their belongings are missing a considerable time after the theft has occurred and are subsequently unable to pinpoint the timeframe within close range. They may have travelled on various trains and through a number of stations. As well as distorting the accuracy of location based reporting, this scenario also impacts upon the secondary investigation, meaning specific CCTV footage is more difficult to obtain. Pickpocketing offences at BTP are concentrated to the morning and late afternoon peak travel times (Newton *et al., 2*014). The significant passenger congestion at these times further reduces both the opportunity for eyewitness accounts and meaningful CCTV evidence. For these reasons, it may be that case-limiting factors are more useful in the analysis of pickpocketing solvability.

Where there is an absence of research into pickpocketing solvability, the interplay between crime occurrence and solvability can be theoretically examined to establish potential leads for further analysis. One explanation as to the formulation of pickpocketing crime concentrations is Routine Activity Theory (Felson and Cohen, 1979). This theory argues that the dispersion of activities away from the home increases criminal opportunities, which occur only where motivated offenders, suitable targets and the absence of capable guardians converge in space and time. BTP's unique challenge stems from increased railway commuting year on year, involving the presence of increasingly high value 'targets' such as personal property, being brought onto the railway network. Exacerbating this, the routine activities associated with travelling naturally lead to passengers congregating in close proximity, which creates the opportunity for suitable pickpocket targets when converging with motivated offenders and a lack of capable guardianship. Even where capable guardians are present, they may be unaware of crime or reluctant to get involved (Reynald, 2009).

Criminal investigations have been known to exert deterrent effects (Maguire, 2003; Jansson, 2005). Deterrence is understood as the avoidance of action through the threat of adverse consequences (Bottoms and Von Hirsch, 2012). Celerity and severity of punishment is crucial, yet-alone this is not sufficient to produce deterrent effects (Durlauf and Nagin, 2011). The offender must *believe* that they will be apprehended and brought to justice. In particularly congested areas such as lifts and train carriages, the mask of the crowd is likely to reduce the perceived risk of adverse consequences. Similarly, in places across the transport network without overt CCTV, station staff or police officers, there is arguably a lack of capable guardianship. The question is not whether these factors would increase the likelihood of crime occurring, as this has already been well evidenced. Yet, to what extent does the perceived risk of apprehension relate to true apprehension? Would factors associated with increased levels of pickpocketing also suppress solvable cases? If so, one would expect to see more solvable cases present in less densely congested areas of the railway infrastructure or at times of the day with reduced passenger footfall.

Although inferences can be drawn from pickpocketing crime concentrations and underpinning theories, there has been no previous research into the solvability factors for pickpocketing offences. It is necessary to conduct further analysis to determine a targeting strategy for crime-screening and allocation of investigative resources. On the transport network pickpocketing occurs in high volumes, with a significantly low detection rate. These characteristics present considerable wasted efforts. Variables should be further tested where they have shown stronger effects across other crime types such as suspect information, number of witnesses, time of reporting etc. However, by considering the specific circumstances of railway pickpocketing it would also be of interest to consider whether the pickpocketing offence occurred on a moving train or a static platform, the congested nature of the location, type of property stolen, CCTV available, the range between committed times pinpointed by the victim and between committed and reported times. It is possible that a number of these circumstantial factors may exhibit relationships with the solvability of pickpocketing.

Categorising Inter-Variable Effects

Coupe (2014) makes the important distinction between circumstantial crime information and subsequent investigatory efforts. Assuming that secondary investigation has some impact upon a selection of cases, the true test of solvability must consider each link in the chain. This could go some way to explain inter and intra crime variance established amongst solvability factors. Demand and resources are critical inputs to the workload-detection model (Coupe, 2014) and the two can operate sequentially. Where investigative resources turn up further leads, both case solvability and subsequent resource investment are consequentially affected. The interplay between solvability factors and investigative efforts is of great interest during the holistic analysis of criminal investigations, yet research often neglects to appropriately combine or separate these elements. For screening model development, only circumstantial data should be considered as this is what would ordinarily be available to those making case-screening decisions. However, there is clear requirement to simultaneously understand the relationships between screening information and subsequent investigative activities.

During analysis it is important to consider inter-variable effects (Olphin, 2015). The presence of individual factors may have distinct effects from their mutual enforcement with other factors to produce combined effects. Although forest plots can display the effect size of each individual factor, they do not account for mutually reinforcing factors, which may have a combined influence on solvability. Binary logistic regression will control for these inter-correlations (Robb *et al., 2*014). Following the screening model development, it would be of interest to understand through hierarchical multiple regression which (if any) categories of investigative actions offer enhanced solvability benefits based on the combined strength of circumstantial factors.

Literature Summary

The evidence casts doubt over the efficiency of allocating equal effort across the broad spectrum of cases (Paine, 2012). The literature also demonstrates that analysis of solvability factors can allow case screening to identify a subset of cases which may be solved, far more accurately than using the intuition of practitioners. There is a clear opportunity to consolidate the learning from previous studies and develop an evidence-based predictive screening model through inputting a number of interacting solvability factors. Although there is a breadth of research into solvability factors which presents a starting point for variable effect size analysis, it cannot be assumed that these would be valid in application to pickpocketing on the railway. There is no published research analysing the strength of solvability factors specific to pickpocketing, which is something this study aims to address. There is still inadequate evidence surrounding the effectiveness of investigative action (Telep and Weisburd, 2012). Investigative action in relation to pickpocketing offences should be scrutinised in terms of their secondary relationship with solvability, controlling for the crime characteristics which dictate screening decisions. As this information is not readily available, it is necessary to derive a series of research questions to target the production and analysis of additional data to sufficiently fill the literature gaps.

Methodology

This chapter will outline the various analytical methods applied to address four specific research questions, designed to deliver targeted results.

1	Which factors available upon **initial assessment** indicate a greater likelihood for solving pick-pocketing offences?
2	Can the solvability of pick-pocketing be predicted by a **screening model** developed from analysis of the initial assessment factors?
3	How does the **predictive accuracy** of this screening model compare to that of BTP's existing decision making process for case screening?
4	During the **secondary investigation**, is there evidence to suggest that the volume of investigative actions would indicate a greater likelihood of pick-pocketing offences being solved?

Table 1: *Research Questions*

These methods include individual statistical tests upon solvability factors, multicollinearity analysis, binary logistic regression, testing for predictive accuracy, individual statistical tests upon secondary investigative action volumes and hierarchical multiple regression. Before the analytical methods can be outlined, it is necessary to clarify terminology, data sources and research design.

Points of Clarification

It is important to clarify the terminology contained within each research question. Solvability is defined as *"the ease with which offences may be solved and whether or not it is possible to solve them."* (Robb *et al., 2*014, p.2). The evidence base of solvability research is broad, including the definitions by which crimes are deemed 'solved'. Whereas older studies used 'clearance' or 'arrest' as an outcome measure of solvability, it is not uniform across agencies (Chaiken *et al., 1*976; Sherman and Glick, 1984). For the purposes of this study, solvability will be measured by the closure of each case through a positive outcome (detection). Arrests were discounted as a measure due to the attrition between arrest and positive outcome, with the threshold being 'reasonable suspicion'; lower than that of any formal sanction. Relying on arrest data could impact upon the threat of adverse consequences and therefore deterrence (Bottoms and Von Hirsch, 2012). Pickpocketing is a colloquialism, defined as 'Theft from the Person' and is coded specifically on BTP systems in line with the Home Office Counting Rules (**Appendix A**; Home Office, 2016). 'Positive Outcome', is a term which only applies in England and Wales and refers to crimes which result in an outcome ranging from C01 to CO9 inclusive. As BTP also has jurisdiction over railways in Scotland, the closest comparable measure to a Positive Outcome would be a 'Scottish Detection', ranging from Det1 to Det9 inclusive. All eventualities which would be deemed 'solved' for the purposes of this study are shown in **Appendix B.**

Data Sources & Research Design

Considering the aforementioned research gaps, it is necessary to generate additional data for analysis to address the research questions. The data required for this study is recorded, stored and controlled by BTP, held in the CRIME system. The crime details are initially recorded by First Contact Centre staff after which the crime is transferred to the CMU for initial assessment and screening decision. Crime which is screened in for secondary investigation will also be formally disposed of by the CMU, either through a positive outcome (solved) or otherwise (not solved). The handling of crime data in this regard is governed by stipulations within the Home Office Counting Rules (Home Office, 2016). Statistical power is the probability of identifying a statistically significant result (Cohen, 1988). The sample size must be sufficient to detect small variances with high significance levels. Data from the CRIME system is available for all pickpocketing offences over a period of at least five years (36,260 cases). This provides very high statistical power for observation, even when split into two equivalent groups.

An initial five year data extraction of all pickpocketing crime will ascertain the most appropriate points in time from which to draw the sample. This step is critical to ensure the study can state with confidence that the solvability of offences is not a result of insufficient time to investigate before the data were drawn from CRIME. The time taken to achieve a solved pickpocketing offence are broken down in days, as illustrated within **Appendix C**. To keep the cases for inclusion as recent as possible to ensure time-bound relevance, yet without significant proportions of incomplete cases, 310 days is set as the delay from crime reports to data extraction. This means that instead of using five years' data from the day of extraction, the time window (considering the 310 day delay) will be between 1st September 2010 and 31st August 2015. At this point, one can be confident that approximately 95.3% of all pickpocketing cases will be completed and disposed as either solved or not solved.

The data in question includes several CRIME fields, categorised as offence details; victim and witness details; property details; crime management and case statistics. Where possible, categorical and binary fields have been used to obtain the data, as some fields are coded as 'free text' which creates complications during quantitative analysis. Each offence has a unique CRIME reference number which were extracted against all data fields belonging to the specific references. These were merged into a single Excel spreadsheet along with the case outcome. Crime management systems are not built for research purposes and often neglect to store important solvability information (Burrows *et al., 2*005). As historic data is being used, the greatest constraint will be the fields available in CRIME. The accuracy of this data is further limited by human error. Any errors made during data entry would affect the results. To mitigate this, the data has been manually cleansed to remove outliers likely to be a result of human error, before any statistical tests can be performed.

After the data has been cleansed to preserve accuracy, it was coded in preparation for SPSS tests and where variable categories contain counts too low for meaningful analysis, categories were aggregated into larger groups. The new groups and their previous categorical contents are documented, as this information would be needed to break down elements of the screening model to potential users. For instance, 'Commercial Property' as a location would draw from a number of related CRIME inputs. The CMU would need to have a record of what these inputs could be to ensure accurate usage of any subsequent statistical screening methods. The final stage ahead of analysis was the randomisation of the entire dataset into two groups; Analysis and Testing. *"Selection bias occurs when the researcher chooses non-equivalent groups for comparison"* (Hagan, 1997, p.84). To ensure selection bias did not influence the results, each case was randomly allocated into the group for Analysis or Testing using SPSS. Chi-square tests confirmed that both groups were not significantly different in either screening decisions (p=0.415) or case outcomes (p=0.734) and therefore were appropriate comparators. From this point forward until the Assessing Predictive Accuracy section, the methodology will set out implementation steps using only the Analysis group of 18,038 crimes.

Solvability Factors in Scope

A series of fields were determined to contain usable data from the CRIME system. This was a combination of ordinal, nominal and continuous data and could be re-categorised to better understand the most powerful indicators of solvability within each field. The final factors of interest are derived from the literature review and system interrogation. These factors subject to the further statistical analysis are detailed along with their descriptions in **Table 2**.

Factor	Description	Categories
Sub-Division	Geographical location of crime	Scotland
		East
		West
		Midland
		Pennine
		Transport for London (TfL)
		South
		Wales
Journey Type	Whether the crime occurred on a moving train between two stations, or was it static on the train or within the confines of a station	Static
		Moving
Location Type	Irrespective of geographical location, type of location in which the crime occurred	Inner Station
		Commercial Property
		Concourse/Outside Station
		Platforms
		On Train
Time of Offence	The time of day the offence was committed	Morning (06:00-11:59)
		Afternoon (12:00-17:59)
		Evening (18:00-21:59)
		Night (22:00-06:00)

Season	The time of year the offence was committed	Spring (March-May)
		Summer (June-August)
		Autumn (September-November)
		Winter (December-February)
Victim Age	Victim age at the time offence was committed	N/A – **CONTINUOUS**
Victim Gender	Gender by which the victim identifies	Male
		Female
Victim Intimidated	Whether there is information to suggest that the victim is intimidated	Yes
		No
Victim Vulnerable	Whether there is information to suggest that the victim is vulnerable	Yes
		No
		No
Offence Witnessed	The presence of at least one witness statement linked to the offence	Yes
		No
Property Value	What is the monetary value of stolen property	N/A – **CONTINUOUS**
Property Value over £500	Monetary value of the property over £500	Yes
		No
Phone or Electronic Device Stolen	The stolen property defined as either a mobile phone or any other variety of electronic device	Yes
		No
CCTV Available	CCTV available which would cover the place and time the offence took place	Yes
		No
Alcohol or Drugs Involved	The presence of either an alcohol or drugs marker connected to the offence	Yes
		No
Additional Suspects	The presence of more than one suspect connected to the offence	Yes
		No
Suspect Description	Descriptive information available on the system, in any category	Yes
		No
Suspect Gender	Gender by which the suspect is described	Male
		Female
Delay from Reported to Committed	The time delay between when the offence was committed and when it was reported to BTP	Within 1 Hour
		Within 24 Hours
		Within 1 Week
		CONTINUOUS also available
Committed Range	The time range between which the victim believes the offence occurred	Exact Time Known
		Less than 5 Minutes
		Less than 10 Minutes
		Less than 15 Minutes
		Less than 20 Minutes
		Less than 25 Minutes
		Less than 30 Minutes
		Less than 45 Minutes
		Less than 60 Minutes
		Less than 120 Minutes
		CONTINUOUS also available
Victim Ethnicity	The ethnicity of the victim	Asian
		Black
		Mixed
		Chinese
		White
		Other
Suspect Age	The age of the suspect described by the victim	N/A - **CONTINUOUS**

Table 2: *Solvability Factors for Analysis*

Statistical Tests for Solvability Factors

It is necessary to understand where the presence of each factor available upon initial assessment is evident in both solved and not solved cases. The individual statistical tests performed were dictated by the nature of each independent variable. For categorical variables with two or more groups, their relationship with case solvability is analysed through chi-square tests. With such a large sample, this is supplemented with Phi (binary) or Cramer's V (multiple) to present the effect of the relationship where p values are universally high. This was the process followed for the majority of variables. However, where the independent variables are continuous, it is necessary to consider independent-samples t tests to examine significance. During the satisfaction of assumptions for t test, the skewness and kurtosis of the data were assessed. Where the skewness was outside the range of ±2 and kurtosis outside of ±7, it can be established that the data were not normally distributed. Therefore, non-parametric Mann-Whitney U tests were applied to the relevant independent variables. This significance level reported from each test must be <p=0.05 to conclude the solvability factor has a relationship with the positive outcome rate which cannot be due to chance factors.

It is anticipated that some factors may have a stronger influence than others. *"When a factor occurs more frequently in solved than unsolved cases, there is a higher positive standard difference in the means of the solved and unsolved cases"* (Robb *et al., 2*014; p7). Following application of the initial statistical tests, it is necessary to consider the magnitude of each variable's effect on the positive outcome rate; the dependent variable. The standard difference in means for each factor's effect will be organised by strength and presented in a forest plot. This will mark the completion of the first research question, determining the effects of individual factors upon pickpocketing solvability. However, the individual factor analysis does not control for inter variable effects. Where independent variables are highly correlated with each other, this must be understood and adjusted for in order to report the precise relationships between each factor and case solvability.

Binary Logistic Regression

To satisfy the second research question concerning the development of a screening model, the independent factors must first be consolidated into a usable format where they can become predictors of solvability. As the dependent variable in this study is dichotomous, binary logistic regression can be used. This methodology aims to predict the outcome of the dichotomous dependent variable through assessing the values of a combination of independent variables; assuming independence of errors and multicollinearity. As each of the 18,069 cases are unrelated, the independence of errors assumption has been satisfied. The next phase is to review multicollinearity statistics to understand where independent variables are highly correlated with each other. Variance Inflation Factors (VIF) is an important step during linear regression which measures the extent of regression coefficient variance inflation compared to circumstances where the independent variables are not linearly related. This can affect the statistical power of the regression model and it may be necessary to remove variables highly correlated with each other to ensure precision. With an understanding of where multicollinearity is high within pairs, a policy decision must be made to remove one factor. Considerations could be based upon the practical application of the ultimate screening model. Ahead of regression, it is also necessary to remove variables with large quantities of missing data. Presence of such variables will negatively impact the significance of the model.

There are a range of logistic regression input methods to consider. Stepwise forwards methods add independent variables to the equation at each block, whereas stepwise backwards methods remove independent variables at each block. As these methods will automatically compute important decision points, this can negate the more subjective policy considerations required with the intent of a usable screening model for crime allocation. For this reason, the 'enter' method has been established as the most suitable. This allows a bespoke combination of variables to be input into the regression model, cognisant of the end objective to develop a powerful and pragmatic system to predict case solvability.

Predicting Solvability

Once the most suitable model has been established the B coefficients will be reviewed for each factor. These are the coefficients of the constant in a null model known as log-odds units and predict the extent to which the crime is likely to be solved or not. The B coefficients for each factor in the regression model will be input along with the constant into a logit formula, where p is the probability of the pickpocketing offence being solved:

$$\mathbf{logit(p) = b0 + (b1 \times X1) + (b1 \times X1) + (b2 \times X2) + (b3 \times X3) \ldots (+bn \times Xn)}$$

As the output from this formula will be reported on a linear scale for each case, it cannot be directly applied to dichotomous screening decisions. To supplement this formula, a decision must be made as to which cut off point will determine whether a case is screened in and investigated further or screened out and closed. Instead of completing this using statistical methods, the cut-off point must be viewed as a critically important policy decision. It should be informed by the organisation's appetite for false negatives and false positives within any given crime type. If the cut off point for screening in is set too low, there would be a significant false positive rate where more cases are screened in yet never solved, creating wasted effort. Conversely, if the cut-off point is too high, there would be a greater false negative rate where more cases would be screened out even if they had potential to be solved. Due to the subjective considerations surrounding the point at which to screen in or out, this value is determined by the researcher for the purposes of completing the regression model. Although the predetermined cut-off score is set at a static level for the purpose of testing, in wider police practice this could vary through a linear relationship to the resourcing levels available (Eck, 1979).

A statistical screening model cannot account for every eventuality within policing. There will be circumstances in which it is felt that through a broader duty to society, a crime must be investigated irrespective of the logit score. In addition to the factors contributing towards the final regression model, it may be necessary to introduce automatic screen-in factors (Olphin, 2015). This allows the model to be flexible to operational and societal pressures such as perceived harm or reputational risk, which cannot be quantified through crime data. These factors would not affect the regression equation but would sit underneath the screening model and where present would ensure the case is automatically screened in for investigation. The complete screening model inclusive of the solvability factors and automatic screen-in factors would satisfy the second research question. At this point, it must be assessed for predictive accuracy. If the model is less accurate than the current practice, it would not be deemed operationally viable.

Assessing Predictive Accuracy

Statistical modelling is derived from data contained within the Analysis group; the half-dataset used to identify solvability factors. The other half-dataset is the Testing group. This group consists of a random, fresh selection of comparable cases and will be used to test the predictive accuracy of the derived model, enhancing data reliability. Therefore, the logit formula inclusive of the determined cut-off point will be applied to each case within the Testing group. The model output will determine whether the case would be screened in or out, which will be contrasted against whether or not the case was eventually solved. Alongside the assessment of the predictive model, further analysis will establish whether each case was screened in or out by the CMU over the past five years and which of those subsequently went on to be solved or not. By following Eck's (1979) Screening Model Accuracy assessment, both models will be compared. This will categorise results into the false positive rate for cases screened in which did not lead to a positive outcome (wasted efforts) and false negative rate for cases screened out where a true positive outcome was achieved (missed opportunity). The overall accuracy of both statistical and intuition based systems will then be compared. This will satisfy the third research question.

Statistical Tests for Investigative Actions

The analysis up to this point concern the moment a crime is reported up until an allocation decision is made. Understanding the relationship between actions taken during the secondary investigation and subsequent solvability would provide a critique to the value of this resource. The data for investigative efforts bring a new set of limitations. The breakdown of the type of investigative actions taken is contained within over 300,000 free text boxes associated with the population of cases. However, it is possible to extract the volume of investigative actions under each of the categories outlined in **Table 3**.

Category	Description
Investigation	Actions uploaded in connection to specific investigation tactics, could include obtaining CCTV, checking lost property store etc.
Victim	Actions uploaded in connection to victim support, could include contacts made, statements taken etc.
Case	Actions uploaded in relation to the ongoing case progression, could include file preparation, charging advice etc.
Supervisory	Actions uploaded in relation to the supervision of the case, could include investigation plans, supervisor direction etc.
Total	Total count of actions inclusive of all above categories.

Table 3: *Secondary Investigative Action Categories*

This limitation means that analysis of investigative actions cannot account for the quality of investigation or exact tactic undertaken by the detective. Presenting the volume of actions against each case presents further limitations. If a case shows multiple actions under the 'victim' category, it does not necessarily follow that the victim has been contacted multiple times. It could be that attempts have been made with no response or that the investigator is simply using multiple entries to detail information which would ordinarily be contained within a single entry. As the investigative action fields are used in a variety of ways, it will limit the inferences which can be drawn. However, this data will be used as a crude estimate of work effort during the secondary investigation.

The actions will be extracted against each case by the count within each category and also the total count. This will be for the entire dataset of 36,260 cases. Descriptive statistics will be reviewed for this data to understand the distribution. Dependent on the distribution of data, t-tests or Mann-Whitney U tests will be applied to each category to report the relationship between the volume of actions and whether the offence was solved, both in terms of significance and magnitude. Following the tests upon the entire dataset, the same method will be applied only to those cases screened in by the statistical model. This will control for those cases which the model would screen out, as the value of secondary investigation for these crimes is arguably of less interest from a policy perspective. Finally, to test the whether the combined influence of solvability factors and investigative effort offer any predictive advantage in terms of solvability, hierarchical multiple regression will be undertaken for the entire population. The pre-determined hierarchical ordering of data during the regression processes allows the supplementary predictive power of secondary investigations to be established, when controlling for the pre-existing solvability factors based on crime circumstances. This closing analytical step will satisfy the final research question.

Results

This chapter will present the results of the methodological application described in the previous section. The data will be introduced in a systematic approach in line with each of the four questions. To begin, an analysis of the relationship between the individual factors and solvability in terms of both their statistical significance and effect is presented. Research decisions are justified as to the exclusion and inclusion of these factors into a binary logistic regression exercise, resulting in the presentation of a statistical screening model. Automatic screen-in factors are identified and used to supplement the screening model, after which the predictive accuracy is contrasted with that of BTP's current intuition based screening processes. Finally, the secondary investigative actions are scrutinised for their relationship with solvability, both for the entire population and a sample limited to cases screened in by the model.

Solvability Factor Analysis

As a proportion of the solvability factors studied were coded as continuous data, the mean and mean ranks of the data were respectively compared. Where the relevant assumptions are satisfied, independent-samples t tests were used to test for significance. **Figure 1** presents the results of t tests upon the age of the victim and that of the suspect (where provided by the victim or witnesses). The suspect age is often given in a range, which is assessed along with the mean of that range, against their relationships with solvability.

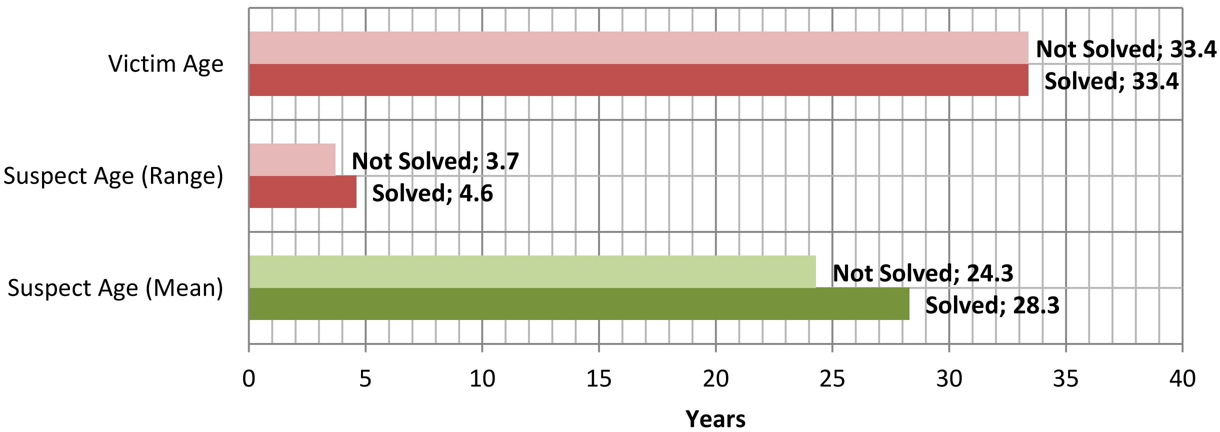


Figure 1: *Independent-Samples T Test Results*

There was no statistically significant difference in the victim age between the solved (M=33.37, SD=14.508) and unsolved (M=33.38, SD=13.777) cases; t (17052) = -0.02, p=0.985. There was also no significant difference in the suspect age range provided by the victim, between the solved (M=4.57, SD=4.178) and unsolved (M=3.67, SD=3.501) cases; t (328) = 1.558, p=0.120. However, there *was* a statistically significant difference in the mean suspect age between the solved (M=28.3, SD=9.8) and unsolved (M=24.3, SD=7.767) cases; t (18037) = 2.935, p<0.001; Cohen's d = 0.449. After reviewing the suspect mean age distribution, a new category of 'Suspect Age under 30' was created for categorical analysis.

In some instances, the data does not follow a normal distribution and therefore Mann-Whitney U tests were applied. During the review of descriptive statistics, the property value; time delay between committed and reported and the time range over which the offence took place all showed unacceptable levels of skewness or kurtosis. **Figure 2** presents the results of Mann Whitney U tests performed upon these factors.

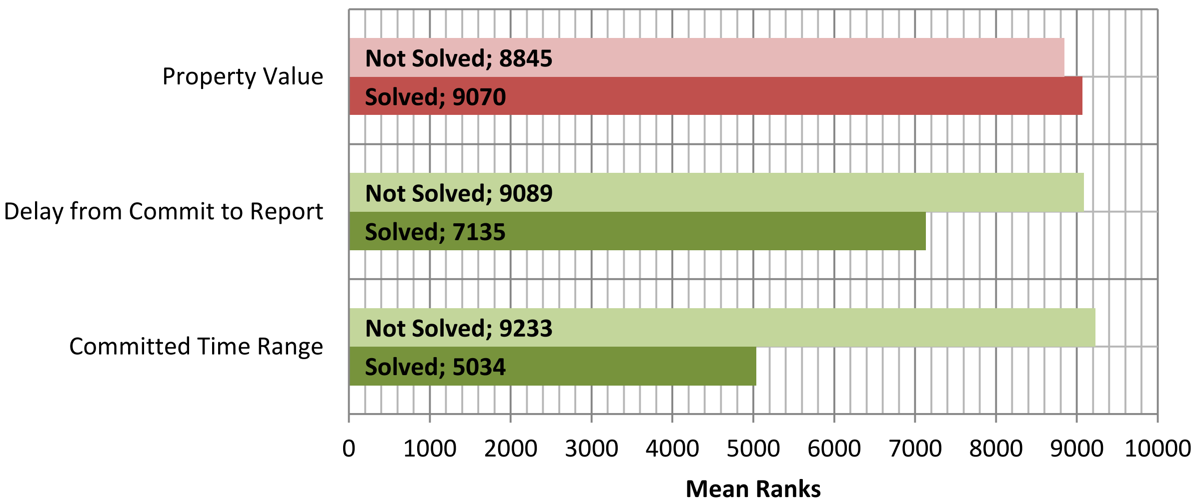


Figure 2: *Mann-Whitney U Test Results*

The property value showed no statistically significant difference between the solved and not solved cases; U=6,237,234.5, p=0.236. However, the time delay from committed to reported was statistically significantly *higher* in the not solved cases than in the solved cases; U=6,084,545, p<0.001. Further to this, the time range was also significantly *higher* in not solved cases than in solved cases; U=4,178,516, $p<0.001$. As significant correlations were established, the data were subsequently categorised within both the delay from committed to reported category and the committed time range.

The new solvability categories developed as a result of the analysis of continuous datasets will supplement the existing nominal and ordinal data. The results of chi square tests are shown in **Figures 3** and **4**, along with the percentage of cases solved and not solved within each category.

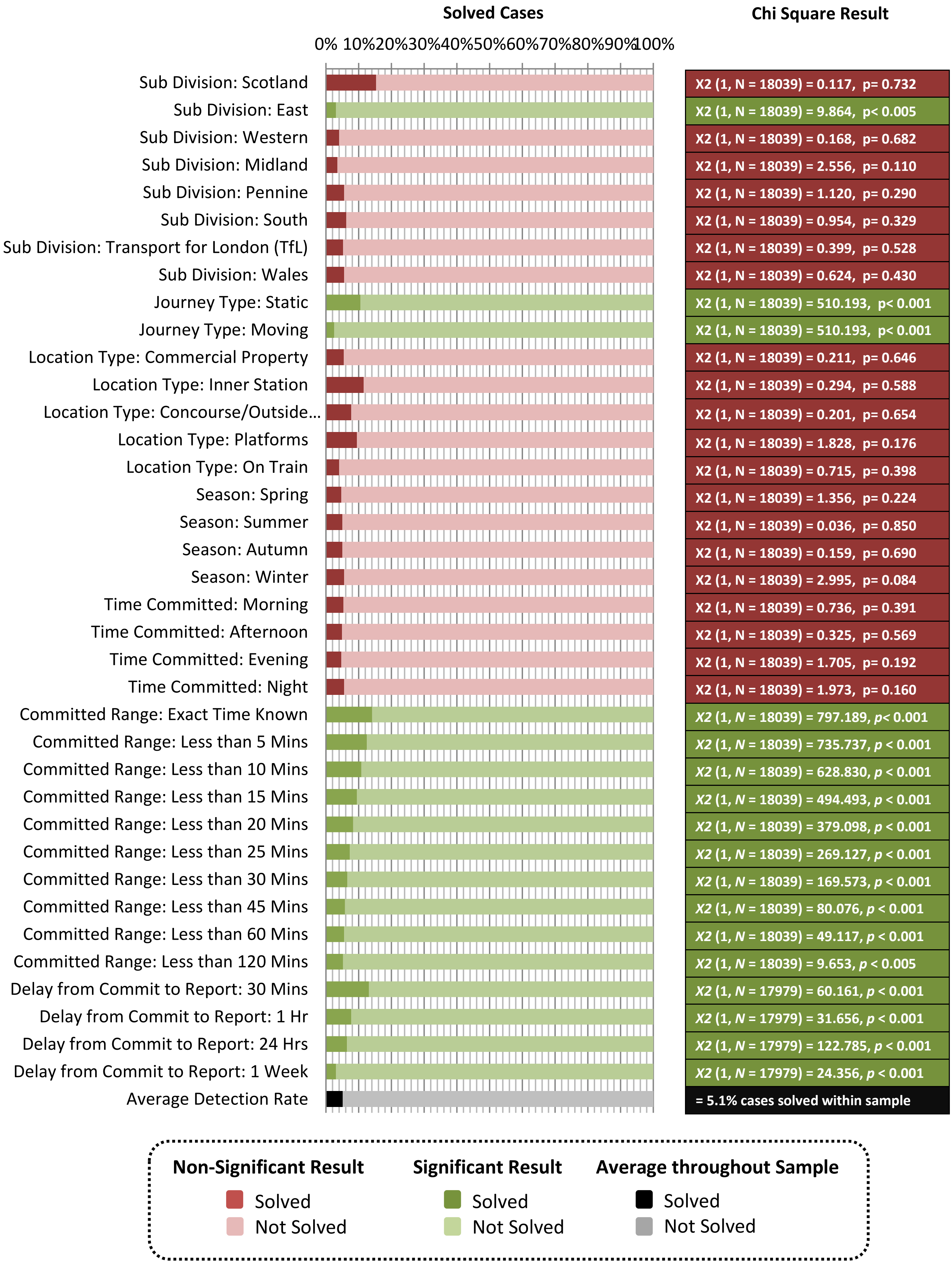


Figure 3: *Chi Square Tests: Place and Time*

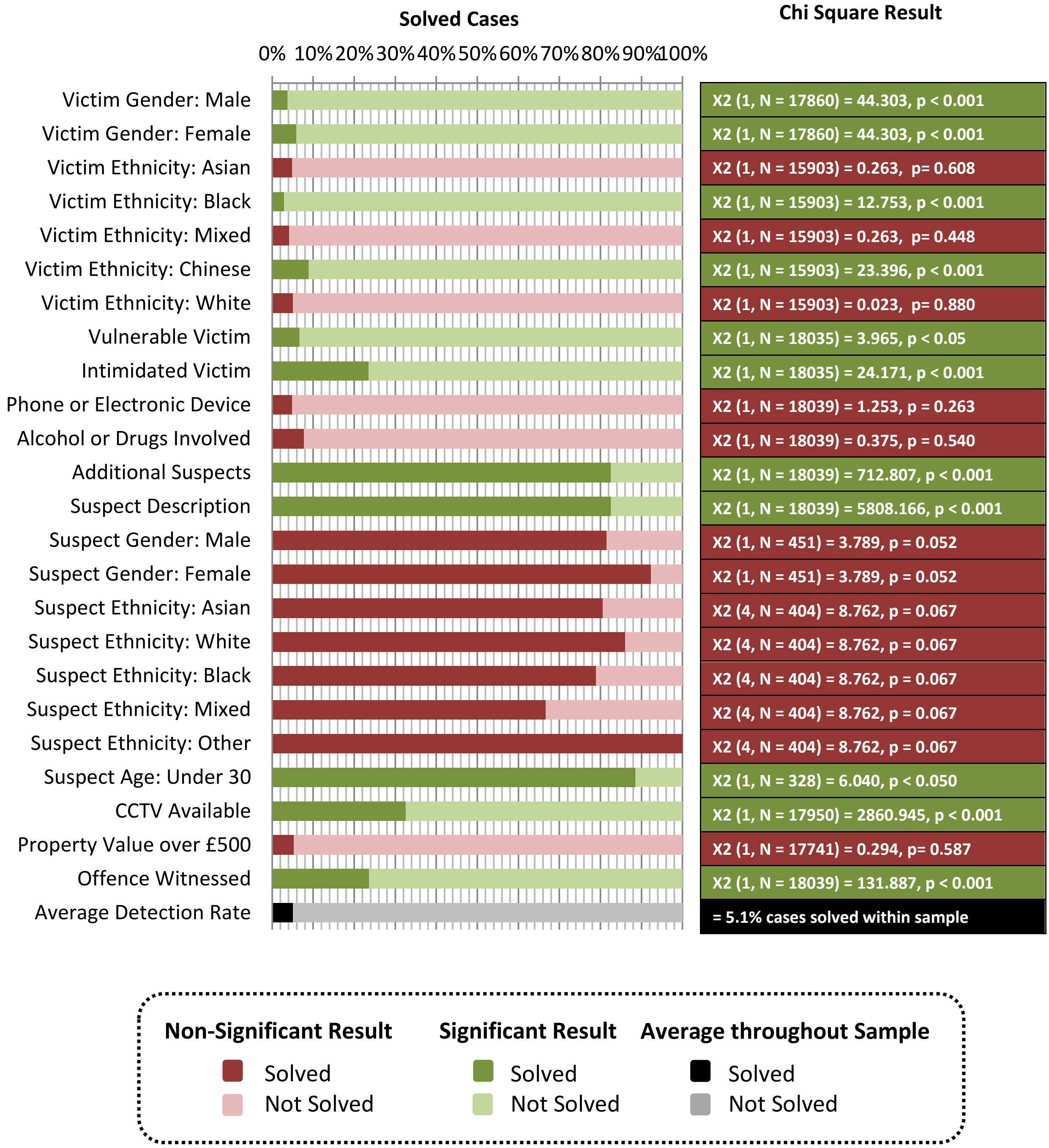


Figure 4: *Chi Square Tests: Victim, Suspect & Property*

When tested individually, 29 out of the 63 categorical independent variables report a statistically significant relationship with solvability. Negative indicators of solvability include the offence taking place on Sub-Division East; on a train between stations; waiting up to a week to report the crime; or the presence of a victim who identifies as either Black or male. Factors positively correlated with solvability include static offences; a committed time range of less than two hours; the victim reporting the crime within 24 hours of it occurring; the victim themselves being vulnerable, intimidated or identifying as female or Chinese; the offence being witnessed by at least one person other than the victim; CCTV available; the presence of a suspect description, named suspect, additional suspects or the suspect's age described as under 30. In addition to the significance of these relationships, it is also important to understand their respective magnitudes. The standard difference in means is presented as a forest plot in **Figure 5** overleaf.

Solvability Factor	Odds Ratio	Lower Limit	Upper Limit	Std. Diff in Means	Standard Error
Suspect Gender: Male	0.366	-1.133	0.025	**-0.554**	0.296
Suspect Ethnicity: Mixed	0.397	-1.000	-0.018	**-0.509**	0.251
Victim Ethnicity: Black	0.544	-0.523	-0.149	**-0.336**	0.095
Victim Gender: Male	0.619	-0.343	-0.186	**-0.264**	0.040
Sub Division: Wales	0.631	-0.889	0.382	**-0.254**	0.324
Sub Division: East	0.705	-0.313	-0.072	**-0.192**	0.062
Suspect Ethnicity: Black	0.709	-0.483	0.105	**-0.189**	0.150
Victim Ethnicity: Mixed	0.836	-0.356	0.157	**-0.099**	0.131
Suspect Ethnicity: Asian	0.872	-0.554	0.403	**-0.075**	0.244
Sub Division: Western	0.875	-0.425	0.278	**-0.074**	0.179
Time Committed: Evening	0.901	-0.144	0.029	**-0.058**	0.044
Season: Spring	0.910	-0.139	0.035	**-0.052**	0.044
Phone or Electronic Device	0.926	-0.116	0.032	**-0.042**	0.038
Location Type: On Train	0.941	-0.112	0.044	**-0.034**	0.040
Victim Ethnicity: Asian	0.944	-0.152	0.089	**-0.032**	0.061
Time Committed: Afternoon	0.961	-0.098	0.054	**-0.022**	0.039
Season: Autumn	0.970	-0.101	0.067	**-0.017**	0.043
Season: Summer	0.985	-0.096	0.079	**-0.008**	0.045
Victim Ethnicity: White	1.012	-0.081	0.094	**0.007**	0.045
Sub Division: Transport for London	1.045	-0.051	0.100	**0.024**	0.039
Property Value Over £500	1.046	-0.065	0.114	**0.025**	0.046
Location Type: Inner Station	1.066	-0.091	0.161	**0.035**	0.065
Location Type: Concourse/Outside Station	1.067	-0.120	0.191	**0.036**	0.080
Time Committed: Morning	1.070	-0.048	0.123	**0.037**	0.043
Location Type: Commercial Property	1.095	-0.163	0.263	**0.050**	0.109
Sub Division: South	1.096	-0.051	0.152	**0.050**	0.052
Season: Winter	1.140	-0.010	0.154	**0.072**	0.042
Sub Division: Scotland	1.143	-0.349	0.496	**0.074**	0.215
Time Committed: Night	1.143	-0.029	0.177	**0.074**	0.053
Sub Division: Pennine	1.154	-0.067	0.225	**0.079**	0.075
Location Type: Platforms	1.189	-0.043	0.234	**0.095**	0.071
Sub Division: Midland	1.358	-0.039	0.376	**0.169**	0.106
Vulnerable Victim	1.364	0.002	0.340	**0.171**	0.086
Alcohol or Drugs Involved	1.564	-0.549	1.043	**0.247**	0.406
Delay from Commit to Report: 1 Hour	1.672	0.184	0.383	**0.283**	0.051
Suspect Ethnicity: White	1.704	0.007	0.580	**0.294**	0.146
Victim Ethnicity: Chinese	1.921	0.212	0.508	**0.360**	0.076
Delay from Commit to Report: 1 Week	1.993	0.226	0.534	**0.380**	0.079
Committed Range < 120 Mins	2.044	0.140	0.648	**0.394**	0.130
Suspect Age: Under 30	2.218	0.083	0.795	**0.439**	0.182
Delay from Commit to Report: 24 Hours	2.322	0.380	0.549	**0.464**	0.043
Committed Range < 60 Mins	2.485	0.357	0.647	**0.502**	0.074
Suspect Gender: Female	2.732	-0.025	1.133	**0.554**	0.296
Committed Range < 45 Mins	2.880	0.450	0.717	**0.583**	0.068
Delay from Commit to Report: 30 Mins	2.955	0.439	0.756	**0.597**	0.081
Suspect Ethnicity: Other	3.285	-0.929	2.240	**0.656**	0.808
Committed Range < 30 Mins	3.432	0.571	0.788	**0.680**	0.055
Committed Range < 25 Mins	4.114	0.679	0.880	**0.780**	0.051
Journey Type: Static	4.475	0.749	0.904	**0.826**	0.040
Committed Range < 20 Mins	4.574	0.747	0.930	**0.838**	0.047
Committed Range < 15 Mins	5.071	0.808	0.982	**0.895**	0.044
Committed Range < 10 Mins	5.523	0.861	1.024	**0.942**	0.042
Committed Range < 5 Mins	5.741	0.886	1.041	**0.963**	0.039
Intimidated Victim	5.812	0.532	1.409	**0.970**	0.224
Committed Range: Exact Time Known	5.886	0.902	1.053	**0.977**	0.038
Offence Witnessed	6.040	0.799	1.184	**0.992**	0.098
CCTV Available	20.718	1.591	1.751	**1.671**	0.041
Additional Suspects	92.893	2.120	2.877	**2.498**	0.193
Suspect Description	149.73	2.620	2.903	**2.762**	0.072
Fixed	N/A	0.338	0.368	**0.353**	0.008

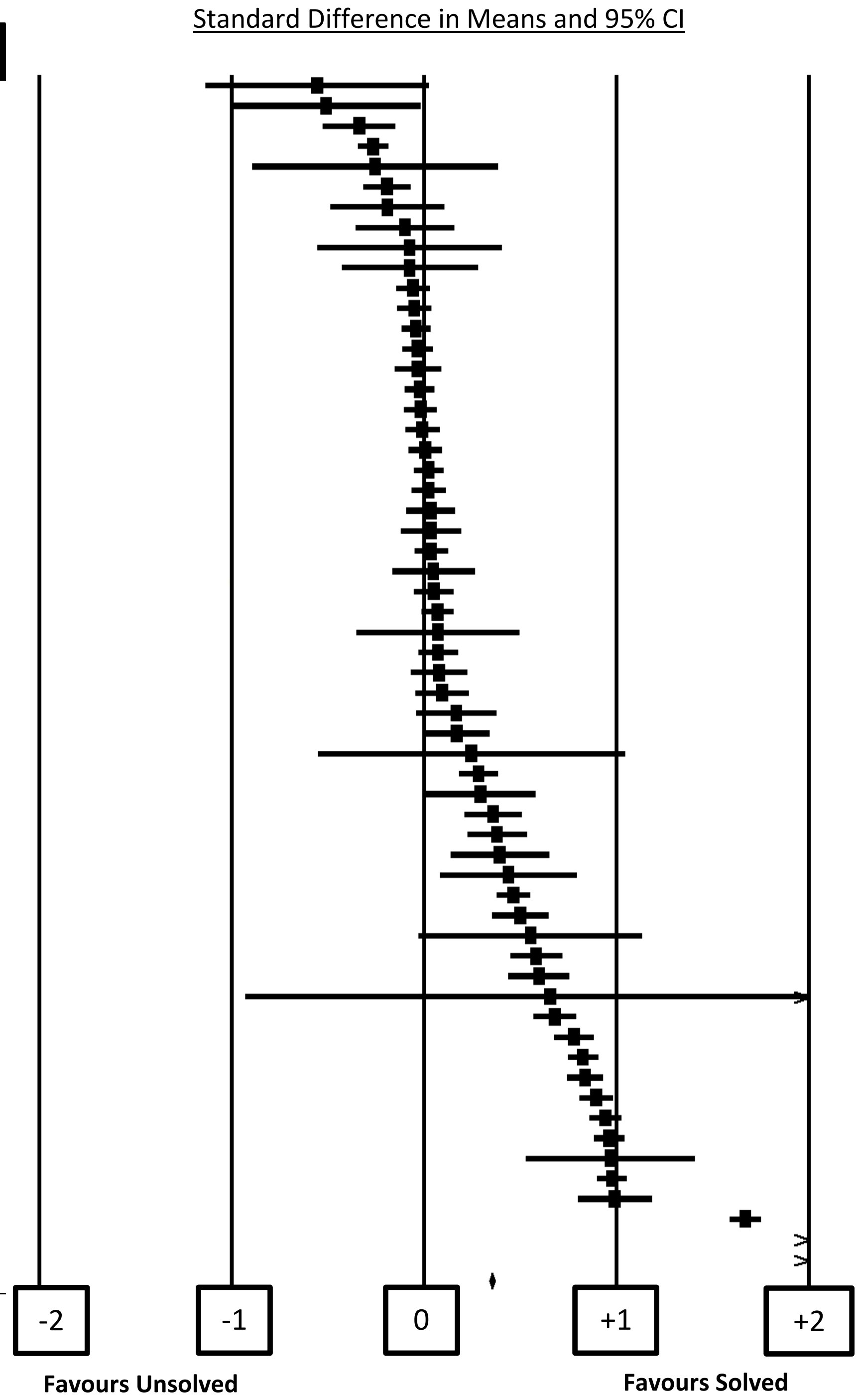


Figure 5: *Forest Plot Presenting Standard Difference in Means*

The forest plot presents the standard difference in means between the two groups against a 95% Confidence Interval (CI). It shows that the strongest positive predictors of solvability include the presence of suspect information including descriptions and additional suspects. Where the suspect's age is described as under 30, the offence is twice as likely to be solved as with older suspects. The presence of witnesses and CCTV are also strong predictors. Where CCTV is available to assist the investigation, the offence is over 20 times more likely to be solved than if no CCTV is available. The committed time range given appears to share a linear relationship with solvability, with reduced time windows reporting greater differences between solved and unsolved cases. This is also the case for any delay leading up to the offence being reported, with shorter intervals associated with a greater likelihood of solvability. Throughout the individual analysis, the season or time of day appear to have no significant upon pickpocketing solvability, as with the majority of geographic locations.

Negative predictors include the suspect being identified as male, although despite the strength of effect this is not a significant relationship at a 95% CI due to the limited sample of suspect descriptions available. With male suspects, the pickpocketing offence is almost 3 times less likely to be solved than with female suspects, despite males constituting 88.5% of all suspects. Where the victim identifies their ethnicity as Black, the offence is over 60% less likely to be solved than those cases involving victims of other ethnicities. The offence location entered as Sub-Division East also presents a significant and relatively strong inverse relationship with solvability. Wales and Western Sub-Divisions are also presenting as negative predictors, although these effects are not significant. In summary, the aforementioned analysis describes the factors available upon initial assessment and their respective relationships with the solvability of pickpocketing cases.

Although individual factor analysis shows the significance and magnitude of each relationship, it does not account for the interaction effects of other independent variables. For instance, a case with the presence of additional suspects reports as 93 times more likely to be solved than a case without additional suspects. However, it is implied that for additional suspects to be present, there must already be at least one suspect description available. The analysis does not control for this interference and so in this case it is highly possible that the presence of any suspect information at all is distorting the effect. It is necessary to understand the true isolated effects of these factors before making predictive assessments upon solvability. The following section will present the results of binary logistic regression, which will isolate these effects.

Predictive Modelling

Multicollinearity is assessed using the VIF measure for the variance of regression coefficients for each independent variable. The lower the variance, the easier the coefficients are to interpret as they are more stable. Linear regression is performed to understand these relationships and removes inappropriate variables list-wise. Due to their VIF score above 10 and subsequent interference with the remaining variables, a number of factors were removed. These included the offence taking place in the afternoon; winter; on Sub Division South; and where the victim's ethnicity was defined as Black, Mixed, Asian or White. The suspect related variables such as their gender, age under 30 and ethnicity were displaying high correlations with the presence of a suspect description. For this reason it was necessary to make a policy decision as to which factors would be removed from the model ahead of applying the logistic regression. As suspect description is more prevalent in the sample than any of its sub-categorical successors, including this at the expense of the other factors would bring more power to the predictive model; whist the difference in effect is negligible. With these factors removed the resulting VIF values are acceptable for each remaining factor, as shown in **Appendix D.**

Unlike previous research, the ultimate aim of this regression is to produce a best-fit, operationally viable model producing accurate solvability predictions. The independent variables are simplified into a single indicator for each category. This reduces crossover in entry. For example, if the committed time range is less than 45 minutes, it would also be less than 30 minutes and so on. A time range of less than 15 minutes was selected for inclusion which presented the optimum balance between strength of effect, cases where the factor is present and significance. When entering variables into the regression model, different combinations were considered. Insignificant factors from the previous individual analysis were not categorically discounted as when the influence of all others was controlled for through regression, they would often show significance. To develop the most powerful model, a number of variable combinations were tested to achieve balance between a high Nagelkerke R square value to explain greater variance, individual significance of the selected factors and complete model, and the percentage of correct classifications the model provides in both solved and unsolved groups. As the objective of this regression is to produce a predictive model which is operationally viable, establishing the most powerful and suitable combination of variables is the priority. The final model is shown in the logistic regression output at **Table 4.**

Variables in the Equation									
		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
								Lower	Upper
Step 1[a]	[redacted]								

Table 4: *Logistic Regression Output: Predictive Screening Model*

There are 10 solvability factors which constitute the final model. [redacted] Out of the 10 factors included in the model, 7 reported individual significance at a 95% CI. Out of a possible 18,039 cases in the analysis group, 17,773 were included in the regression (98.5%). The regression model analysis will compare the results of a baseline model with that of the constructed model.

Table 5 reports that if each case was predicted to be not solved, the baseline model would be correct in 95% of cases. This is due to the low detection rate for pickpocketing and would be problematic in practice as it would screen out all cases.

	Observed		Predicted		
			Positive Outcome		Percentage Correct
			Solved	Not Solved	
Step 0	Positive Outcome	Solved	0	885	.0
		Not Solved	0	16888	100.0
	Overall Percentage				95.0

Table 5: *Classification Table: All Cases Screened Out*

To compare the constructed model's fit with that of the baseline model; the Omnibus Test of Model Coefficients uses chi-square tests to note any difference between the log-likelihoods of each model. It tests the assertion that both the intercept and coefficients are zero, as the null hypothesis. **Table 6** indicates that the null hypothesis can be rejected in this case as the relationship is significantly different: X2 (10, N = 17,773) = 2,722.6, p<0.000).

		Chi-square	df	Sig.
Step 1	Step	2722.566	10	.000
	Block	2722.566	10	.000
	Model	2722.566	10	.000

Table 6: *Omnibus Test of Model Coefficients*

Table 7 indicates the extent to which variance in outcomes can be explained through the model. Considering the Nagelkerke R Square score, it can be determined that the predictive model accounts for approximately 43.5% of the variance in solved and unsolved cases.

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	4312.347[a]	.142	.435

Table 7: *Model Variance Summary*

The classification table assesses the predictive accuracy of the logistic model using the cases from within the Analysis group. **Table 8** shows that using a cut-off point of 0.950 to reflect the positive outcome rates for pickpocketing, 629 of the solved cases (71%) and 15,602 of the not solved cases (92%) were predicted accurately by the model. The overall predictive accuracy is 91%, which is lower than the baseline model although the predictive accuracy of solved cases is increased significantly.

	Observed		Predicted		
			Positive Outcome		Percentage Correct
			Solved	Not Solved	
Step 1	Positive Outcome	Solved	629	256	71.1
		Not Solved	1286	15602	92.4
	Overall Percentage				91.3

Table 8: *Classification Table: Predictive Accuracy within Analysis Group*

The B coefficients for each solvability factor in the model vary according to their effect when controlling for the effects of other variables. Using the logit formula, the coefficients and constant from the regression output have been entered to derive the predictive algorithm where factors are replaced with '1' if present and '0' if not present:

REDACTED

The output from this formula when applied to cases is a score on a linear scale. Before testing the accuracy of the model on the remaining data, a cut-off score must be determined by which to screen cases in or out based on their score. The logit formula was applied to the Analysis group to show what each graduating cut-off point would mean in terms of false negatives and false positives. **Figure 6** presents the regression output scale along the X axis and an indication of the cases incorrectly screened in and out at each point upon the scale.

The appropriate cut-off point for the purposes of testing a binary screening decision will be **-11.7** on the regression output scale. Values greater than this will be screened in for secondary investigation and values lesser will be screened out and closed. This point was established through comparing false negative and false positive rates. As BTP has a lower tolerance for false positives (solvable cases incorrectly screened out resulting in a missed opportunity to solve) than false negatives (unsolvable cases incorrectly screened in resulting in wasted investigative effort), the line must be drawn as far right as possible before any significant rise in false negatives. The -11.7 cut-off point sits before a rapid increase in anticipated wasted efforts whilst suppressing missed opportunities to around 100 over the five year period from which the data was drawn.

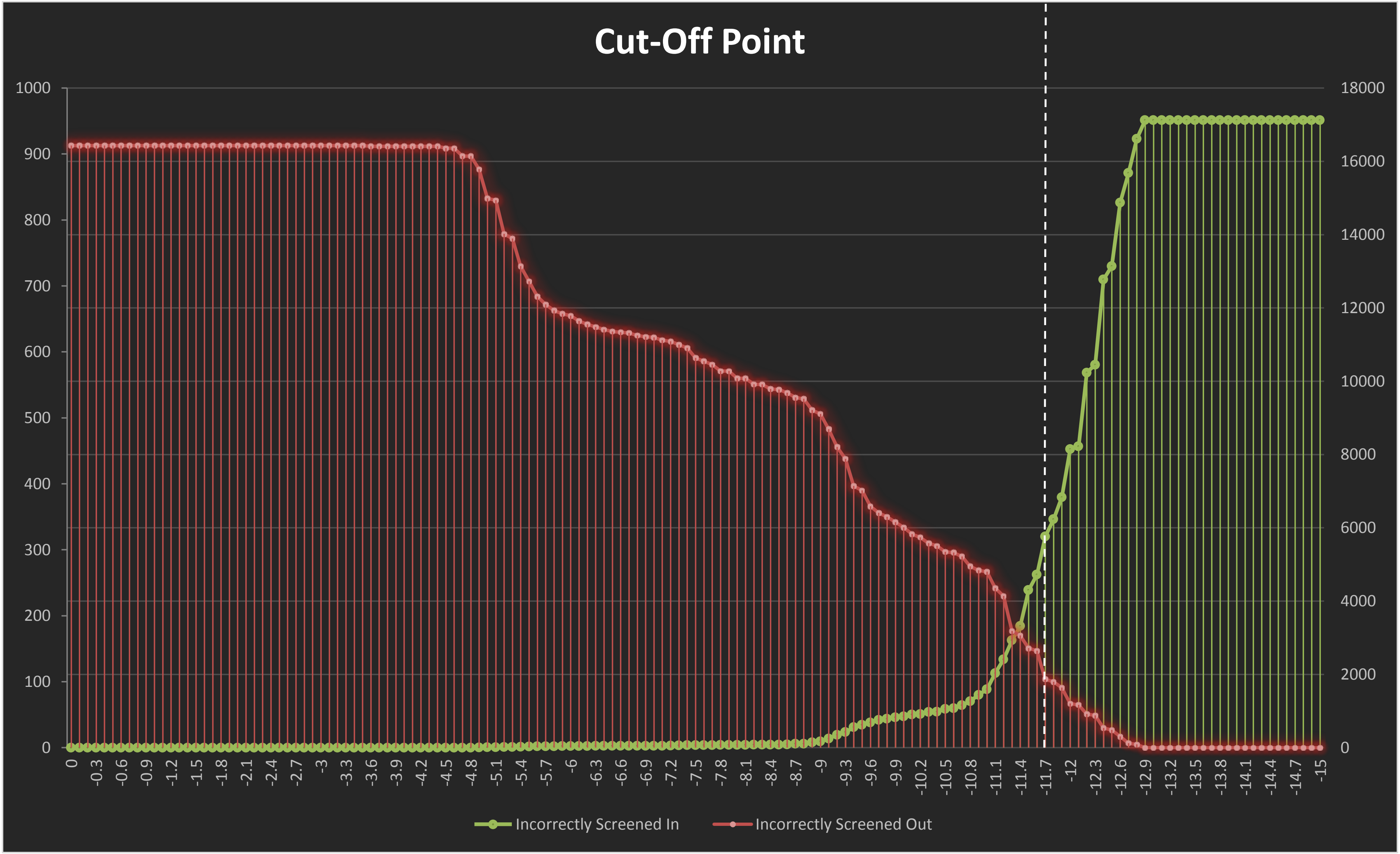


Figure 6: *Model Cut-Off Point Implications*

The final logistic regression formula is as follows:

REDACTED

Overriding Factors

To complete the screening model, it is necessary to capture all eventualities. There may be operational requirements to mandate that certain offences are always investigated irrespective of the formula output. These overriding factors have been determined as follows: property value over £5,000; named suspect associated with the crime; reputational risk associated with not investigating. The final screening model will screen in pickpocketing cases for secondary investigation based upon a score equal or greater than -11.7, which considers the presence of the 10 identified solvability factors or any of the defined automatic screen-in factors. The final model satisfies the second research question, through the statistical prediction of pickpocketing developed from initial assessment factors. However, there is little practical application for such a formula if, when tested, it does not offer operational advantages over current practice. As such, the following results section will critically evaluate both BTP's current intuition based assessment along with the statistical model and subsequent formula. As data is only held on the property value automatic screen-in factor, this can be supplemented. However, for the reputational risk and named suspect, there is no reliable data to draw from and therefore this must be accepted as a limitation when testing for predictive accuracy.

Predictive Accuracy Assessment

At the initial investigation stage conducted by the CMU, a decision is made whether to screen a pickpocketing offence in or out. If an offence is screened in, it is allocated along with an investigation plan to a Detective for secondary investigation; if screened out, it is closed. With the current process screening-in the clear majority for further investigation despite the low detection rate, it is evident there is likely to be a considerable false positive rate associated with current practices. By analysing the Testing group of 18,221 cases it is possible to understand the extent of false positives and subsequent wasted investigations created by the current approach over the past five years. Where cases were screened in but never solved, this would constitute a false positive whereas those screened in and later solved, would show as a true positive. Cases screened out and not solved would be true negatives, whereas cases screened out but identified as solvable would be false negatives. The latter will not be evident from examining the current practices as the cases screened out were never investigated and therefore not afforded any opportunity to be solved. **Figure 7** presents the predictive accuracy assessment of BTP's current practice.

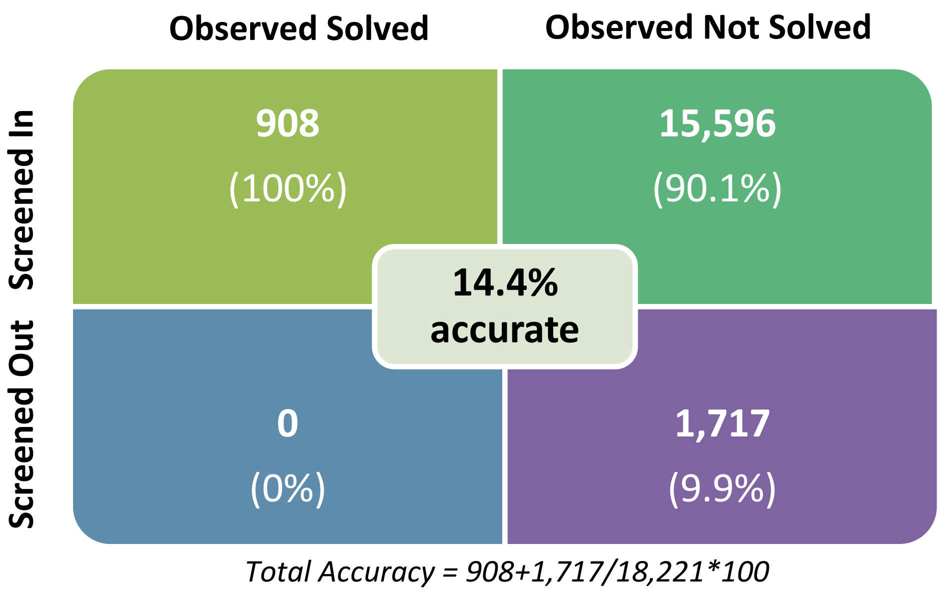
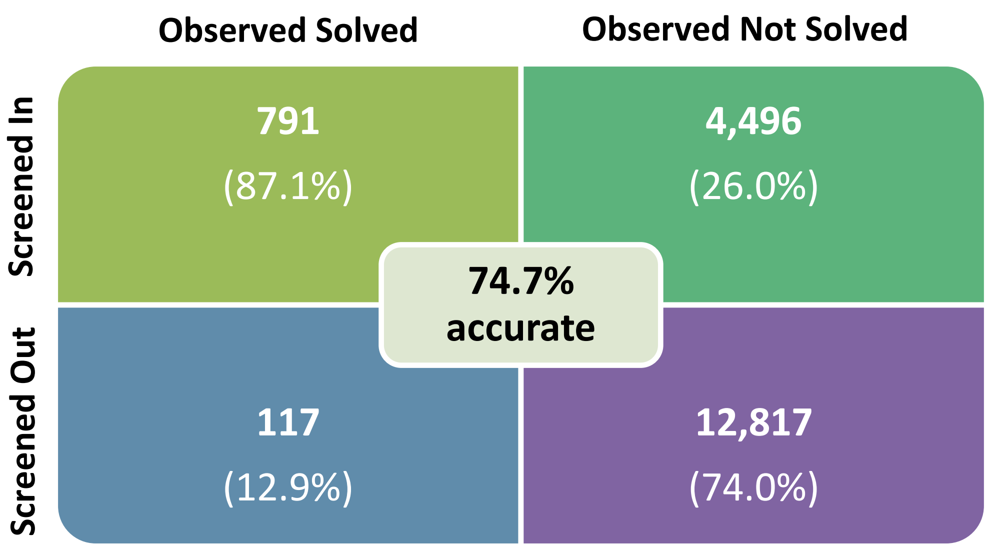


Figure 7: *Screening Model Accuracy: Current Practice*

From reviewing the Testing group data, it is clear that over the past five years the CMU have screened in 16,504 out of 18,221 cases for investigation (90.6%) based on subjective assessment. 908 cases were correctly screened in as they were later solved. 1,717 cases were screened out and never solved, for which it must be assumed that this decision was correct in the absence of contrary information. However, 15,596 crimes were incorrectly screened in and never solved. It is estimated from internal BTP demand data, that each pickpocketing on the railway takes an average of 4.5 hours for the secondary investigation to complete. To investigate these crimes which were never solved amounts to over 70,000 hours of wasted police time over the past five years just within this half-dataset. Overall, 14.4% of the cases within the Testing group were accurately screened through the current intuition based assessments. This data can be compared to both the false negative and positive rates associated with the statistical model by applying the formula to the Testing group and assessing predictive decisions (model screening) against outcomes. **Figure 8** presents the predictive accuracy assessment of the screening model developed using the Analysis group data, with the inclusion of one automatic screen-in factor.



*Total Accuracy = 791+12,817/18,221*100*

Figure 8: *Screening Model Accuracy: Statistical Model*

This model screened in 5,423 out of the 18,221 pickpocketing offences for secondary investigation; 29.8% of all cases. Whereas 791 true positive cases were correctly screened in and subsequently solved, a further 4,496 false positive cases were incorrectly screened in but never solved. The vast majority of cases were true negatives; screened out and never solved. However, there were 117 false negative cases screened out by the model which in reality were solved. The overall predictive accuracy of the screening model is 74.7% based on the results when applied to the Testing dataset. It accurately predicts the outcome of 13,608 cases compared to 2,625 accurately predicted through the current intuition based screening system. This means that the statistical screening model is over 5 times more likely to accurately screen pickpocketing offences.

Over the past five years, there have been 36,260 pickpocketing offences on the railway network. If the results of the predictive accuracy analysis upon the Testing dataset can be applied to the entire population, 32,670 of these offences would have been wasted investigations as they were screened in but never solved. If the statistical screening model had been in place for the past five years, only 9,428 of these offences would have resulted in this wasted effort. This would mean 23,242 fewer wasted secondary investigations, accounting for approximately 104,589 hours of police time saved over the five year period. The final research question is concerned with the value of investigative efforts. It is critical to understand this relationship in order to develop policy decisions surrounding the efficiency which the statistical screening model could potentially create. If the question is: *'what should we do with the detective hours saved?'* the answer will be dependent upon the value of these resources during the secondary investigation.

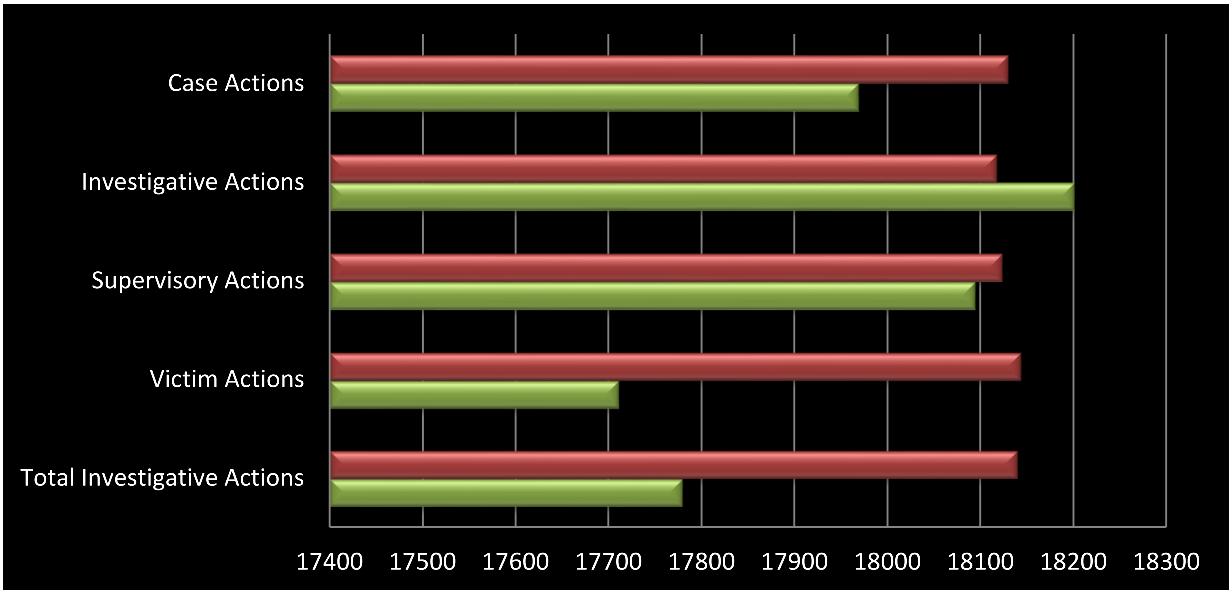
Secondary Investigation Analysis

The data obtained for the secondary investigation stage is limited, as previously discussed. Instead of measuring the quality or type of investigative actions, the only available data is the volume of actions for each case, against each category. As there is no testing required for this step, the total five year sample was used. **Table 9** reports the distribution of actions undertaken throughout the secondary investigation.

		Case Actions	Investigation Actions	Supervisory Actions	Victim Actions	Total Actions
N	Valid	36242	36242	36242	36242	36242
	Missing	19	19	19	19	19
Skewness		10.422	4.298	2.652	2.877	3.702
Std. Error of Skewness		.013	.013	.013	.013	.013
Kurtosis		211.644	36.927	19.520	14.880	26.153
Std. Error of Kurtosis		.026	.026	.026	.026	.026

Table 9: *Investigative Actions Distribution for Entire Population*

As the skewness and kurtosis of the data indicate that it is not normally distributed, an assumption of the independent-samples t-test is violated and therefore the non-parametric test Mann-Whitney U will be used to establish relationship significance. **Figure 9** presents the comparison between the average number of actions for both solved and unsolved cases for the entire sample of 36,242 cases.



	Total Investigative Actions	Victim Actions	Supervisory Actions	Investigative Actions	Case Actions
Not Solved	18139.64	18143.25	18123.02	18117.31	18129.67
Solved	17778.49	17710.17	18092.77	18200.79	17966.99

Figure 9: *Mean Ranks of Investigative Actions by Case Outcome for Entire Population*

Table 10 presents the results of individual Mann-Whitney U tests for each category of actions within the sample.

	Case Actions	Investigation Actions	Supervisory Actions	Victim Actions	Total Actions
Mann-Whitney U	31042815.00	31179707.50	31271730.50	30575402.50	30699744.50
Wilcoxon W	32699925.00	623633960.50	32928840.50	32232512.50	32356854.50
Z	-.964	-.335	-.123	-1.781	-1.441
Asymp. Sig. (2-tailed)	**.335**	**.737**	**.902**	**.075**	**.149**

Table 10: *Mann-Whitney U Tests: Investigative Actions across Entire Population*

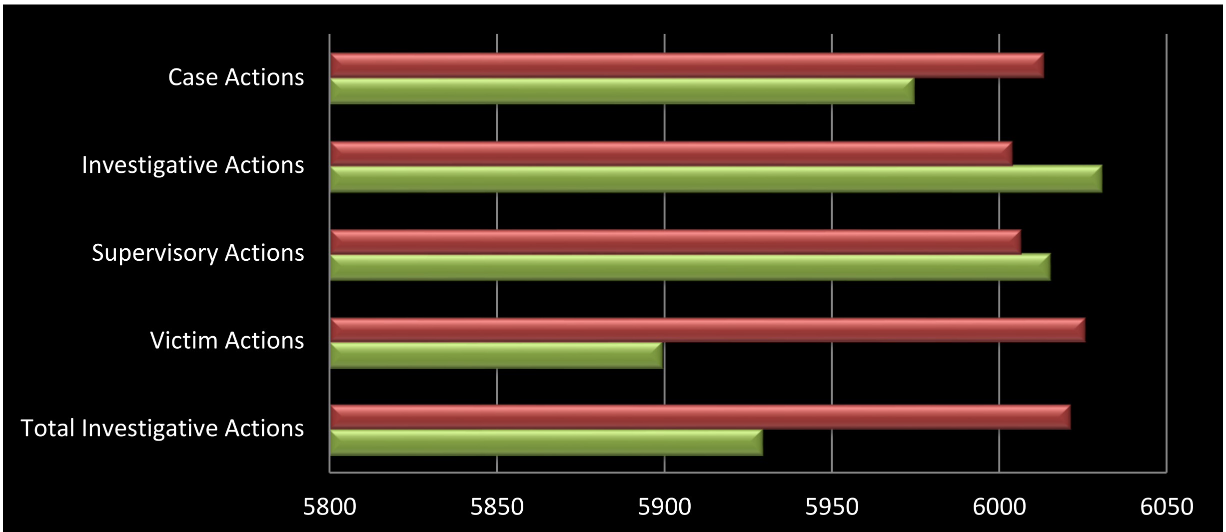
There is no statistically significant relationship between the average number of Case (p = 0.335), Investigation (p = 0.737), Supervisory (p = 0.902) or Victim (p = 0.075) actions and case solvability. This is also true for the relationship between the total number of investigative actions for each case and subsequent solvability (p = 0.149).

This analysis does not control for the cases which would be screened out and closed based upon the new statistical model. It is necessary to further isolate the sample of investigative actions to those cases which would be deemed 'solvable' by the model, as it is possible that these crimes by nature would benefit from secondary investigative efforts more so than crimes which would be screened out. **Table 11** confirms the normality of distribution assumption remains violated and therefore the non-parametric test should be used to compare mean ranks.

		Case Actions	Investigation Actions	Supervisory Actions	Victim Actions	Total Actions
N	Valid	12014	12014	12014	12014	12015
	Missing	7	7	7	7	6
Skewness		8.266	4.759	2.948	2.890	3.752
Std. Error of Skewness		.022	.022	.022	.022	.022
Kurtosis		122.661	47.524	25.571	14.491	26.498
Std. Error of Kurtosis		.045	.045	.045	.045	.045

Table 11: *Investigative Actions Distribution for Cases Screened-in by Model Screening*

Figure 10 presents the mean ranks associated with each category of investigative actions.



	Total Investigative Actions	Victim Actions	Supervisory Actions	Investigative Actions	Case Actions
Not Solved	6021.23	6025.61	6006.29	6003.70	6013.13
Solved	5928.56	5898.76	6014.75	6030.34	5973.69

Figure 10: *Mean Ranks of Investigative Actions for Cases Screened-in by Model*

Table 12 presents the results of Mann-Whitney U tests for the relationship between the number of investigative actions and solvability, purely for those cases which would be screened in by the statistical model.

	Case Actions	Investigation Actions	Supervisory Actions	Victim Actions	Total Investigative Actions
Mann-Whitney U	8773401.50	8792219.00	8818959.00	8644895.50	8696018.00
Wilcoxon W	10244871.50	61832069.00	61858809.00	10116365.50	10167488.00
Z	-.656	-.298	-.095	-1.453	-1.029
Asymp. Sig. (2-tailed)	**.512**	**.766**	**.924**	**.146**	**.304**

Table 12: *Mann-Whitney U Tests: Investigative Actions for Cases Screened-in by Model*

The results indicate that neither the relationship between individual categories of secondary actions nor the total actions taken and case solvability are statistically significant, even when removing those cases which would be screened out by the statistical model.

Hierarchical Multiple Regression

To test whether the introduction of the investigative action volumes within each category would offer any predictive advantage beyond the circumstance-based model, hierarchical multiple regression was undertaken. The first level of hierarchy was the set of ten solvability factors identified in the existing regression model (**Table 4**). The second level of hierarchy was the volume of Victim, Case, Supervisory and Investigative secondary actions. **Table 10** presents the hierarchical multiple regression model summaries, using data from the entire population of 36,260 cases.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
Circumstance-based (Step 1)	.620	.384	.384	.171	.384	1966.784	10	31518	.000
Circumstance & Efforts based (Step 2)	.620	.384	.384	.171	.000	1.965	4	31514	.097

Table 13: *Hierarchical Multiple Regression Summaries*

For the first model, the R square value is significant at *F* (10, 31,518) = 1,967, p < 0.001. However, the second model which introduces investigative effort is not significant with an identical R of 0.620 and R square of 0.384 accounting for variance. The change in R square is not significant at *F* (4, 31,514) = 2, p = 0.097. Therefore, the introduction of investigative actions offers no solvability advantage over the existing circumstance-based model. Based on the data available, the volume of secondary actions does not enhance pickpocketing clearance. This satisfies the final research question.

Discussion

The intention of this study was to close the gaps in existing research to provide an alternative solution to the screening tactics used when investigating pickpocketing on the railway. As a volume crime for BTP, the ability to predict pickpocketing solvability and act accordingly presents potential to considerably enhance efficiency. Although many solvability factors included within the analysis have been considered in previous studies, they are contextually limited to the crime types studied. The review of a fresh dataset also presents an opportunity to review new, specific factors based on pickpocketing characteristics. Eck's triage hypothesis (1983) formalised three categories; crimes which are likely to be solved, irrespective of investigative effort; crimes which are unlikely to be solved, irrespective of investigatory effort and finally those which could be solved as a *direct result* of investigatory effort. The results presented have tested each category of Eck's hypothesis along with presenting new findings specific to pickpocketing crime. This section will discuss those findings in addition to implications for the future not just for research, but for policing.

Influence of Solvability Factors

Existing literature demonstrates that a range of factors associated with crime circumstances show significant relationships with solvability. Whereas the impact of these factors can vary amongst crime types, the presence of suspect information remains consistent throughout acquisitive crime (Isaacs, 1967; Reiss and Bordua, 1967; Greenwood, 1970; Greenwood *et al.,* 1975; Chaiken *et al.,* 1976; Eck, 1979; Brandl and Frank, 1994; Coupe and Kaur, 2005; Burrows *et al.,* 2005) and violent crime (Eitle *et al.,* 2005; Peterson *et al.,* 2010; Olphin, 2015). This study found that 82.6% of cases containing suspect information within the initial report were later solved. When controlling for the inter-variable effects, the presence of a suspect description meant that pickpocketing offences were over four times more likely to be solved. The variance in solvability within specific suspect attributes is broadly limited by the small sample of cases containing this data and therefore most correlations were not significant. However, the exception was the mean age of the suspect as described by victim or witness accounts, which indicated that offenders over the age of 30 were more likely to be associated with solved cases. The findings further reinforce the enduring relationship between suspect information and solvability whilst suggesting that, for pickpocketing, this is the strongest single indicator of solvability.

One factor correlated with suspect descriptions is whether a witness statement was received by anyone other than the victim. Where the offence was witnessed, the positive outcome rate was 23.6% in comparison to an average of 5.1% across the sample. This supports previous findings (Coupe and Griffiths, 1996; Baskin and Sommers, 2012; Farrington and Lambert, 2000; Tilley *et al.,* 2007). During regression, this factor was removed due to its correlation with suspect description which holistically was a stronger factor. However, the presence of witness accounts stands up individually as a key predictor of pickpocketing solvability. Unlike witness accounts and suspect information, a factor specific to BTP is whether the offence was moving or static. Moving offences occur on in-motion trains; creating highly congested environments with less opportunity to secure usable CCTV. Conversely, when the offence is static it is four times more likely to be solved when factors were examined individually. Similarly, when removing the interaction of other independent variables during regression, pickpocketing which occurs specifically on station platforms was positively associated with solvability (p=0.054). This could be due to increased passenger vigilance when waiting for a train or clearer CCTV images due to the generally lower passenger density.

Pickpocketing is described as a stealth crime by Smith (2008) and often due to its unique nature, victims will not notice they have been targeted for some time. This can make it difficult to pinpoint the time of offence within a close range. This study found a linear relationship between the committed time range and solvability, with tighter ranges associated with significantly more solved cases. This could be due to the investigative limitations presented by broad time ranges, such as the ability to secure reliable CCTV footage or pinpoint the movements of the suspect. This is important because the availability of CCTV itself was also found to be a strong predictor of solvability in this study, with associated offences over 20 times more likely to be solved. The findings support previous evidence from Robb *et al.,* (2014) concerning railway metal theft offences. CCTV was, however, found to be a negative predictor of solvability for violent assaults (Olphin, 2015) which suggests its benefits may be limited to acquisitive crime. The time delay between when the offence was committed and when it was reported is also a critical factor to consider. Clawson and Chang (1977) identified a correlation between immediate reporting and solved cases. BTP data did not provide significant volumes of cases reported within five minutes for meaningful analysis. However, pickpocketing reported within 30 minutes led to a solved case in 13.1% of incidents. This relationship was significant and reported degrading strength as the delay from when the crime was committed to reported increased.

Whereas previous research has found that crime committed during daylight hours is positively correlated with burglary (Couple and Blake, 2006) and homicide (Alderden and Lavery, 2007) solvability, this study found no significant relationship between either the time of day or season in which the offence was committed during individual factor analysis. This could be attributed to the fact that the vast majority of pickpocketing offences take place on the London Underground; a system lit to appear very similar irrespective of daylight. When controlling for inter-variable effects during the regression, offences taking place in the morning were more likely to be solved (p=0.054). It is possible that this result is influenced by broadly reduced crowding during the morning hours, with high passenger densities offering increased anonymity to offenders (Newton *et al., 2*014). It could also be that morning victims are more likely to be regular commuters as opposed to tourists, who may be less vigilant to the risk of pickpocketing and less aware of their surroundings. This supports the assertion by Coupe (2014) that the strength of this factor will vary across crime types. Another observation to explain the concentration of pickpocketing on the railway is Routine Activities Theory (Cohen and Felson, 1979) and the presence of high value targets. However, in terms of solvability, this study found no significant relationship between the value of property stolen and whether the offence was solved, although it is possible that lower value property accounts for a higher ratio of under reporting.

The link between victimology and solvability in pickpocketing also presents some interesting findings. Whereas Roberts (2008) found that non-white victims showed positive correlations with solvability for rape, Snyder (1999) found them to have a negative correlation with robbery. This study found that where the victim's ethnicity was recorded as Chinese, 8.9% of associated cases were solved. This is in contrast with ethnicity recorded as Black, accounting for just a 2.9% solvability rate. These relationships were significant, although victim ethnicity was removed during regression. However, male victims were consistently significantly, negatively associated with solvability and appear in the final regression model as a negative predictor. Where the victim is in some way intimidated by the offender, there is a significant positive correlation even when controlling for the presence of a suspect description. Finally, the items stolen from the victim vary in their solvability effects between individual and collective analysis. Individually, phones or electronic devices stolen show no significant relationship, yet during regression this becomes a significant negative predictor. It is possible that offenders targeting electronic items are more likely to be connected to organised crime groups and consequently have greater development and support in evading capture.

A New Way of Screening

The current process at BTP for deciding which pickpocketing offences to investigate involves an initial assessment completed by the CMU. The CMU Operatives will review the information available and make a decision based upon whether or not they believe the crime can be solved, introducing cognitive bias through System 1 thinking (Kahneman, 2011). Upon visiting the CMU during this research, it became clear that if there was doubt over a case's solvability it would ordinarily be screened in for investigation, operating upon a '*better safe than sorry*' principle. Through analysing the five year population, it was found that unsurprisingly the vast majority (90.6%) of cases were screened in for secondary investigation, whilst only 5.1% were solved. When assessing the predictive accuracy of current practices, it was found that over the five-year period 15,596 crimes were incorrectly screened in and never solved. This significant false positive rate not only contributes to the poor overall predictive accuracy score (14.4%) but creates a vast workload for detectives, much of which could be pre-determined as wasted effort. It is estimated from internal BTP demand data that each pickpocketing on the railway takes an average of 4.5 hours for the secondary investigation to complete. To investigate these crimes which were incorrectly allocated to detectives amounts to over 140,000 hours of wasted police time during the past five years.

In contrast, the statistical model screened in just 29.8% of cases. Out of those screened in, 4,496 were false positives which were never solved. The vast majority of cases were true negatives; screened out and never solved. However, 117 false negative cases screened out by the model were, in reality, solved. This would have let the victim down (Eck, 1983). The overall predictive accuracy of the screening model is 74.7%. This means that the screening model is over 5 times more likely to accurately screen pickpocketing offences than current practices. This is in keeping with the RAND study which produced a model presenting between a 67% and 92% predictive accuracy rate (Greenberg *et al.,* 1973) later replicated by Eck (1979) to present at 85%. Better comparators would arguably be more recent studies, which have used detections and positive outcomes as the measured output such as Paine (2012) between 63% and 81%, and Olphin (2015) at 64%. Through assessing the predictive accuracy of this model, it is established that statistical case screening is far more accurate than clinical methods, in this instance the intuition of multiple CMU Operatives. This supports the original findings of Meehl (1954), sustaining the findings of Greenwood and Petersilia (1975) and the circumstance-results hypothesis later categorised by Eck (1983). Therefore, it can be concluded that for pickpocketing crime in the railway environment, statistical models offer more accurate investigative targeting than screening through intuition.

Overriding the Formula

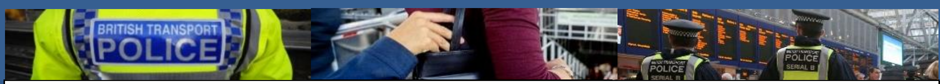
The statistical model does not account for every eventuality where investigations would be appropriate. Consequently, the final model follows the methodology applied by Olphin (2015) in introducing factors which supplement the statistical model, resulting in an automatic screen-in decision. Data surrounding named suspects was discounted early on as it cannot be determined at which point in the investigation the data was input. However, this is an important factor which may not necessarily be covered by 'suspect description' if BTP have made an on-scene arrest. The presence of a named suspect is therefore included as an automatic screen-in factor for all cases. It could also be claimed that the model does not account for the range in harm caused to the victim through deprivation of their property. Although property value does not offer a predictive advantage, it has been established that pickpocketing involving high value items (over £5,000) would always be screened in. Finally, depending on the circumstances of the case, the offender or victim may be of high interest. If not investigating the case is likely to generate negative attention from the media or wider society, it should always be screened in. This final factor is deliberately more vague to allow operational control over the more nuanced cases.

The Importance of Cut-Offs

The conversion of the string output from the logit formula to a binary screening decision can be heavily influenced by policy. The point has been defined at -11.7 for the purposes of model testing within this study, however this value can fluctuate over time as directed by the organisation. The final screening model presents 117 missed opportunities over the five-year period within the Testing group. This equates to approximately 48 missed opportunities per year and when combined with a model five times more accurate with significantly fewer instances of wasted effort, it is likely to be considered tolerable. However, if BTP's appetite for balancing false positives against false negatives were to change, the cut off score can simply be increased or decreased with an indication as to what the estimated implications would be. For instance, if the new screening approach is adversely affecting public confidence, the cut-off can be increased to ensure more crimes are screened-in. Similarly, if the resource levels available for pickpocketing investigations were to change in the future, the cut-off point could fluctuate in line with this to ensure the optimum ratio of detectives to crimes (Coupe, 2014). It is necessary to derive a practical tool which allows ongoing operational control over such decisions, negating the need to rely upon further statistical analysis which may not be continuously available.

Case Screening Calculator

The logit formula and associated cut-off score will predict whether a pickpocketing offence is solvable or not. When the additional automatic screen-in factors are introduced it becomes quite complex to decipher screening decisions on a case by case basis. The CMU need to make decisions which are not only thorough but expedited, due to their substantial caseload traffic. To support the transition from statistical analysis into practice, a bespoke tool has been developed which provides a simple structure to the decision making process during the initial assessment phase. **Figure 11** presents a screenshot of a Pickpocketing Case Screening Calculator developed on Microsoft Excel.



PICKPOCKETING CASE-SCREENING CALCULATOR

Did the crime occur on TfL jurisdiction?	No
Was the crime static as opposed to on a moving train?	No
Did the crime happen on the Platforms?	No
Did the crime happen in the morning? (06:00-11:59)	Yes
Does the victim identify as male?	No
Is the victim flagged as intimidated?	No
Was the property stolen a phone or other electronic device?	No
Is there CCTV available?	Yes
Is there any kind of suspect description available?	No
Did the crime happen within a time range of 15 minutes?	Yes

Is the value of stolen property £5,000 or over?	No
Is there a named suspect associated with the crime?	No
Is there a reputational risk associated with not investigating?	No

SCREEN IN

Figure 11: *Excel Case Screening Calculator*

This calculator asks the CMU Operative to select either 'Yes' or 'No' from each dropdown box associated with the case circumstances. The logit formula sits on a separate worksheet and calculates whether the output is within the -11.7 cut off point. The lower box of the calculator will populate automatically with the appropriate screening decision. The final three questions establish the presence of automatic screen-in factors. If any of these factors are present, it will override the logit formula and populate the lower box with 'SCREEN IN'. If the cut-off point was to change in the future, a single value in the worksheet formula would be amended to reflect the decision. This calculator will allow the practitioners a simple and structured decision making process which maintains predictive accuracy along with ownership and expedience.

Realising the Benefits

Assuming the new screening model is implemented; what does this mean? Arguably it is futile to increase the accuracy of resource targeting if there are no service benefits in terms of efficiencies of performance improvements. It is necessary to understand the context in which potential benefits may exist. Over the past five years, there have been 36,260 pickpocketing offences on the railway network. If the results of the predictive accuracy analysis are applied to the entire population, 32,670 of these offences would have been wasted investigations as they were screened in but never solved. If the statistical screening model had been applied during the past five years, only 9,428 of these offences would have resulted in this wasted effort. This would mean 23,242 fewer wasted secondary investigations. Based upon an average secondary investigation time of 4.5 hours, this accounts for approximately 104,589 hours of police time saved over the five-year period. The policy implications depend on *how* this benefit is realised. Assumptions must be made to explore the options available.

Firstly, it is assumed that BTP will replace the existing processes with the statistical model for pickpocketing offences. Secondly, it is assumed that the volume and nature of pickpocketing offences taking place, workforce levels and cost of detectives remain largely static. Under these circumstances, it is possible to exploit the efficiency of 104,589 hours of police time over the next five years. Annually, this is the equivalent to 10 full time detectives working 40 hours per week for 52 weeks, or £502,832. There are three distinct options BTP could endorse to benefit from the new policy. The first is cognisant of reduced workloads and would involve moving 10 detectives away from investigating pickpocketing offences and into an area of criminal investigation which would benefit from additional resources. The second, in a similar thread, would be to remove 10 detective positions entirely from the establishment, creating an annual cashable saving of £502,832 to be reinvested in another area of policing (excluding potential overhead savings) cumulatively rising to over £2.5M after five years. The final option is to maintain current resource levels and leave the 10 detectives (or 20,918 additional hours per year) to continue investigating pickpocketing, albeit with reduced workloads and therefore capable of higher volumes of secondary investigative activity. It could be asserted that this will lead to higher positive outcome rates and therefore enhanced performance. To understand whether this will be the case, it must be assessed whether more activity during the secondary investigation contributes to pickpocketing solvability.

The analysis in connection with the secondary investigation was twofold. Initially, the relationship between secondary work efforts and solvability was examined for the entire population of cases. This allowed conclusions to be drawn around the impact of secondary investigations upon solvability, irrespective of screening decisions. The results showed that the mean ranks of investigative actions were not significantly different between solved and unsolved cases. This means that without accounting for data limitations, there is no discernible value to conducting secondary investigations. This is inclusive of case progression actions, victim contacts, investigative tactics, supervisory notes or the total volume of actions recorded for each case. However, assuming the introduction of a statistical model for case screening would this still be the case? Are there subtle differences in the type of cases deemed solvable by the model, in terms of how they may benefit from secondary investigation?

To understand this distinction, the same method for significance testing was applied only to those cases deemed solvable by the model. The results echoed those of the entire population. There was no significant relationship between the volume of actions associated with cases in the sample and whether or not they were solved. This means that the cases screened in by the model are representative of the wider population in terms of their relationship with secondary investigations. This finding also fails to reinforce previous findings that investigative efforts are critical to solvability (Folk, 1971; Block and Weidman, 1975; Block and Bell, 1976) and thusly contradicts the effort-results hypothesis categorised later by Eck (1983). This result falls in line with Weisburd and Eck (2004) and Coupe (2014) who found no significant relationship between work effort and solvability, supporting Goldstein's 1977 assertion that detectives' abilities are often significantly exaggerated. However, it should be noted that the data used for this analysis is limited to volume of actions updated on the CRIME system. It does not take into consideration any measure of investigation quality or specific tactics applied. Therefore, the findings are not sufficient to disprove the triage hypothesis without further research into these elements.

To revisit the question concerning how to best take advantage of the resourcing efficiency created, the findings are more useful from a policy perspective. With the absence of any alternative research in relation so pickpocketing on the railway, it can be established that positive outcome rates are unlikely to benefit from greater investigative activity associated with additional resources. Consequently, leaving the surplus detective resources to deal with fewer pickpocketing investigations would offer no operational advantage. Instead, it would be more productive to remove the 10 Detective positions and either release cashable savings of £502,832 per year for reinvestment or transfer the posts to an area of the Force which may benefit from a greater resource levels. Despite the clear potential to enhance resource targeting for pickpocketing solvability, the practical translations must also be considered before such findings can be applied in an operational setting. By understanding the limitations of the study, a cohesive strategy can be developed to ensure findings can be safely embedded in a real life setting.

Implications for Policing

The extent to which the findings from this study can be applied across the policing profession depends very much on the respective environments. The broad conclusions concerning the benefits offered by the statistical screening model over intuition based decision making processes sustain an extensive body of previous research findings across a wide range of policing areas and crime types. This reinforcement will therefore support the application of the circumstance-results hypothesis (Eck, 1983) and should encourage the adoption of such models in other Forces. The efficiencies offered by predictive modelling involve the elimination of unsolvable crime to reduce wasted investigative efforts. Application to low harm, high volume crimes would provide the greatest return, especially when positive outcome rates are low. Screening in this manner will allow police to identify and target the 'power few' cases deemed solvable (Sherman, 2007).

Analysis of well-known solvability factors such as suspect information, witness accounts, CCTV and reporting timelines contributes to the growing body of evidence supporting their relationship with solved cases across multiple crime types. This study's findings contribute to painting a more detailed picture of solvability factors' cross-border and intra-crime type variance or their ability to endure. However, findings in relation to some of the more specific solvability factors are limited in external application to pickpocketing on the railway. Factors such as moving or static offences and platform location are likely to be confined to the railway. Learning could be transferred to international police agencies, specifically focused upon transit system crime. Similarly, the findings around factors associated specifically with pickpocketing as a crime type such as committed time range, property value and the type of property stolen, are applicable to wider policing outside of mass transit systems.

Limitations and Strengths

A key strength of this study over previous research was the sample size. With 36,260 crimes available for analysis it was possible to pinpoint the significance of relationships with a high degree of certainty. The sample size also provided great statistical power, and it was possible to split the population of cases for the purposes of testing the statistical screening model with fresh, comparable data. The study was also able to identify and categorise the requisite investigative stages; initial assessment and secondary investigation. The factors examined upon initial assessment have far-reaching implications for both research and policing. This includes the identification and analysis of new data including crime circumstances which had previously never been scrutinised or understood. The greatest strength of the study is the efficiency offered and connecting operational implications. At a time where police budgets continuously scrutinised and tightened, the findings offer the opportunity to target resources intelligently to maximise their impact upon crime detection.

The societal implications concerned with implementing a statistical screening model are important. It could be seen as a way for police to handpick which crimes to investigate and which to simply close. If the model were to be understood by potential offenders, it is possible that they would avoid certain circumstances when targeting their victims, allowing them to slip under the radar. The final screening model endorsed by the Force ahead of implementation must be restricted only to those who need to apply the calculator. Similarly, screening in fewer crimes limits opportunities to link offences to the same offender where patterns exist. To mitigate against this potential loss, the CMU must ensure intelligence systems are update to include all available details of the crime, which must be searchable to detectives investigating the screened-in crimes. Finally, communication to the victim is critical to ensure confidence in the police is maintained. The messaging must be clear; crimes will be closed where the lack of evidence prohibits solvability. A mathematical model is arguably less discriminatory than subjective assessments although inclusion of victim gender in the formula could prove controversial if viewed in isolation.

Use of the CRIME system is limited by human error and design. Although obvious outliers were removed from the data during cleansing, it is possible that there were still a number of errors within the dataset. This is mitigated in part by the sample size, although as the system was not intended for research purposes it is likely that with the number of operators over the five-year period, subjective interpretations may have distorted the dataset. The study is also limited by the reliability of data, particularly concerning investigative actions. Although broad conclusions can be drawn in relation to secondary investigative effort, using the volume of investigative actions recorded on the CRIME system is not a reliable measure of the quality of work which goes in to detecting pickpocketing. The data unavailable for secondary actions also include specific tactics used and the workload of teams involved in each case during this five-year period. Both of these elements would have added great value to the assessment of this phase and subsequent level of contribution provided by the efforts-result hypothesis (Eck, 1983). Yet, as it stands, there remains insufficient evidence on the actions undertaken by investigators (Telep and Weisburd, 2012).

Further Work

The limitations identified cast doubt over the direct translation of the findings into an operational context. To safeguard against data reliability issues, further information is required to make informed decisions as to the manner in which the model and subsequent efficiencies can be implemented and captured. It is therefore proposed that the stages of pickpocketing investigation are further scrutinised during a Randomised Control Trial (RCT) which aims to test both the true accuracy of the model during the initial CMU assessment and the impact of resource availability, investigation quality and tactics applied during the secondary investigation. **Figure 12** outlines the design of the experiment which is Level 5 on the Maryland Scale (Sherman *et al., 1*998).

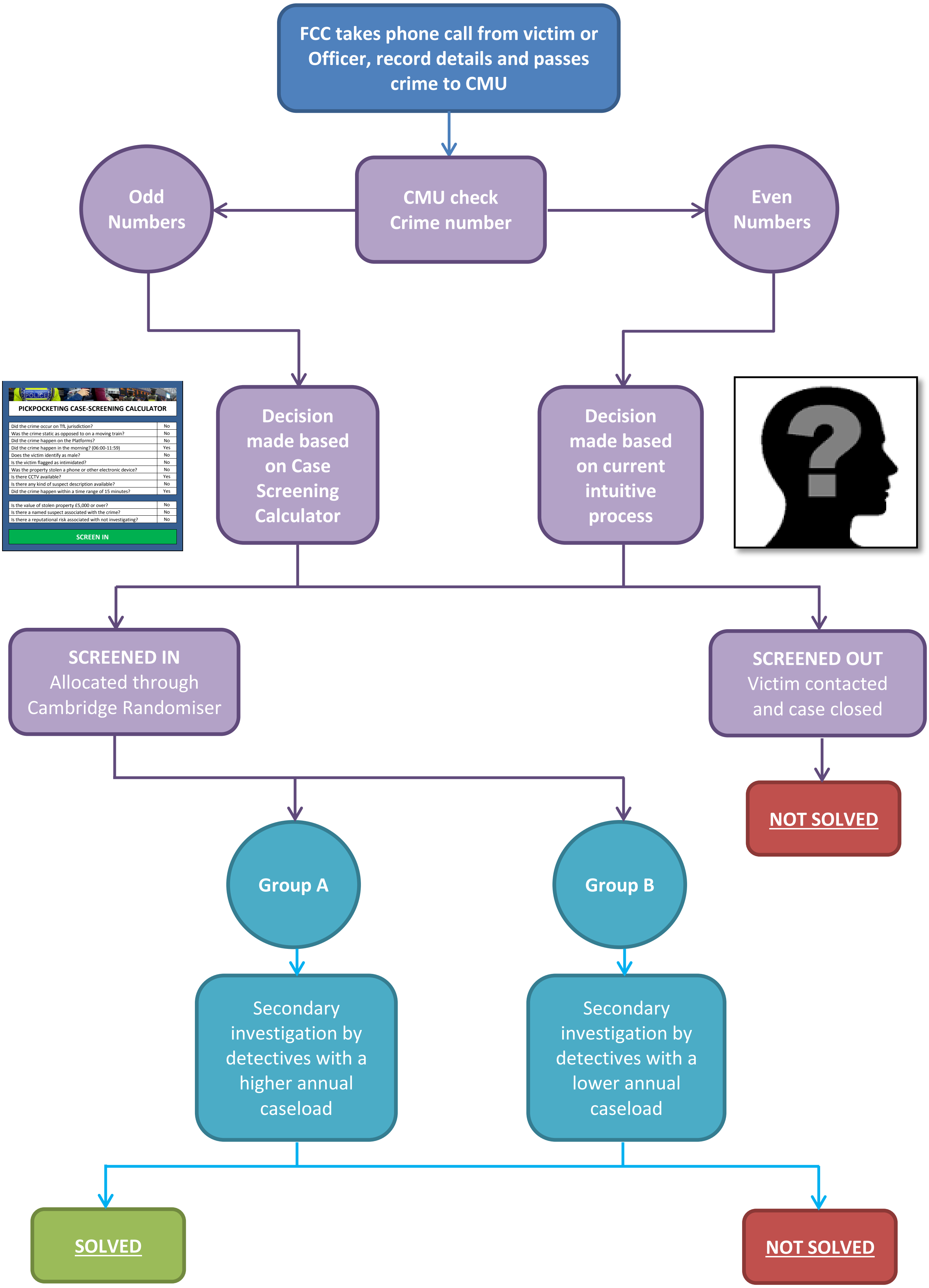


Figure 12: *Proposed Experimental Design*

Within this experimental design, odd crime reference numbers would undergo screening based upon the Case Screening Calculator (**Figure 11**) whilst even crime reference numbers would undergo screening based purely upon the intuition of CMU Operatives. This phase will screen in a certain volume of crime for secondary investigation. Using the Cambridge Randomiser (Ariel *et al., 2*012) tool, screened-in crimes will be allocated to either Group A detectives or Group B detectives. Group A would be set higher caseload levels than Group B which will be maintained through the Cambridge Randomiser. The recorded outputs during secondary investigation will be the group in which the allocated detective falls, the tactics applied, a supervisory assessment of investigation quality and time taken for completion. This two-block design will allow the testing of both the screening model accuracy and impact of secondary investigations in an operational environment. It will generate further data previously absent from the secondary investigation which can be used in additional multivariate analysis to test the resource allocation effects (Block and Weidman, 1975) and workload-detection model (Coupe, 2014). It may be possible to develop bespoke investigation plans dependent on the circumstances of the allocated cases, to maximise solvability opportunities.

Volume crime on the railway is not limited to pickpocketing. Other areas of interest include cycle theft and assaults against rail staff. It is possible to apply the methodology used within this study to further crime types to expand upon the more focused targeting strategy, up-skilling BTP Analysts to undertake this work. In the future, statistical predictions of crime solvability can become more sophisticated by employing more sophisticated techniques such as Random Forest Modelling (Breiman, 2001). Such a model would automatically screen cases entered in the CRIME system, learning from the subsequent outcomes and incrementally improving accuracy. This method has been used previously in policing to predict the risk of reoffending during probation in Philadelphia (Barnes and Hyatt, 2012) and is applicable to solvability predictions. There is great potential to continue the practical application of statistical screening models, whilst developing learning in terms of what exactly should take place during the secondary investigation. This direction will allow the screening and investigation to align in a consolidated evidence-based targeting strategy.

Conclusions

Pickpocketing on the railway creates an immense strain on investigative resources. Despite the efforts expended on bringing offenders to justice, this materialises in just a small proportion of cases. If investigative resources could be targeted to predictable concentrations of solvable crime, it would afford policing inordinate and systematic efficiencies (Sherman, 2013). Previous research has presented evidence to support this case (Greenwood and Petersilia, 1975; Eck, 1979; Eck, 1983; Brandl and Frank, 1994; Coupe and Griffiths, 1996; Coupe and Kaur, 2005; Robinson and Tilley, 2009; Paine, 2012; Olphin, 2015). As many of these studies are limited in external validity though organisational context and their focus upon specific crime types, it was necessary to generate further data to address the bespoke issues presented by pickpocketing on the railway. Using five years of BTP data (consisting of 36,260 pickpocketing crimes) split into two equivalent groups, the crime circumstances available upon initial assessment within the Analysis group were tested for their individual and collective correlations with solvability.

The solvability analysis leads the researcher to conclude that several factors available upon initial assessment were strong predictors of solved cases after controlling for inter-variable interference. Suspect descriptions were found to display the strongest positive correlation with solved cases, supporting previous findings to suggest the relationship is enduring across crime types. The presence of witness statements, older suspects, Chinese or female victims, expedient crime reporting and the availability of CCTV are all associated with higher rates of solved cases. More specific positive indicators and perhaps those limited in applicability to either pickpocketing or more general transit crime include; a limited range over which the offence was committed, static offences, those which occur on station platforms or in the morning. A phone or electronic device being the target of theft was determined as a case limiting factor, whereas the total value of property stolen exhibited no significant relationship with case solvability. In conclusion, upon initial assessment, case outcomes can be foreseen through identifying the presence of multiple solvability factors.

This preliminary conclusion led to the development of a predictive model, consisting of a formula derived from a selection of these mutually reinforcing solvability factors, isolating their individual effects. [redacted] REDACTED [redacted] These factors are both predictors of solved and not solved cases and report individual B coefficients controlled by a constant. The model is significantly different to the null model, with a Nagelkerke R square score of 0.435, meaning that it accounts for 43.5% of the variance in solvability. A Case Screening Calculator has been developed based on this predictive model, including three automatic screen-in factors: property value over £5,000, presence of a named suspect or reputational risk associated with not investigating. This relaxes the total exclusion of subjective influences to ease the transition from statistics into operational practice.

When this model was applied to the Testing group, the predictive accuracy was 74.7%. In contrast, the intuition based screening techniques currently applied by CMU Operattives in BTP reported a predictive accuracy of 14.4%. In addition to being over 5 times more accurate in its decision-making process, the statistical screening model also allocates far fewer cases (29.8%) than current practices (90.6%). A notable difference between the two screening systems was the significantly increased rate of false positive cases present in the intuition based approach, resulting in considerable wasted efforts. This could be due to the pressure felt by the CMU to allocate cases for further investigation based on perceptions of detectives' ability to generate solved crime.

When assessing the value of secondary investigations, it is concluded that based upon the dataset available there is no significant relationship between the volume of actions undertaken by detectives and pickpocketing solvability. This leads the researcher to conclude that increasing the ratio of detectives to pickpocketing investigations is unlikely to offer performance benefits in terms of enhanced positive outcome rates. This conclusion is of particular value when considering the practical implications of the predictive screening model. If it were to replace the current intuition based screening system, fewer crimes would be allocated. This reduces detective workloads and would ordinarily increase the ratio of detectives to crime. Instead, it is concluded that a greater operational advantage would be secured if these resources were released back to the organisation, either to invest in established crime prevention techniques such as hot spot policing (Braga *et al.,* 2012) or released as cashable savings.

This study involved looking back over the past five years to generate pickpocketing data. Although the investigative efforts previously wasted due to inefficient screening techniques cannot be undone, it is important to look to the future to establish how this learning can assist the development of evidence-based policy. Now that evidence is available contrary to current practice, it would be wrong to continue wasting money on practices which do not work (Bueerman, 2012). If the model were to be implemented at this cross-road, in five years' time BTP could create a cashable efficiency in the region of £2.5M. Although this presents a strong temptation for senior leaders, the results are limited by several data accuracy and reliability issues, most notably within the secondary investigation stage. Therefore, it is recommended that a staged RCT is conducted to test a combined treatment of allocation through the statistical model and the subsequent detective workload and activity, over a six-month period. This will generate further information to enhance understanding whilst guiding any subsequent operational implementation to maximise benefit realisation. BTP have committed to invest in this experiment, making it the first police agency in the world to test the practical application of a predictive screening model.

The findings of this study are not only important from a research perspective in terms of bridging the gaps, but are especially powerful when considering how policing can evolve in line with the growth of evidence. The study's findings contribute to painting a more detailed empirical picture of cross-border and intra-crime type variance in solvability factor strength, or even their ability to endure. Statistical screening models continue to offer prevailing advantages in the precise targeting of police resources. Yet, despite this, not a single police agency in the UK employs this tactic within crime allocation strategies. Further interrogation is required into the effects of secondary investigation tactics upon crime solvability, which should be tested in conjunction with the practical application of the statistical screening model. This will strengthen both theoretical and practical understanding of the resource efficiencies available to policy holders. Finally, upon reflection, it does not always follow that scarce resources continue to limit the efficiency of policing. Rather, scarce resources can encourage innovation, allowing policing to be more efficient than ever before.

Appendices

Appendix A – Theft from the Person: Home Office Counting Rules (Extract)

GENERAL RULE: ONE CRIME FOR EACH PERSON
(from whom a theft has been made).

EXAMPLE 1: Ten people on a crowded train report having their pockets picked. None report any force being used.
Ten crimes (class 39).

APPLICATION OF THE RULE
Items stolen from a person, but belonging to others, should not be counted additionally.

Example 1: A bag is snatched from a woman's shoulder and it contains items that belong to her and two friends.
One crime of theft from the person (class 39).

Robbery or Theft from the Person:

A victim is 'asked' to turn out his/her pockets in order to steal from him/her.
One crime of robbery [Nobody consents to such action unless they have been put in fear at the time of the offence. Where the actions of the suspect alone cause the victim to fear he/she may be subjected to force and in doing so, give up his/her property, a robbery has occurred.]

Example 1: A victim is walking down the street and the suspect grabs his/her shoulder bag.

(i) The grab is insufficient to pull the victim off-balance.
One crime of theft from the person (class 39).
(ii) The grab pulls the victim off balance but force is not applied directly to the victim.
One crime of robbery (class 34B).
(iii) The grab causes the victim to be knocked over, swung around or injured in any way.
One crime of robbery (class 34B).

Example 2: Suspects approach the victim and ask for the time. While victim takes her phone out of her handbag to check this, suspects grab the phone and run off.
One crime of theft from the person (class 39).

Example 3: Suspect sits next to victim on a bus. Victim has phone in her hand. Suspect tries to grab phone, after a tussle victim keeps hold of it, and suspect runs off bus.
One crime of attempted robbery (class 34B).

Example 4: A man has his pocket picked.

(i) He feels it but cannot prevent it.
One crime of theft from the person (class 39).
(ii) He feels it and his wallet is stolen only after a tussle.
One crime of robbery (class 34B).
(iii) He manages to keep hold of his wallet after a tussle.
One crime of assault with intent to rob (class 34B).
(iv) He is barged with intent to steal his wallet.
One crime of attempted robbery (class 34B).

Theft from the Person or Other Theft:

Example 1: Five people have possessions stolen from the changing room of a swimming pool while they are swimming.

Five crimes of other theft (class 49).

Example 2: A purse is stolen from a shopping trolley:

(i) While being pushed around a supermarket.
One crime of theft from the person (class 39).
(ii) When left momentarily.
One crime of other theft (class 49).

Whether to record:

Example 1: CCTV picks up an apparent pick-pocketing, but neither the victim nor persons acting on their behalf come forward to report it. No other information is available.
Classify as a crime related incident but do not record the crime.

Example 2: As above, but further investigation locates the victim who confirms the loss of valuables around the same time and location. On the balance of probabilities the officer decides that a crime has occurred.
One crime of theft from the person (class 39).

Example 3: A man reports having a wallet stolen from his possession. He was not aware of it actually being taken.

(i) During the initial reporting of the circumstances with the police, he realises that it is more likely, on the balance of probabilities, that he has lost the wallet.
Register the incident and deal with in accordance with NSIR.
(ii) As above, but after providing details he still thinks that it is more likely to have been stolen. On the balance of probabilities the officer decides that a crime has occurred.
One crime of theft from the person (class 39).
(iii) The wallet is later handed in, with its contents intact and the additional verifiable information determined that it was lost and no notifiable crime occurred.
C3 - Cancel the theft (if it has already been recorded).

Appendix B – Case Results Counted as 'Positive Outcome'

England and Wales		Scotland	
C01	a) Charged b) Summonsed/ postal requisitioned	**Det1**	Accused charged & report sent to Procurator Fiscal
C02	a) Caution – Youth b) Caution – Youth conditional	**Det2**	Accused charged & released on a written undertaking to appear at court
C03	a) Caution – Adult b) Caution – Adult conditional	**Det3**	Offender detected by means of notice of intended prosecution
C04	Taken into consideration	**Det4**	Accused not charged – evidence available & warrant craved report submitted
C05	The offender has died (all offences)	**Det5**	Accused charged and detained in custody for court
C06	Penalty notice for disorder	**Det6**	Accused dealt with by means of a fixed penalty notice number
C07	Cannabis warning	**Det7**	Offender detected but not being reported
C08	a) Community resolution b) Youth restorative disposal	**Det8**	Accused identified – Police Direct measure applied (<over 18 yrs)
C09	Not in the public interest (CPS decision – all offences)	**Det9**	Early & Effective Intervention juvenile judicial procedure (>18 yrs)

Appendix C – Time between J04 Offences Recorded and Detected

BTP J04 OFFENCES RECORDED BETWEEN 01/01/2011 TO 31/12/2015 THAT WERE DETECTED BY 07/07/2016				
Days Taken to Clear	Weeks Taken to Clear	Count Crimes	% of Cleared Crime Cleared Within Time Period	Cumulative % of Cleared Crime Within Time Period & Earlier
0-6	1	505	27.4%	27.4%
7-13	2	104	5.6%	33.0%
14-20	3	104	5.6%	38.7%
21-27	4	83	4.5%	43.2%
28-34	5	83	4.5%	47.7%
35-41	6	69	3.7%	51.4%
42-48	7	64	3.5%	54.9%
49-55	8	75	4.1%	58.9%
56-62	9	69	3.7%	62.7%
63-69	10	52	2.8%	65.5%
70-76	11	42	2.3%	67.8%
77-83	12	39	2.1%	69.9%
84-90	13	29	1.6%	71.5%
91-97	14	31	1.7%	73.2%
98-104	15	42	2.3%	75.4%
105-111	16	23	1.2%	76.7%
112-118	17	28	1.5%	78.2%
119-125	18	28	1.5%	79.7%
126-132	19	33	1.8%	81.5%
133-139	20	17	0.9%	82.4%
140-146	21	18	1.0%	83.4%
147-153	22	30	1.6%	85.0%
154-160	23	17	0.9%	86.0%
161-167	24	14	0.8%	86.7%
168-174	25	17	0.9%	87.6%
175-181	26	14	0.8%	88.4%
182-188	27	14	0.8%	89.2%
189-195	28	13	0.7%	89.9%
196-202	29	12	0.7%	90.5%
203-209	30	6	0.3%	90.8%
210-216	31	13	0.7%	91.5%
217-223	32	12	0.7%	92.2%
224-230	33	6	0.3%	92.5%
231-237	34	4	0.2%	92.7%
238-244	35	4	0.2%	93.0%
245-251	36	8	0.4%	93.4%
252-258	37	2	0.1%	93.5%
259-265	38	1	0.1%	93.5%
266-272	39	2	0.1%	93.7%
273-279	40	10	0.5%	94.2%
280-286	41	7	0.4%	94.6%
287-293	42	9	0.5%	95.1%
294-300	43	1	0.1%	95.1%
301-307	44	2	0.1%	95.2%
308-314	**45**	**2**	**0.1%**	**95.3%**
315-321	46	3	0.2%	95.5%
322-328	47	1	0.1%	95.6%
329-335	48	2	0.1%	95.7%
336-342	49	5	0.3%	95.9%
343-349	50	6	0.3%	96.3%
350-356	51	5	0.3%	96.5%
356-363	52	0	0.0%	96.5%
364 & Over	53 & Over	64	3.5%	100.0%
TOTAL	**ALL**	**1844**	**100.0%**	

Appendix D – Multicollinearity Statistics

Model		Unstandardized Coefficients		Standardised Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	.335	.128		2.618	.009		
	Journey Type - Static	.003	.004	.007	.921	.357	.701	1.427
	Commercial Property	.001	.010	.001	.120	.905	.725	1.379
	Inner Station	.003	.007	.004	.461	.645	.540	1.852
	Concourse/Outside Station	.002	.008	.002	.285	.776	.619	1.616
	Committed on Platforms	.010	.007	.011	1.407	.159	.596	1.678
	OnTrain	.001	.005	.002	.172	.863	.341	2.928
	Time - Morning (6-12)	.001	.004	.003	.414	.679	.806	1.240
	Evening (6-10)	-.006	.004	-.012	-1.764	.078	.802	1.247
	Night (10-6)	-.002	.004	-.003	-.373	.709	.847	1.181
	Spring (March-May)	-.001	.004	-.002	-.308	.758	.677	1.476
	Summer (June-August)	-.002	.004	-.005	-.602	.547	.688	1.453
	Winter (Dec-Feb)	.005	.004	.009	1.213	.225	.677	1.477
	Exact Time Known	.044	.007	.079	6.705	.000	.282	3.542
	Reported Within 30 Mins	.000	.010	.000	.022	.982	.783	1.277
	Reported Within 1 Hour	-.026	.005	-.038	-5.097	.000	.700	1.429
	Reported Within 24 Hours	.015	.003	.034	4.814	.000	.761	1.314
	Reported Within One Week	-.008	.005	-.011	-1.652	.098	.833	1.201
	Victim Gender - Male	-.008	.003	-.019	-3.044	.002	.976	1.025
	Victim Ethnicity - Chinese	.033	.007	.031	4.963	.000	.977	1.023
	Vulnerable Victim	-.010	.005	-.012	-1.878	.060	.986	1.014
	Offence Witnessed	-.031	.013	-.015	-2.370	.018	.968	1.033
	Property Value Over £500	.001	.003	.002	.333	.739	.994	1.006
	Phone or Electronic Device	-.006	.003	-.013	-2.075	.038	.971	1.030
	CCTV Available	.147	.005	.195	27.958	.000	.797	1.255
	Alcohol or Drugs Involved	-.006	.037	-.001	-.149	.881	.996	1.004
	Suspect Description	.694	.009	.508	74.909	.000	.847	1.180
	Committed Range less than 5 Mins	.005	.008	.009	.605	.545	.177	5.648
	Committed Range less than 10 Mins	.003	.007	.007	.489	.625	.183	5.464
	Committed Range less than 15 Mins	4.144E-5	.007	.000	.006	.995	.165	6.056
	Committed Range less than 20 Mins	.002	.007	.005	.335	.738	.174	5.763
	Committed Range less than 25 Mins	.001	.006	.003	.182	.856	.195	5.123
	Committed Range less than 30 Mins	-.003	.006	-.006	-.452	.651	.249	4.021
	Committed Range less than 45 Mins	.007	.007	.013	.972	.331	.228	4.394
	Committed Range less than 1 Hour	-.010	.008	-.016	-1.320	.187	.266	3.766
	Committed Range less than 2 Hours	.001	.008	.001	.112	.911	.761	1.315
	Intimidated Victim	-.012	.008	-.009	-1.433	.152	.992	1.008
	Scotland	-.010	.018	-.003	-.537	.591	.957	1.045

	East	-.013	.005	-.020	-2.434	.015	.587	1.705
	West	-.012	.013	-.006	-.929	.353	.923	1.083
	Midland	.002	.009	.002	.227	.820	.865	1.156
	Pennine	.003	.007	.003	.420	.674	.693	1.442
	Location - London (TfL)	-.001	.004	-.002	-.221	.825	.473	2.114
	Wales	.003	.020	.001	.142	.887	.968	1.034

a. Dependent Variable: **Positive Outcome**

References

ACPO (1989) ‘*Progress Report (II) of the Detection of Crime Working Group’.* London: HMSO – Cited in Gill, M., Hart, J., Livingstone, K. and Stevens, J. (1996) ‘*The Crime Allocation System: Police Investigations into Burglary and Vehicle Crime’.* Police Research Series Paper 16, London: Home Office.

Alderden, M. and Lavery, T. (2007) ‘*Predicting homicide clearances in Chicago: Investigating disparities in predictors across different types of homicide’.* Homicide Studies, 11, pp.115-132.

Andersson, P. (2014) *‘Bustling, crowding, and pushing: pickpockets and the nineteenth-century street crowd’.* Urban History, pp.41:02.

Ariel B., Sherman, L. and Vila, J. (2012) ‘*Random Assignment without Tears: How to Stop Worrying and Love the Cambridge Randomizer’.* Journal of Experimental Criminology 8(2), pp.193-208.

Barnes, G. and Hyatt, J. (2012) ‘*Classifying Adult Probationers by Forecasting Future Offending’*. Final Technical Report.

Baskin, D. and Sommers, I. (2012) ‘*The Influence of Forensic Evidence on the Case Outcomes of Assault and Robbery Incidents’.* Criminal Justice Policy Review: 23, pp.186-210.

Bieck, W. & Kessler, D.A. (1977) ‘*Response Time Analysis’.* Kansas City: Missouri Board of Police Commissioners.

Bloch, P. and Bell, J. (1976) ‘*Managing investigations’: The Rochester system.* Washington DC: The Police Foundation.

Bloch, P. and Weidman, D. (1975) ‘*Managing Criminal Investigations’.* U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice.

Bond, J. (2009) ‘*Value of DNA in Detecting Crime’.* Journal of Forensic Science, 52, pp.128-136

Bottoms, A. and Von Hirsch, A., (2010) '*The crime preventive impact of penal sanctions'.* The Oxford handbook of empirical legal research, pp.96-124.

Braga, A., Papachristos, A., and Hureau, D. (2012) *'Hot spots policing effects on crime',* Campbell Systematic Reviews, 2012:8.

Brandl, S.G. and Frank, J. (1994) *'The relationship between evidence, detective effort, and the disposition of burglary and robbery investigations'*, American Journal of Police, 3, pp.149-168.

Breiman, L. (2001) *'Random Forests'.* Machine Learning. 45 (1): pp.5–32.

British Transport Police (n.d.) '*Pickpocketing and Theft*'. Retrieved 3rd August 2016 from http://www.btp.police.uk/advice_and_info/how_we_tackle_crime/pickpocketing_and_theft.aspx

Bueerman, J. (2012) '*Being Smart on Crime with Evidence-based Policing',* National Institute of Justice Journal, 269, pp.12-15.

Burrows J., Hopkins M., Hubbard R., Robinson A., Speed M., Tilley N. (2005) *'Understanding the attrition process in volume crime investigations.'* Home Office research Study 295. London: Home Office Research, Development and Statistics Directorate.

Chaiken, J.M., Greenwood, P.W. and Petersilia, J. (1976) '*The Criminal Investigation Process: A Summary Report'*, CA: The RAND Corporation.

Clawson, C. and Chang, S. (1977) '*The Relationship between Response Delays and Arrest Rates'.* Journal of Police Science and Administration. 5, pp.53-68.

Cohen, J. (1988) '*Statistical power analysis for the behavioral sciences'*. Hillsdale, N.J., L. Erlbaum Associates.

Coupe, R.T. (2014) *'An evaluation of the effects of police resources and incident solvability on crime detection',* Legal Studies Research Paper Series: University of Cambridge.

Coupe, R.T. and Blake, L. (2006) *'Daylight and Darkness Targeting Strategies and the Risks of Being Seen at Residential Burglaries'*, Criminology, 44, pp.431-464.

Coupe, T. and Griffiths, M. (1996) *‘Solving Residential Burglary: Crime Detection and Prevention Series’*, Paper 77, London: Home Office.

Coupe R.T. and Kaur S. (2005) *‘The role of alarms and CCTV in detecting non-residential burglary.’* Security Journal, 18, 2, pp.53-72.

D’Alessio S.J. and Stolzenberg L. (2003) *‘Race and the Probability of Arrest.’* Social Forces, 81, 1, pp.381-1,397.

Durlauf, S. and Nagin, D. (2011) *‘Imprisonment and Crime: Can both be reduced?’* Criminology and Public Policy, 19, 1, pp.13-54.

Eck, J.E. (1979) *‘Managing Case Assignments: The Burglary Investigation Decision Model Replication’*, Washington, DC: Police Executive Research Forum.

Eck, J.E. (1983) *‘Solving Crimes: The Investigation of Burglary and Robbery’*, Washington, DC: Police Executive Research Forum.

Eitle, D., Stolzenberg, I. and D’Alessio, S.J. (2005) *‘Police Organizational factors, the racial composition of the police, and the probability of arrest’*, Justice Quarterly, 22, pp.30-57.

Farrington, D. and Lambert, S. (2000), *'Statistical approaches to offender profiling'* in Canter and Alison, Profiling Property crimes Aldershot: Ashgate. pp.233-273.

Felson, M. and Cohen, L.E. (1979) *‘Social change and crime rate trends: a routine activity approach’,* American Sociological Review, 44(4): pp.588-608.

Folk, J.F. (1971) *‘Municipal Detective Systems – A Quantitative Approach, Technical Report’* Number 55, Boston: Operations Research Center, Massachusetts Institute of Technology.

Gill, M., Hart, J., Livingstone, K. and Stevens, J. (1996) *‘the Crime Allocation System: Police Investigations into Burglary and Vehicle Crime’*, Police Research Series Paper 16, London: Home Office.

Goldstein, H. (1977) ‘*Policing a Free Society’.* Cambridge, MA: Ballinger.

Greenberg, B., Yu, O. and Lang, K. (1973) *'Enhancement of the Investigative Function'*, Volume I, Menlo Park, CA: Stanford Research Institute.

Greenwood, P.W. (1970) *'An Analysis of the Apprehension Activities of the New York City Police Department'*, New York, NY: The New York City RAND Institute.

Greenwood, P.W. and Petersilia, J. (1975) '*The Criminal Investigation Process',* 1,: Summary and Policy Implications, California: Rand.

Greenwood, P.W., Chaiken, J.M., Petersilia, J. and Prusoff, L. (1975) *'The Criminal Investigation Process',* Volume III: Observations and Analysis, Santa Monica, CA: The RAND Corporation.

Hagan, F.E. (1997). '*Research methods in criminal justice and criminology'* (pp. 347-48). Boston: Allyn and Bacon.

Home Office (2016) '*Counting rules for recorded crime.'* Retrieved 3rd December 2016 from https://www.gov.uk/government/publications/counting-rules-for-recorded-crime

Isaacs, H. (1967) *'A Study of Communications, Crimes and Arrests in a Metropolitan Police Department'*, Task Force Report: Science and Technology, Washington, DC: UN Government Printing Office.

Jansson, K. (2005) *'Volume crime investigations – a review of the research literature.'* Online report OLR 44/05, London: Home Office.

Kahneman, D. (2011). *'Thinking, Fast and Slow'*, London: Penguin Group, pp. 20-21.

Maguire, M. (2003) '*Crime Investigation: Thief-taking, crime-making and the CID'* in T. Newburn (ed.) A Handbook of Policing.

Meehl, P (1954) '*Clinical vs Statistical prediction; a theoretical analysis and a review of the evidence',* Minneapolis: University of Minnesota Press.

Newton, A., Partridge, H. and Gill, A. (2014) *'Above and below: measuring crime risk in and around underground mass transit systems'* Crime Science, 3 (1), pp.1-14.

Olphin, T. (2015) *'Solving Violent Crime: Targeting Factors that Predict Clearance of Non-Domestic Violent Offences'*, Thesis, University of Cambridge. (Unpublished)

Paine, C. (2012) *'Solvability Factors in Dwelling Burglaries in Thames Valley',* Thesis, University of Cambridge. (Unpublished)

Peterson, J., Sommers, I., Baskin, D. and Johnson, D., (2010) '*The role and impact of forensic evidence in the criminal justice process'*. National Institute of Justice, pp.1-151.

Reiss, A., and Bordua, D.J. (1967) *'Environment and Organization: A Perspective on the Police.'* The Police: Six Sociological Essays, edited by David J. Bordua. New York: John Wiley.

Reynald, D.M. (2009). *'Guardianship in action: Developing a new tool for measurement.'* Crime Prevention and Community Safety: An International Journal 11 (1): pp.1-20.

Robb, P., Coupe, T. and Ariel, B. (2014) *''Solvability' and Detection of Metal Theft on Railway Property',* European Journal of Criminal Policy Research, In Press.

Roberts A (2008) *'The influences of incident and contextual characteristics on crime detection of nonlethal violence: A multilevel event history analysis.'* Journal of Criminal Justice, 36, 1, pp.61-71.

Robinson, A. and Tilley, N. (2009) *'Factors influencing police performance in the investigation of volume crimes in England and Wales',* Police Practice and Research, 10, pp.209-223.

Sherman, L.W. (2007). *'The Power Few Hypothesis: Experimental Criminology and the Reduction of Harm'* Journal of Experimental Criminology 3: pp.299-321.

Sherman, L. (2013). '*The rise of evidence-based policing: targeting, testing and tracking'* in M. Tonry (ed.) Crime and Justice in America,-1975-2025, Crime and Justice, Vol. 42, Chicago: University of Chicago Press, pp.377-452.

Sherman. L. and Glick, B. (1984) *'The Quality of Police Arrest Statistics.'* Washington, D.C.: Police Foundation Reports, 2, pp.8.

Sherman, L.W., Gottfredson, D.C., MacKenzie, D.L., Eck, J., Reuter, P. and Bushway, S.D. (1998). *‘Preventing Crime: What works, what doesn’t, what’s promising’,* Research in Brief NCJ 171676, National Institute of Justice, pp.1-19.

Smith, M. (2008) *‘Addressing the Security Needs of Women Passengers on Public Transport’,* Security Journal 21 (1-2) pp.117–133.

Snyder HN (1999) *‘The overrepresentation of juvenile crime proportions in robbery detection statistics.*’ Journal of Quantitative Criminology, 15, pp.151-161.

Spelman, W. and Brown, D.K. (1981) ‘*Calling the Police: Citizen Reporting of Serious Crime’*, Washington, DC: Police Research Executive Forum.

Telep, C. W., & Weisburd, D. (2012). ‘*What is Known About the Effectiveness of Police Practices in Reducing Crime and Disorder?’* Police Quarterly, 15(4), pp.331-357.

Tilley, N., Robinson, A. and Burrows, J. (2007) *‘The Investigation of High Volume Crime’,* In T. Newburn, T. Williamson and A. Wright (eds.) Handbook of Criminal Investigation, Cullompton: Willan.

University of Pennsylvania (1955) ‘*Pickpocketing: A Survey of the Crime and Its Control”’,* Pickpocketing: A Survey of the Crime and Its Control. University of Pennsylvania Law Review 104.3: pp.408–420.

Waegel, W. (1982) *‘Patterns of Police Investigation in Urban Crimes’*, Journal of Police Science and Administration, 10, pp.452-465.

Weisburd, D. and Eck, J.E. (2004) *‘What can the police do to reduce crime, disorder and fear?’* The Annals of the American Academy of Political and Social Science, 593, pp.42-65.