General introduction

This chapter is an adaptation of:
Chapter 1

1.1 Introduction

Most knowledge on offenders and their offending behaviour is based on what we know about offenders who have been arrested or convicted. Many criminological studies on offending behaviour use police arrest data. These data only contain a small percentage of all offenders, and what maybe even more important, it is likely that offenders who end up in police arrest data are not representative for the entire offender population (see for example Elliott, 1995). Not only in terms of offender characteristics, but also in terms of their offending behaviour, the exact behaviour that is studied using these data. Concerns about the possible bias in results because only arrested offenders are studied are expressed by many authors (see for example Eck & Weisburd, 1995; Johnson, Summers, & Pease, 2009; Mazerolle, Brame, Paternoster, Piquero, & Dean, 2000; Miethe, Olson, & Mitchell, 2006). However, so far no research exists on whether offending behaviour of arrested offenders is different from that of non-arrested offenders, a logical consequence of the fact that regularly used data sources do not contain information about non-arrested offenders. It is thus important to study the offending behaviour of non-arrested offenders, and to study what influences the probability that an offender will be arrested and consequently ends up in arrest data. This thesis will take a new step in studying offending behaviour, more specifically spatial characteristics and criminal careers characteristics of this behaviour, by including non-arrested offenders in the sample. To be able to study the offending behaviour of non-arrested offenders, an alternative data source is used: data from the Dutch DNA database for criminal cases. If DNA of the same offender is found at different crime scenes, we know what types of crimes this offender has committed, and when and where he\(^1\) has committed them, even if the offender has not been arrested. DNA thus offers the unique opportunity to study the criminal behaviour of non-arrested offenders and compare this to the criminal behaviour of arrested offenders.

The purpose of this thesis is to study the offending behaviour of non-arrested offenders and compare it to the offending behaviour of arrested offenders. This comparison can help us draw conclusions on whether offender behaviour affects the probability of arrest. It should be emphasized here that these two formulations (to compare arrested and non-arrested offenders versus to assess effects on arrest) are almost equivalent ways to articulate the main subject of the study. The former formulation is static and applies to a situation at a fixed moment in time at which an offender has either been arrested or has never been arrested. The latter formulation acknowledges that arrest is a dynamic characteristic of an offender: all offenders are initially non-arrested, and over time some get arrested but others not. The latter formulation emphasizes that offending causes some offenders to get arrested, but not the other way around. Note that throughout

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\(^1\) To prevent an awkward stylistic construction, only male pronouns are used in this thesis when referring to persons.

\(^2\) http://dnadatabank.forensischinstituut.nl/dna_dossier/nieuws/nieuwe-aanlevercriteria-voor-dna-
this thesis ‘being arrested’ is an absorbing state: any subsequent offending taking place after offenders have been arrested (and identified through DNA) is not further analysed.

The main question of this thesis is: Which characteristics of offending behaviour influence the probability that an offender will be arrested?

This thesis focuses on two main types of characteristics: criminal career characteristics and spatial characteristics. The main question of this thesis can therefore be divided into two sub-questions: (1) Do criminal career characteristics influence the probability that an offender will be arrested?; and (2) Do spatial characteristics of offending behaviour influence the probability that an offender will be arrested? Given that these questions regard offending behaviour, only serial offenders (offenders who have committed at least two crimes) are studied in this thesis.

Studying whether characteristics of offending behaviour influence the probability of arrest, also gives the opportunity to study whether offenders present in arrest data are representative for the entire offender population: if certain characteristics have an influence on the probability that an offender ends up in arrest data, these data are not formed by chance and are thus selective when it comes to these characteristics. Offenders with these characteristics are over- or underrepresented in arrest data. Answering the main question of this thesis therefore also gives insight into whether arrest data, on which many criminological studies are based, are representative in terms of spatial and criminal career characteristics of offending behaviour. The following example illustrates this.

**Example**

Suppose that one of the conclusions of this thesis is that the probability of arrest is influenced by the type of crime an offender commits: the probability of arrest for offenders who commit violent crimes is 80 per cent, and the probability of arrest for offenders who commit burglaries is 40 per cent. Further suppose that there are 20 offenders: 10 offenders who have committed a violent crime and 10 offenders who have committed a burglary. The proportion of violent offenders in the total offender population is thus .5, the same as the proportion of burglary offenders in the total offender population. 80 per cent of the offenders who have committed a violent crime will be arrested, which means that 8 offenders are arrested. 40 per cent of burglary offenders are arrested, which means that 4 offenders are arrested. In the arrested offender population the proportion of violent offenders is now .67 (8 out of 12) and the proportion of burglary offenders is .33 (4 out of 12). When arrest data are subsequently used to study the proportion of offender that committing a violent offense, the conclusion would be that 70 per cent of offenders commit a violent crime. However, this conclusion is not correct for the total offender population, it only holds for arrested offenders. See Figure 1.1 for a schematic representation of this example.
This example shows that it is important to study whether characteristics of offending behaviour influence the probability that an offender will be arrested and subsequently will end up in arrest data: if it is known that certain characteristics of offending behaviour influence this probability, than we know what the nature and extent of the selectivity of arrest data is. In the case of this example: the conclusion that the probability of arrest is larger for violent offenders than for burglary offenders shows that compared to the total offender population, violent offenders are over-represented in the arrested offender population.

The goal of the current chapter is showing that DNA can have an added value for studying criminal career and spatial characteristics of offending behaviour compared to data sources that are commonly used for this type of research, as well as clarifying the manner in which DNA can be used for criminological research.

In this thesis the forensic use of DNA traces will not be discussed, nor will the usefulness of DNA traces for the police, or the reliability of DNA traces when used in court. There are already numerous studies on the forensic use of DNA traces (see for example Bond & Hammond, 2008; Bond & Phil, 2007; Broeders, 2003, 2005; De Knijff, 2004; De Poot & Kruisbergen, 2006; Jobling & Gill, 2004; Kloosterman & Meulenbroek, 2009; Meulenbroek, 2008; Sjerps & Kloosterman, 2005; Taroni, Bozza, Bernard, & Champod, 2007; Thompson, Taroni, & Aitken, 2003), while there is only little research on the use of DNA traces in environmental criminology and life course criminology. Moreover, the forensic use of DNA is not the focus of this thesis. This thesis will also not discuss the ethical aspect of using biological material for any type of research (see for example Patyn & Dierickx, 2009), on the one hand because the research in this thesis has no direct repercussions for the persons whose genetic material is stored in the database, on the other hand because this thesis does not use any biological traces or genetic characteristics of offenders.

In the remainder of this chapter first an oversight is given of the terminology used in this thesis. After that the added value of DNA compared to other commonly used data
sources is discussed. These data sources are arrest data and self-report data. Subsequently, three criminological studies are discussed that have used DNA traces for criminological research to a limited extent. This chapter will also discuss the Dutch DNA database, from which the data used in this thesis was collected, how DNA traces can be used for criminological research, and the (dis)advantages of using DNA traces for criminological research.

**Terminology**

**Unit of analysis**
In this thesis the unit of analysis is the crime series of a unique offender. The unit of analysis is not a single crime.

**DNA trace**
DNA found at a crime scene/ a crime scene stain

**DNA (person) profile**
DNA retrieved from a suspect or a previously convicted offender, by means of a buccal swab.

**Trace-trace match**
A match between two DNA traces found at different crime scenes: the DNA traces (actually: the DNA profiles extracted from the traces) are so alike, and the probability that this match is a coincidence is so small, that it is concluded that the traces originate from the same person.

**Trace-profile match**
A match between a DNA trace found at a crime scene and a DNA profile retrieved from a suspect. Again: the DNA profiles are so alike, and the probability of this match being a coincidence so small, that it is concluded that the trace originated from the suspect.

**Crime series**
A series of crimes at which DNA traces of the same person are found, which is established by trace-trace matches. In this study this person is considered to be the offender of these crimes. A crime series is the same as a trace series.

**Trace series**
The same as a crime series: a series of crimes at which DNA traces of the same person are found. In other words: (multiple) trace-traces match(es).
Cleared crime series  A crime series of which the DNA traces found at the crime scenes matched the DNA profile retrieved from a suspect. This suspect is now known to be the offender of this crime series (also see ‘arrested offender’).

Arrested offender  DNA of a suspect is taken by means of a buccal swap, loaded onto the DNA database, and matches a series of crimes (series of traces) already in the database. This person is now known to be the offender of this crime series (also see section 1.5).

Identified offender  Synonym of arrested offender.

1.2 DNA data versus arrest- and self-report data

DNA is used by the police for the detection of crimes and in the courtroom as evidence. However, DNA also offers unique opportunities for non-forensic criminological research. Until now, these opportunities have seldom been used. The added value of DNA for criminological research is that DNA traces secured at crime scenes enable us to study the criminal behaviour of a person – where and when crimes are committed and which types of crimes – even if the offender has not been arrested. Similarities between DNA traces found at different crime scenes make it possible to attribute these crimes to one and the same person. This means that DNA enables us to study the offending behaviour of offenders who have not been arrested. No research on the important question whether arrested offenders differ from non-arrested offenders in terms of offending behaviour exists so far. This is a consequence of the fact that no systematic data are available on the offending behaviour of non-arrested offenders in data sources that are commonly used for criminological research.

Three types of data sources are mainly used when crime is studied: (1) police and judicial registrations of reports of crimes, arrests and convictions (in short: arrest data); (2) self-reported criminal behaviour; and (3) victimization surveys (Kirk, 2006; Maxfield, Luntz Weiler, & Spatz Widom, 2000). Criminological knowledge about spatial aspects of criminal behaviour and on the criminal careers of offenders is mainly based on the first two of these three sources, namely police data and self-report data. Victimization surveys cannot contribute to studying patterns in offenders and their offending behaviour. These surveys namely do not contain questions about the offenders, mainly because a victim often does not know anything about the offender. Gaining information on spatial and criminal career characteristics of offending behaviour is therefore not possible from victimization survey data.

The other two data sources, arrest data and data from self-reported criminal behaviour produce information about identified offenders. The question is whether identified
offenders are representative for the entire offender population. Many studies have been conducted on the (dis)advantages of using police data and self-reported data as sources for criminological research. A short overview of the main findings is presented here.

From victimization surveys it has become clear that victims not always report crimes to the police (Kirk, 2006; Wittebrood & Nieuwbeerta, 2006). Especially less serious crimes like theft and public order offenses are often not officially reported to the police (Engelhard, Huls, Meijer, & van Panhuis, 2001). Whether a reported crimes leads to police investigations, how extensive these investigations are and whether suspects are arrested for these crimes, are decisions made by the police. Only a minority of crimes lead to arrest (Maxfield et al., 2000; Wittebrood & Junger-Tas, 1999). Whether a reported crime is actually registered, depends, among other things, on police policy, on the policy of the public prosecutor, changes in the criminal law, and publicity campaigns (Wittebrood & Junger-Tas, 1999). Not all crimes that are reported to and officially registered by the police are subsequently investigated. Figure 1.2 shows that cleared crimes are a subsample of all crimes that are reported to the police, which in turn are a subsample of all committed crimes.

So when arrest data are used for criminological research, only a small percentage of all offenders is studied. Moreover, as stated before, it is likely that the offenders who end up in arrest data are not representative for the entire offender population. How many offenders are not arrested is difficult to establish, it is however clear that a large number of offenders will never be arrested.

As offenders proceed through the judicial system, information about them becomes more selective, because selection processes take place at every step (for examples because a
public prosecutor decides not to press charges, see Kalidien & Eggen, 2009, pp. 202-203). Therefore information about the offender and his offending behaviour can best be measured as close to the source as possible. Self-report surveys offer an opportunity to do so. In a self-report survey respondents are asked whether they have ‘ever’ or during a certain period committed particular crimes (Bijleveld, 2009). Research on criminal careers shows that self-report surveys offer more detailed information than arrest or conviction data (Junger-Tas & Haen-Marshall, 1999). And without exception self-report studies show a larger number of crimes and offenders than that are known to the police (Maxfield et al., 2000).

Using self-report surveys as a data source for criminological research also has some limitations. Self-report surveys have mostly been conducted among (subgroups of) adolescents (Wittebrood & Junger-Tas, 1999). Also, because offending is generally rare, large samples are needed to be able to form an accurate image of the offender population (Pepper & Petrie, 2003). Since drop-outs are unavoidable, the intended sample is hardly ever achieved. Moreover, this drop-out is often selective: people who have a less favourable position in society are underrepresented (Riele, 2002).

Self-report surveys are plagued by a number of validity problems. First, most people are not eager to report about their criminal behaviour. Respondents can deliberately omit crimes, or report more crimes than they have actually committed. People may forget events, or they may report crimes that are not committed within the period of interest. The more frequent certain behaviour is, the greater the risk that it will be forgotten and consequently will not be reported. Compared to official (arrest and conviction) data, less serious and more frequent crimes are over-reported, while more serious crimes are under-reported (Junger-Tas & Haen-Marshall, 1999). Summarized, self-report studies suffer from both over- and underreporting (Junger-Tas & Haen-Marshall, 1999; Kirk, 2006). As a consequence, data from self-report surveys are less suitable for studying patterns in criminal behaviour.

Research on crime rates can be reasonably well based on victimization surveys or self-report surveys and to a certain extent on police arrest data. However, when patterns in criminal behaviour are concerned, these data sources are less suitable because of the above described problems. Police data could be used when patterns in the criminal behaviour of arrested offenders are studied, but not that of non-arrested offenders. In comparison, DNA traces do offer the unique opportunity to study the offending behaviour of non-arrested offenders. While arrest data only contain information about arrested offenders, DNA traces are not only left behind by offenders who are subsequently caught, but also by offenders who will not be arrested. DNA thus offers the opportunity to compare patterns in the offending behaviour of arrested offenders to patterns in the offending behaviour of non-arrested offenders, and thereby to study whether characteristics of this behaviour influence the probability of arrest. Although DNA has this advantage, it has not been used for many
criminological studies before. The next section discusses the three criminological studies that did use DNA traces.

1.3 Previous criminological research using DNA traces

To establish whether studies exist that use DNA traces for criminological research, a number of databases were systematically searched. This search produced three studies that (partly) utilize the opportunities that DNA databases offer.

Wiles and Costello (2000) use DNA collected between June 1997 and December 1997 to study the spatial behaviour of offenders in England and Wales. In their analysis they include a total of 15451 hits (matches) between either two crime scene traces or between a crime scene trace and a person profile. The crimes included in the study are high volume crimes: burglaries and what the authors call autocrime (theft of or from a car). Of these hits, 7745 pairs of DNA traces/profiles are submitted to the database by different police stations. The authors call these ‘movement hits’ (p.26). Half of the 15451 matches are therefore from within the same police force and police division. From the 7745 that are not, 5534 are still within the same force, but in different divisions. Only 1067 matches (or hits) are from non-adjoining forces. The authors thus conclude that in accordance with most other research on the spatial behaviour of offenders, offenders of high volume crimes like burglary and vehicle crime mostly operate locally (no conclusion can be drawn on whether the offender also resides in this area). The study by Wiles and Costello is the only one that uses DNA traces to study the spatial behaviour of offenders.

There are two studies that use DNA traces to study criminal careers. Townsley, Smith and Pease (2006) use DNA sampling to investigate offender specialization. They obtained a sample on solved serious offenses within the Metropolitan Police Service jurisdiction (UK) for the year 2003. For 11 per cent of these offenses a DNA crime scene trace could be matched with an offender who’s DNA was already in the National Database (NDNADB). The crime that led to the taking of the offender’s DNA (they call this the precursor event) is compared to the serious crime in the original sample committed by this same offender. This comparison of two crimes committed by the same offender (of which one is a serious offense: murder, robbery, sexual offense, or a violent offense) leads the authors to conclude that only around 10 per cent of these offenders is specialized, which is defined by the authors as the precursor event being the same crime type as the crime for which DNA was taken from the offender before. Townsley Smith and Pease (2006) therefore state that their analysis reflect the offender versatility found in other criminal career research.

Leary and Pease (2003) investigate the proportion of crime scene trace submissions that match DNA samples taken from persons already present in the database. They use data from the NDNADB, covering a 19-month period from one police force area (West Midlands Police, UK, between April 2000 and October 2001). The number of crime scene
traces submitted to the DNA database by the West Midlands police increases steadily during the 19-month period, by an average of 19 per month. However, the proportion of submitted crime scene traces that match a person profile already in the database, does not change during the study period. They conclude that this is a result of a fast-changing population of active offenders: many offenders of whom DNA is stored in the database do no longer offend, and those offenders that leave their DNA behind at crime scenes are not yet present in the DNA database. Also consistent with this conclusion is their finding that match-rates are not decreasing as the number of submitted samples increases.

1.4 DNA databases

As described, both arrest data and self-reported data suffer from limitations when it comes to studying offending behaviour. Arrest data suffers from a lack of representativeness because of the low clearance rate and selections in various stages of the investigative process, self-report data suffer from a possibly incorrect and/or incomplete representation of crimes reported by respondents. As a consequence difficulties arise when patterns in criminal behaviour are studied using these data sources. These limitations in the empirical foundation of criminological knowledge might be avoided partially by using DNA traces. Based on DNA traces found at different crime scenes, crimes can be attributed to an offender and be studied in cohesion, independent from the question whether the crimes have been solved (independent of the question whether the offender is present in arrest data) and independent from the question whether the offender would report this crime in a self-report survey. It is therefore also possible to study whether the criminal behaviour of non-arrested offenders shows the same patterns as the criminal behaviour of arrested offenders. Databases with DNA traces offer unique opportunities to do this.

Most Western European countries established a DNA database between 1998 and 2000. Differences in laws did cause differences between counties in the possibilities to retrieve DNA from suspects and storing DNA traces and profiles in a database. Compared to other European countries, the UK is an exception: the UK DNA database was established in 1995 and compared to all other European DNA databases, this database contains by far the most DNA profiles of suspect and DNA traces from crime scenes (Schneider & Martin, 2001).

The Dutch DNA database

Data used for this thesis comes from the Dutch DNA database for criminal cases, which was established in 1997 (Schneider & Martin, 2001). The database is managed by the Netherlands Forensic Institute (NFI) and contains DNA profiles for which the Dutch law allows storage. The database contains DNA profiles of suspects (arrested for committing a crime for which the law allows custody), DNA traces found at crime scenes and DNA profiles of deceased victims.
The different types of DNA profiles can be stored for limited amounts of time, which are regulated by the Dutch law: DNA profiles of deceased victims can be stored twelve, twenty or eighty years (depending on the type of crime), DNA traces from crime scenes can be stored twelve, twenty or eighty years or until a person is convicted for the crime, DNA profiles of persons convicted for a crime for which a prison sentence of four to six years can be imposed can be stored twenty years, and DNA profiles of persons convicted for a crime for which a prison sentence of more than six years can be imposed can be stored thirty years. There are a number of quality requirements for DNA profiles to be loaded onto the database. These requirements are published by the manager of the Dutch DNA database on http://dnadatabank.forensischinstituut.nl/.

The number of traces loaded onto the Dutch DNA database was minor until 2002, on average about 690 traces per year. Before 2001 DNA could only be retrieved from suspects arrested for serious crimes like homicides or serious sexual offenses, because the law only allowed DNA to be taken from suspects arrested for a crime for which the maximum prison sentence is 8 years or more. A law amendment in 2001 shifted the sentence length threshold down from eight to four years. As a consequence it became possible to retrieve DNA of a suspect suspected of committing a high volume crime, for example burglary. After 2001 police also started to collect DNA traces at crime scenes of high volume crimes. Before 2001 collecting DNA traces from high volume crime scenes was not very useful, because DNA could not legally be taken from a suspect for that type of crime and a comparison of crime scene DNA with suspect DNA was therefore not possible. Since the law amendment, the average number of crimes that is loaded onto the database increased to 4219 a year (NFI, 2013).

To answer the main question of this thesis one section of the DNA database in particular is important: the part that contains the non-biological information of the DNA traces. In this part of the database information about the crime itself and about the suspect are stored. For every DNA trace in the database, this part contains information about which police region submitted the trace, which type of crime was committed, when the crime was committed, and whether a person profile taken from an arrested offender matches this crime scene trace (in other words: whether the offender is arrested or not). This part of the database also contains information about which DNA traces match other DNA traces, and also the case number of each DNA trace.

The only geographical information in the database is the police region in which the crime was committed. At the time the research for this thesis was conducted, the Netherlands consisted of 25 police regions and one national police force (KLPD) (the Netherlands now consists of one national police force and 10 regions, which will be discussed in the general discussion of this thesis). The geographical information present in

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the database is therefore somewhat limited. However, each DNA trace has a case number that can be used to search police files for additional, detailed information, for example about the exact location of the crime (this will be discussed in more detail in chapter 4). Not only crime/trace series are stored in this section of the database, it also contains the same information about DNA traces that not match other crime scene traces (single crimes). The website http://dnadatabank.forensischinstituut.nl/ shows exactly how many traces and person profiles are in the database en how many trace-trace matches and how many trace-person matches there currently are.

1.5 Remarks on using DNA traces for criminological research

A number of remarks need to be made on using DNA traces for criminological research.

‘Arrested offender’

As described above, an offender is considered arrested in this thesis when his DNA profile matches DNA traces of different crime scenes already present in the DNA database. This person does not have to be arrested or convicted for all of these crimes, however, this person is now known to the police as being the probable offender. Possibly, the DNA of this person is found at different crime scenes while this person is not the offender, but a witness or a passer-by. However, as the crime scenes at which the DNA of this person is found increases, the likelihood that this person is not the offender but just a passer-by or a witness decreases. Because this thesis focusses on offenders who have committed at least two crimes, the probability that this person who’s DNA is found at a minimum of two crime scenes is not the offender, is small enough to consider this person responsible for the two crimes. Also, the crime scene examiner from the forensic department will reconstruct what happened at the crime scene, using all available information about the crime to try to make sure that he is actually collecting offender-DNA (Meulenbroek, 2008). The crime scene examiner will, based on his experience and on the specific situation of the crime scene, collect traces at places where offender-DNA can be expected (Van Koppen, 2004). By comparing the found DNA traces with the DNA profiles of the victim and of possible witnesses, both the victim and the witnesses will be ruled out as donors of the found DNA. Although this person, who left his DNA behind at a minimum of two crime scenes, may not be arrested or convicted for all crimes in the series, he has been arrested for at least one crime, otherwise his DNA profile would not have been taken. In this thesis, therefore, this person will be referred to as an ‘arrested offender’, with the side note that this does not mean that the offender is legally held responsible for all the crime in a series. What also has to be kept in mind is that for criminological research other error margins apply than in court. In court an error margin of one per cent would be unacceptable, while in the social sciences the same error margin is negligible.
Selectivity

A crime needs to be reported to the police before a DNA trace can be secured at a crime scene. DNA traces can thus be seen as a form of police data, which means that problems with selectivity (victims who do not report crimes to the police, police that will not investigate a crime, etc.) will also affect DNA data. If the crime is reported to the police, and the police are investigating the crime, there is still a probability that no DNA traces will be secured at the crime scene. Causes for this might be that the offender did not leave a DNA trace behind, that the forensic department does not visit the crime scene, that this particular type of crime is not currently a priority, that the offender is already arrested and there is no longer a need for DNA evidence, the quality of the DNA is not good enough (see for example Bond & Hammond, 2008), etc. Experienced criminals might also be aware of the current investigative techniques and will try to avoid leaving traces behind.

As stated earlier a law amendment in the Dutch law in 2001 made it possible to collect DNA traces at high volume crime scenes. The percentage of traces collected at high volume crime scenes submitted for analysis at the NFI differs between police regions and varies between 35 per cent and 75 per cent (Jacobs & Bruinsma, 2008). It might therefore be possible that the types of crimes present in the DNA database are not representative. Additionally, the types of crime, and the proportion of the different types of crime present in the database, will differ (largely) before and after 2001. Therefore the data used in this thesis only consist of DNA traces loaded onto the database after January 1st 2002.

DNA data thus also suffer from the disadvantages that arrest records suffer from: selectivity and under-reporting. However, the selectivity might be of a different nature that is partially traceable. The type of crime and the likelihood that a DNA trace is left behind when committing that type of crime can cause different groups of offenders to be excluded from the analyses compared to for example self-report studies (for example, more serious violent crime are less often reported in self-reports while DNA traces are found at a large portion of homicides). Section 5.2 of the general discussion will discuss the representativeness of DNA data extensively.

Figure 1.3 shows a graphical representation of the relationship between solved crimes, crimes that are known to the police and all crimes, as well as a subset of crimes where DNA traces are secured. The research in this thesis consists of a comparison between part A, solved crimes where DNA traces were found (DNA traces of arrested offenders) and part B, unsolved crimes where DNA traces were found (DNA traces of non-arrested offenders).
Figure 1.3  Graphical representation of the relationship between crimes, crimes known to the police, solved crimes, and crimes at which DNA traces are secured

**Reliability**

Another remark on using DNA traces for criminological research concerns the reliability of matches between DNA traces. Each DNA profile is extremely rare but we can never be sure whether a profile is unique. It is impossible to test the entire world population on whether two persons have the same DNA (besides identical twins, who are known to have the same DNA). It could therefore be possible that a match between two traces is a coincidence, and that they are not actually originating from the same person. However, the NFI calculated that the probability of a match being coincidental is always smaller than one in one billion when a complete DNA profile is used (Broeders, 2003; Meulcnbroek, 2008). Again, for criminological research other error margins apply than in court

**Little previous research**

As described above only three criminological studies could be found that use DNA traces as a data source. There may be several causes why the possibilities that DNA traces offer for criminological research have seldom been used until now. First, DNA traces are associated with forensics because of their important role in police investigations and in the court room. Many studies on DNA are therefore conducted from a legal point-of-view. There are, for example, many studies on the reliability of a match between a DNA profile of a suspect and DNA traces found at crime scenes (see for example Broeders, 2003). Second, databases that store DNA profiles contain sensitive information because the DNA itself contains information about biological characteristics, and ethical issues make it more difficult to get access to the database for other than legal purposes. In the Netherlands
access to judicial data for scientific purposes is regulated by law and possible under certain conditions. Scientists in the Netherlands are granted access to judicial data on a large scale. The not-biological DNA data used for this thesis do not have a different status than other judicial data, such as arrest data. Another reason might be that the DNA database was just recently developed. Maybe researchers did not yet think about the opportunities that the database offers. A last point might be that researchers can have professional objections against using DNA traces for criminological research, for example that offenders present in the database only form a subsample of the entire offender population. However, the opportunities that the DNA database offers are such interesting opportunities that it is worth the effort to use DNA data to study the offending behaviour of non-arrested offenders.

1.6 Conclusion

Besides the forensic context in which DNA traces have their value, they can also have an added value for research on spatial and criminal career characteristics of offending behaviour. DNA traces can be a new data source next to the other data sources in criminology, arrest data, data from self-report surveys, and data from victimization surveys. These data sources all have their limitations of which under- or over-reporting and selectivity are the most important ones. DNA traces offer the unique opportunity of collecting information about the offending behaviour of non-arrested offenders. The question whether arrested offenders are representative for the entire offender population, a question often raised in criminological studies, is by using DNA traces a topic of empirical research instead of just of topic of discussion.

1.7 Remainder of this thesis

Chapters 2, 3 and 4 will answer the two sub questions, and thus the main question of this thesis by studying which criminal career and spatial characteristic of offending behaviour influence the probability than an offender will be arrested. Because these three chapters were or will be published as peer-reviewed journal articles, they overlap in some respects. First, the methodology used in these chapters is the same: survival analysis is used to study whether characteristics of offending behaviour have an influence on the probability that an offender will be arrested. Second, chapters 2 and 3 have a similar theoretical background: both chapters use prior studies on clearance to explain why offender behaviour may influence the probability of arrest. In chapter 4 a different theoretical point-of-view is taken, as this chapter discusses how representative arrest data are.
Chapter 1

Chapter 2
In chapter 2 the first sub question of this thesis is discussed, by studying whether criminal career characteristics influence the probability that an offender will be arrested. The criminal career characteristics studied are (1) the number of committed crimes (the length of the criminal career); (2) the seriousness of the committed crimes; and (3) offense specialization.

Chapter 3
Chapter 3 studies whether the spatial dispersion of crime locations of an offender on a meso-level influences the probability of arrest. More specifically this chapter studies whether offenders who offend in multiple Dutch police regions have a different probability of being arrested than offenders who commit their crimes in a single police region.

Chapter 4
Chapter 4 studies whether the spatial dispersion of crime locations of an offender on a micro-level, namely the criminal range of the offender, influences the probability of arrest. The criminal range of an offender is measured as the average distance between committed crimes. Chapters 3 and 4 combined answer the second sub question of this thesis.

General conclusion and discussion
This thesis will conclude with a general conclusion and discussion in which the main question of this thesis will be answered, and the limitations of this thesis and of using DNA data for criminological are discussed. Also, future research possibilities and the implications of the results from this thesis for policy will be discussed.
References


